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Lighting the Welland Ship Canal

An Outline of the Investigation, Design and Installation Features of the Lighting of the Welland Ship Canal

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Senior Assistant Engineer, Welland Ship Canal, St. Catharines, Ontario.

Paper to be presented at the General Professional Meeting of The Engineering Institute of Canada, Ottawa, Ont., February 7th and 8th, 1933.

SUMMARY.—The author discusses the considerations governing the selection and installation of the lighting equipment of the canal as decided by the requirements for safe navigation at night, for safe traffic over the bridges and for the operation of the various services of the canal. The lighting installations include those necessary for the locks, gate yard, canal prism, bridges and buildings, navigation signals and the harbours.

The Welland Ship canal is the fourth canal between Lake Erie and Lake Ontario and was projected following the opening of the St. Lawrence route in 1901. Exhaustive surveys were made for a ship canal across the Niagara Peninsula and led to the adoption of the Ten Mile Creek location for the canal and the inception of the work in 1913. The Great War in 1914 halted the work, but it was recommenced at the conclusion.

The canal cuts across a comparatively narrow peninsula which is one of the most heavily travelled sections of North America. Crossing the canal are five steam railways, of which three are double tracked; three electric railways and provisions for one other; thirteen highways; a large number of overhead high tension electric power lines; also submarine crossings for electric power, telephone and telegraph services. During construction, traffic on the above and all navigation traffic on the old canal had to go on without interruption and this created many difficult engineering problems.

The total length of the canal is 25 miles or 27.7 miles between the outermost ends of Port Weller and Port Colborne harbours. The length of canal prism, i.e., that part between the locks and lock approach walls, is between 21 and 22 miles. The difference in level between the two lakes is overcome by seven locks of 46½ feet lift each, which has no precedent in actual construction for locks of their size. The canal is 200 feet wide at the bottom and 310 feet wide on the water line and all structures are built for 30-foot draught. The depth at other places is 25 feet and 27½ feet, and at any future date can be deepened by simply dredging out the canal prism and the harbour entrances. (See profile and map of Welland Ship canal, Fig. 1.)

1. General

The primary reason for lighting the locks and reaches of a canal is to facilitate the safe navigation of ships through the canal during the night. The lighting of the Welland Ship canal presented many interesting and unusual illumination problems in design and application. This was especially true in regard to the canal prism lighting, viz., the lighting of the reaches between locks. The lighting for the entire canal was first considered about two years or so after the world war and the development in the technique of lighting from that time until the canal engineers were ready to prepare specifications with the view of purchasing and installing the equipment, was closely followed. During this period of time studies were made to determine the location of the lighting standards on the masonry at the machinery ends of the locks and considerable experimentation was done. After careful study, it was decided to use the constant current series system for lighting the canal prism and for all other canal lighting it was decided to use a 220/110-volt distributing system with 110-130 multiple volt lamps, because of its decided economy and safety as compared with any other system now in general use, and also because of the superior physical characteristics, higher efficiency and lower first cost of the 110/130-volt lamps. The gate lifter uses 230-volt lamps because the gate lifter power is direct current at 230 volts. The lamps in the lock machinery and operators' houses are 230-volt in order to discourage the possibility of pilfering the 110-volt standard lamps.

2. Lock Lighting

The lighting of the canal locks was not a simple problem, owing to many points connected with the particular purposes of the lighting and the physical shape of the lock structures and approaches.

The area to be lighted and the proper amount of light for the operators working at the various locks had to be decided, and the spacing and the distance of the lighting units from the edge of the lock chamber had to be fixed. It was desirable that a certain area back of the lock walls should be lighted in order to guard against prowlers and for appearance. The future doubling of present single locks had to be considered. At the locks several hundred feet of the lock approach walls are included as part of the lock lighting system. Anything beyond this is a part of the canal prism lighting system.

It was desirable that glare from lighting units be kept as low as possible especially to navigators approaching and

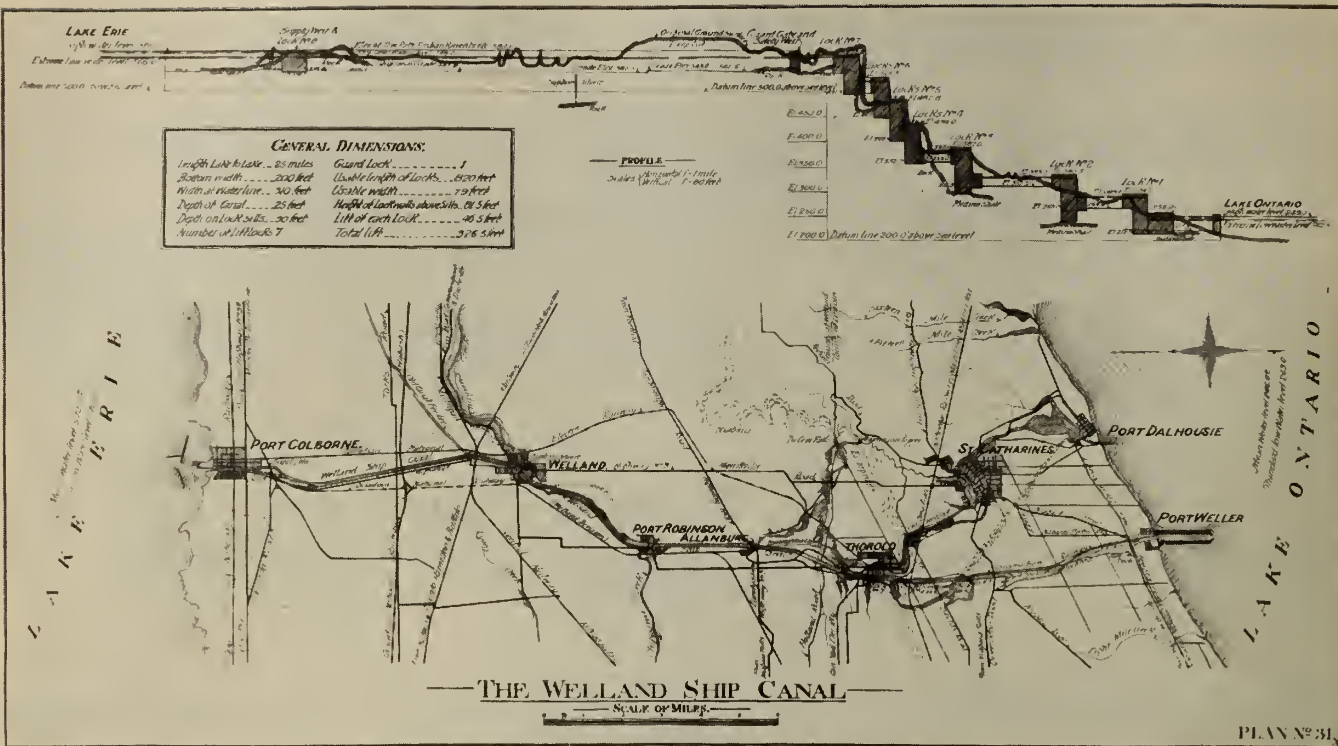


Fig. 1—Profile and Map of the Welland Ship Canal.

entering the lock, therefore it was necessary to mount the units high up and to keep the intensity of the light source as low as possible, which indicated the use of refracting units of large area as well as high mounting.

Some of the principal operations around the locks consist of throwing lines, hauling in ropes and cables, mooring ships, the operation of capstans, fenders and other machinery, also men moving about and signalling to each other. It is desirable that the lock operator in the control house be able to see easily the position of the lock gates, fenders, the ship and other things about him, hence the amount of light required is that which will allow the eye to focus quickly upon objects at various distances, and to keep a clear vision of the necessary details of an object under continuous observation, thus tending to lessen the liability of accidents. It was also considered desirable to reduce sharp contrasts in illumination and to eliminate dark areas on the working surfaces of the locks.

The canal engineers decided that there should be an illumination not less than 0.20-foot candles measured at the lock coping and at the edge of the lock chamber. It was also decided to use lamps not greater than 500 watts, but at the same time to choose a refractor that would be suitable for 750-watt and 1,000-watt lamps if for any reason it might be advantageous to use these larger lamps either at the locks or elsewhere—for instance lighting the harbours.

The distance from the lighting standard to the edge of the lock wall is nineteen feet for all locks except lock

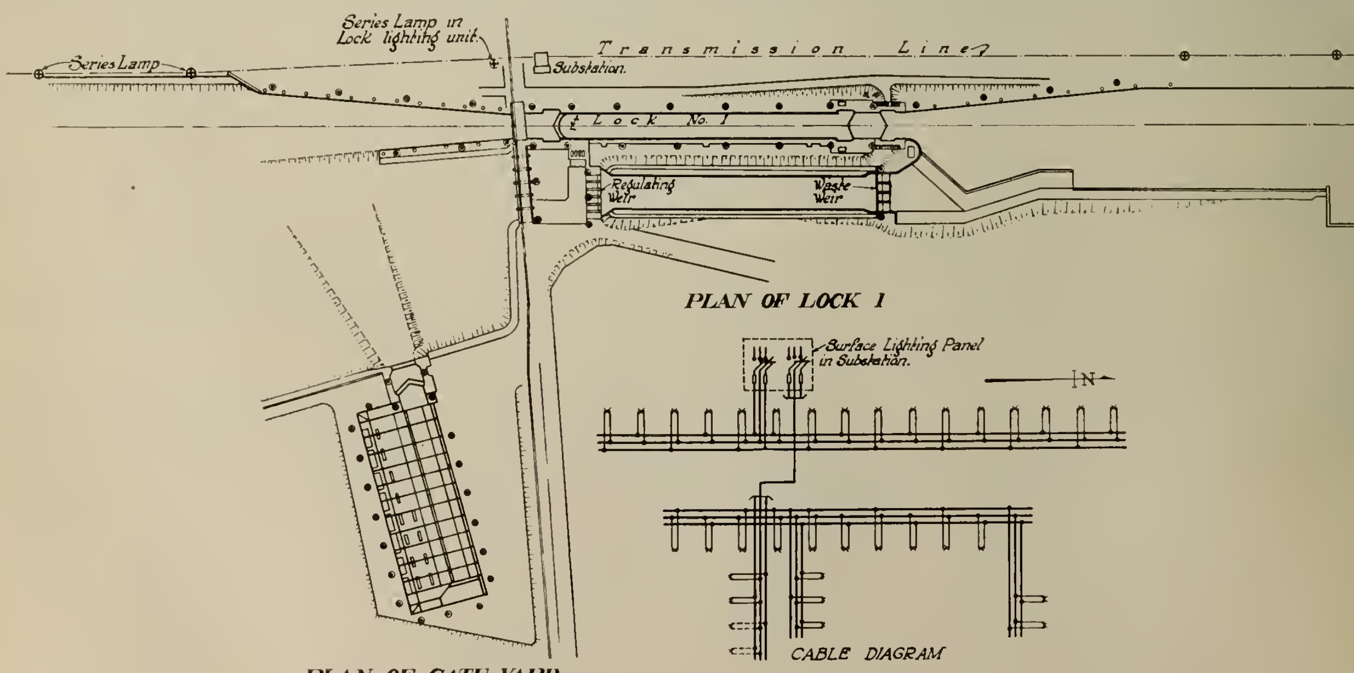


Fig. 2—General Arrangement of Lights at Lock No. 1 and Gate Yard.

No. 8 where this distance is 23 feet. On the approach walls this distance varies from 19 feet to 23 feet or more, depending on the local conditions. On all single locks there is a row of lights on each side. On the twin locks in flight there is a single row of lights on each of the outside walls and two rows of lights, one for each lock chamber, on the centre wall. Each standard has a single arm bracket with a pendent fixture.

Calculations were made from tables and photometric curves for various lighting units and for different spacings and heights, based on using 500-watt multiple lamps, and

Fig. 3—Lock Lighting Unit.

it was found that the desired illumination for the locks could be obtained by using a Holophane asymmetric B-way bowl refractor at a mounting height above coping level of 22 feet 6 inches to the centre line of the light, and with a spacing of approximately 160 feet between centres along the row of lights. (See Fig. 2.) On the entrance walls the spacing of the units varies from 160 feet to 200 feet depending on the conditions affecting the installation.

Layouts to scale were made for various types and sizes of concrete and metal poles or standards with brackets and lighting fixtures, and after due consideration for strength, durability, economy and aesthetics, the design was used which appeared to be the most suitable for the particular purpose.

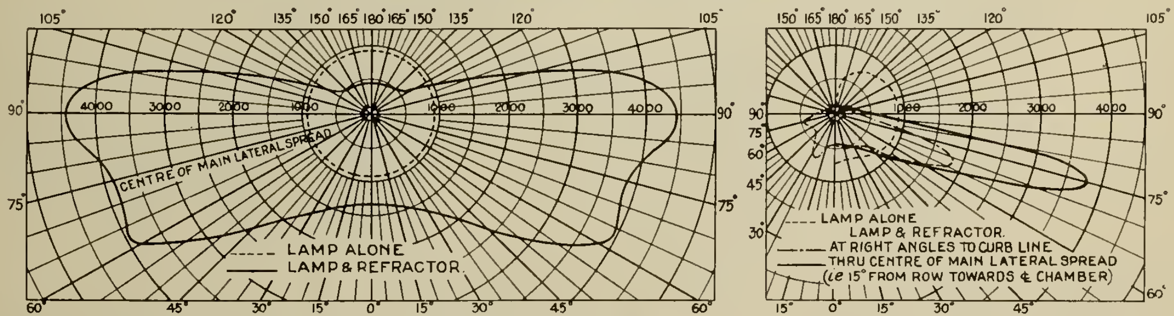
Hood

The lighting unit selected is of the pendent type suspended from a bracket, and consists of a hood made up of an upper part, the cap, and a lower part, the skirt, and a glass refractor with its supporting ring fastened to the skirt. The cap and skirt are made of cast iron porcelain enamelled a dark green colour on the outside and white on the inside. The skirt which holds the glassware is approximately eighteen inches in diameter at the bottom. Provision is made inside the hood for raising and lowering the lamp in order to bring the filament to the proper focal centre and for adjustment so that the centre of the maximum beam can be brought to any position between 65 and 80 degrees from the vertical axis of the unit regardless of the size of the lamp or the type of refractor, and so that the lamp used can be quickly centred or focused without taking down the unit or taking apart the cap and skirt or without changing the position of the refractor relative to the fixture. The unit is so made that it will take lamps from 300 watts to

Fig. 5—Night View of Lock No. 8.

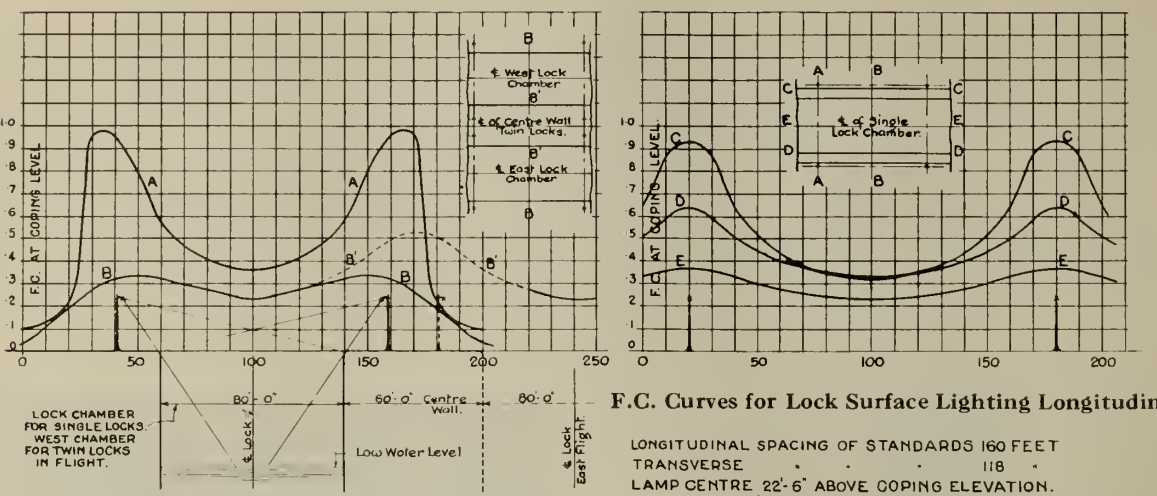
1,000 watts. The whole body was carefully designed for appearance, utility and ease of maintenance. The skirt is equipped with a cast aluminum ring arranged to hold either an 8-inch or an 11-inch bowl refractor or a dome type refractor. The refractor is securely fastened to the supporting ring so that it cannot drop off or out of the ring in any position. The ring is hinged to the skirt in such a manner that the refractor with its supporting ring will swing clear of the largest lamp used and without dropping off the skirt when relamping, cleaning or adjusting the lamp socket, etc. The supporting ring is held closed with a wing nut arrangement that can be quickly unfastened and fastened without any part dropping off. The rings used for the different sizes of bowl refractors are identical so far as their hinges and fastening devices and the parts in contact with the skirt are concerned, so that hinge and latch are common to all supporting rings. Orientation of the refractor is provided for by making it possible to mount the refractor in its ring in one way only. Fig. 3 shows the assembled unit.

Light Distribution Curves for 11″ Asymmetric B-Way Bowl Refractor
500 Watt (9,500 Lumen) Multiple Lamp



Lateral Distribution at 75° (15° Below the Horizontal) **Vertical Distribution in Two Planes**

Fig. 4



F.C. Curves for Lock Surface Lighting Transverse

F.C. Curves for Lock Surface Lighting Longitudinal

Fig. 6—Curves for Lock Surface Lighting.

Refractors

The refractor used at the locks and weirs is made of two sections of clear glass firmly held together in the proper mutual relation and is of the closed type. The inner surface of the inside section and the outer surface of the outside section are smooth so that they will not readily become dirty and are easy to clean. For lock lighting the refractor is a standard Holophane 11-inch asymmetric B-way bowl which projects most of the light in the form of a wide fan to the front and downwards at a slight angle as indicated by the light distribution curves shown in Fig. 4. On the weirs an 8-inch refractor is used.

The illumination effect produced is shown by Fig. 5, which is reproduced from a night photograph of lock No. 8, taken from the centre of the bridge sidewalk looking towards the south end of the lock. Fig. 6 shows the light distribution obtained in the longitudinal and transverse directions respectively, and it will be seen that the illumination with 500-watt lamps does not fall below the minimum specified value of 0.20-foot candles at any point on the lock coping. An inspection of the light illumination curves, Fig. 6, will also show that the wheelsman of a ship entering the lock, when it is full of water, is well above the maximum beam of light, and when entering the empty lock is well below it, so that in either case there is no objectionable glare.

Standards

The standards used had to be strong and rugged so as to withstand successfully any hard knocks that they might be subjected to such as the impact of heavy steel mooring ropes breaking under strain. They should be of such a size and shape that they would harmonize with the monolithic lock structure and they should have a clear record of successful life for at least twenty years under severe service conditions and should be reasonable in cost and readily available. Various types and makes of standards were investigated and after careful consideration it was decided to use a standard made up of three sections of welded steel pipe, these being 8 inches in diameter and 28.8 pounds per foot for the bottom section, 7-inch diameter and 23.8

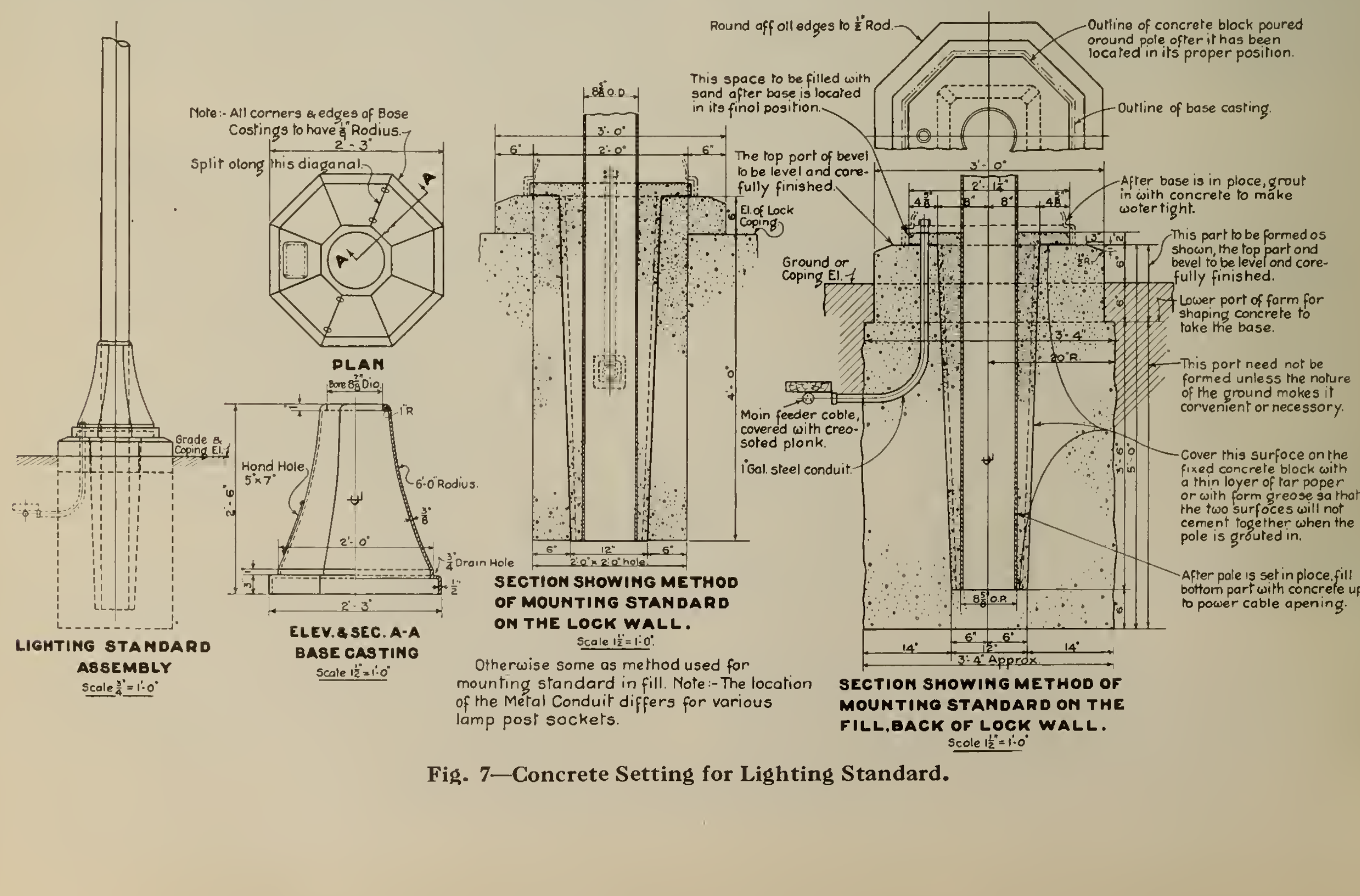


Fig. 7—Concrete Setting for Lighting Standard.

pounds for the middle section and 6-inch diameter and 19.2 pounds for the top section. The overlap of the sections at the joints is 18 inches. The poles are straight, no pole being accepted if it had more than a ½-inch bow from end to end. The finished pole is round and has no overlapping vertical seams.

Each pole is equipped with a cast iron base octagonal in shape. The base is split in halves which are bolted together and is set on a concrete pedestal which rises 6

Fig. 8—Lock Lighting Standard.

inches above the coping and ground level. The bracket holding the lighting fixture is made of cast iron and is bored and finished to fit the top of the pole so that when it is bolted in place it is at right angles to the axis of the pole. A hole was made in the fixture end of the bracket for convenience in wiring, this hole being stopped with a threaded plug. The opening in the top of the pole and the bracket is covered by a finial so that the top of the pole and bracket casting are made weatherproof. Lead covered cable is carried inside the pole to the top and into the bracket and is jointed to asbestos insulated wire which enters the cap to the lamp socket.

The standard is set in the concrete in such a manner that it is possible to jack out the pole without damaging the concrete setting or lock masonry. This and other features are shown in Fig. 7. Fig. 8 shows a general view of a lighting standard including base and concrete pedestal and how it is set back to clear the lock wall and mooring posts.

Lighting Circuits

All lamps for the lock and approach wall surface lighting are fed directly from 220/110-volt circuits. Alternate lamps are fed from the same side of the circuit, so that in case a fuse in the outside conductors of the circuit should blow, alternate lamps would remain lighted. The circuit for the lamps on the west side of the lock is separate from that on the east and each of the west and east group of lamps and its circuit has its own individual feeder from the switchboard in the lock substation and is controlled from the lock substation. The general arrangement of the lights for locks Nos. 1, 2 and 3 and the gate yard at lock No. 1, also the cable diagram for lock No. 1, are shown in Fig. 2. The arrangement for lock No. 7 is the same, except that owing to the number of lights on the east side, the lamp circuit is divided into two parts, both being fed from a 550- to 220/110-volt transformer common to both circuits; the transformer is fed by a 550-volt circuit from the lock substation switchboard. The general arrangement of the lights and lighting circuits at lock No. 8 is shown in Fig. 9. It might be noted that the south groups of lights on the east side for the south approach wall and on to Port Colborne are fed from bridge No. 21 substation and are automatically switched on when the east side lock chamber lights are lighted. This was necessary because of the distances involved.

A general arrangement of the surface lighting for the twin locks in flight, Nos. 4, 5 and 6, is shown in Fig. 10. All lighting for the east flight locks is entirely separate from that for the west flight and is divided into four groups, i.e., one group for each end of a lock, or a total of eight groups for the whole of the twin locks in flight. With this group arrangement no lock chamber would be without light in case one or two circuits were out of commission. Each of these groups of lights is fed by a 37½ kv.-a. 550- to 220/110-volt transformer located in the control house at the machinery end of the lock on the centre wall. The switchboard for the control of the various lighting circuits is located in the control house at the lower end of lock No. 5. Power is brought from the 550-volt three-phase bus in the flight lock substation situated in the vicinity of the lower (north) end of lock No. 5 to the cable disconnecting switches on this switchboard. The circuits are arranged so that one cable feeds the transformer for the east lock group of lighting from the hinged side of its disconnecting switch and an exactly similar arrangement is used for the west lock lighting. Means are provided for switching the east transformer on to the west feeder cable and vice versa as desired. The lighting switchboard for the lower ends of locks Nos. 4 and 6 is fed from that for lower lock No. 5 and the switchboard for the upper end of lock No. 6 is fed from that for the lower end of lock No. 6. The distributing system consists of lead covered cable in the lock ducts and lead covered steel tape armoured cables buried in the ground where the lighting standards are in the fill. All wiring was calculated for a drop of not greater than three per cent when using 500-watt lamps and under the worst condition of circuit and load.

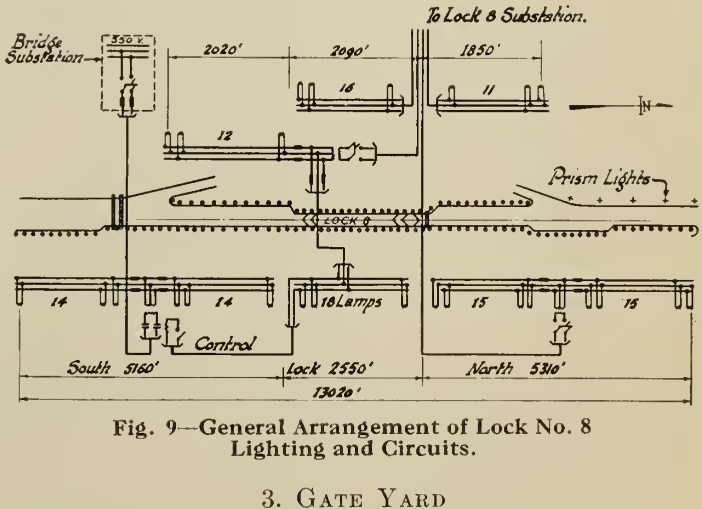


Fig. 9—General Arrangement of Lock No. 8 Lighting and Circuits.

3. Gate Yard

The general arrangement of the lights and the lighting and auxiliary power circuits for the gate yard are shown in Fig. 11. The four lighting units on the gate monoliths are exactly the same as those used on the lock surface lighting. The remainder of the lighting equipment is the same except for the glassware, which consists of an 8-inch asymmetric dome type refractor enclosed in an 11-inch rippled clear glass globe. On each of the standards on each side of the gate yard is an outlet box equipped with watertight plug receptacles for 550-volt three-phase, 220-volt single-phase and 110-volt single-phase circuits for power and lighting extension cords. There is also a 220-volt three-phase "shore circuit" to operate the gate lifter bilge pump and for lighting the gate lifter when it is tied up in the gate yard and no steam power is available. This shore circuit is brought to a post support just back of the wall near the gate lifter. Power for the lighting circuits and the 220-volt three-phase gate lifter circuit is furnished by a bank of three 37½ kv.-a. 550- to 220/110-volt single-phase transformers and that for the 550-volt three-phase power to plugs is taken from the bus of the main switchboard for the gate yard. The switchboard, located in the gate machinery house, is fed by an underground cable from the substation at lock No. 1 and switches the power to the transformers and to the various circuits of the distributing system, which consists of lead covered steel tape armoured cables, in some cases carried in ducts, and in others, buried in the ground near the lighting standards.

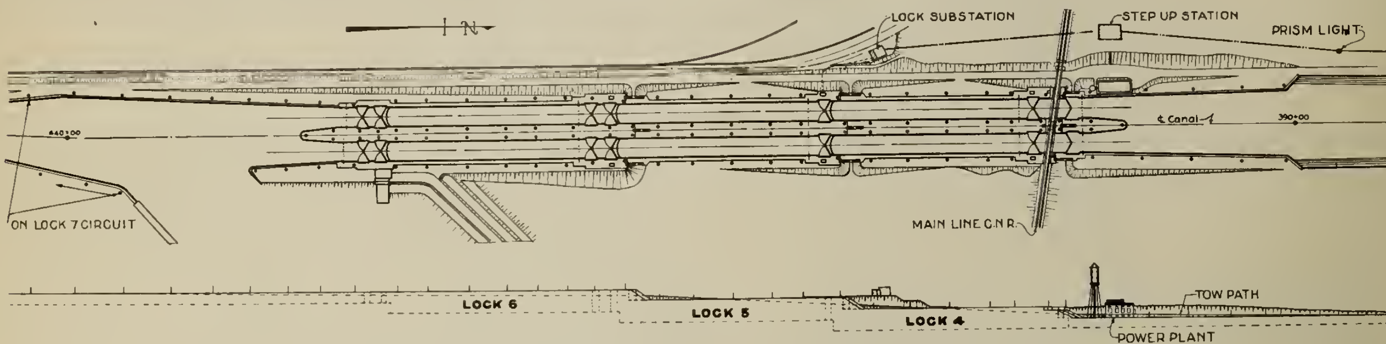


Fig. 10—Plan and Elevations of Twin Locks in Flight Nos. 4, 5 and 6.

4. Mooring Galleries

Each lift lock has a long mooring post gallery approximately 29 feet below the coping level. This gallery extends nearly the entire length of the lock chamber and has openings every 120 feet into the lock chamber for the purpose of mooring ships in the lock when the water level is below the gallery floor. There are three stairways, one near each end of the gallery and one about the middle. These stairways are in some cases straight but are generally spiral. A light is placed in the gallery at each mooring opening and midway between, i.e., 60 feet, and the stairways are lighted. A coloured light is placed in the gallery at the entrance to each stair. Provision is made for switching off the lights when the gallery is not being used.

The mooring gallery lighting units have to stand rather unusual and severe conditions. Every time a lock is filled, the units, while lighted, are submerged under at least 25 feet of water and may be submerged for hours at a time, and must be perfectly watertight under such conditions. Each unit is designed to take lamps from 40 to 100 watts and has an overall height of approximately 8 inches and a maximum diameter of about 5 inches. All metal parts are of bronze. The glass globe is made of a special heat-resisting glass and is cemented into a bronze ring or holder which is screwed into the body of the fixture. A protecting wire guard surrounds the globe and is screwed on to the globe holder.

The unit is fastened to the concrete ceiling of the mooring gallery by bolts cinch anchored into the concrete. The conductors are brought to the unit by lead covered cable, and the cable is wiped on to a wiping sleeve that is part of the body of the fixture. This insures a watertight connection to the fixture.

The units were subjected to very rigid tests before being accepted as each unit was completely assembled with a 100-watt lamp and allowed to burn for twenty-four hours; at the end of that period it was submerged in ice cold water at 32 degrees F. while still burning. The globes accepted withstood this test without breaking. To insure against porous castings and poor thread, all units were subjected to an air pressure of 5 pounds per square inch inside the unit while submerged in soapy water, the absence of air bubbles being an indication that all joints, threads and other parts of the fixture were watertight. Fig. 12 shows the assembled unit.

Various cements were experimented with for cementing the glass into its retaining ring. Some of the litharge cements seemed to be satisfactory but others soon disintegrated. The cement that appears to be most satisfactory is Hydroline.

5. Canal Prism

The lighting of that part of the canal on the reaches between the locks, generally designated as the canal prism, presented many unusual problems. There are approximately 24 miles of canal prism, the banks of which had to be illuminated, at least, to the equivalent of full moonlight, so that they could be easily distinguished by the navigators.

At various places along the canal from the guard gate at Thorold down to Port Weller and located along the east bank are large pondage areas for storing water used in filling the locks, hence the contour of the east bank of the canal is not suitable for the placing of lighting units. On the west there are no pondage areas and the contour of this side of the canal is, generally speaking, straight and parallel to the centre line of the canal. The transmission line is placed along this bank on wooden poles spaced 90 feet apart and in most places is approximately 30 feet back from the top of the slope but in others it is more. On the straight reaches of the canal the width from top of slope to top of slope is approximately 330 feet and from the top of the east slope to the transmission line poles on the west bank, in most places, 360 to 380 feet and in others is as much as 480 feet or more.

On the summit reaches between Thorold and Port Colborne it was decided to place the lighting units on the transmission line poles at a height of approximately 18 feet above the top of the slope, i.e., approximately 31 feet above the normal water level, and on the reaches between Thorold and Port Weller as near 31 feet above normal water level as the height and contour of the canal bank would allow. At a mounting height less than 18 feet the top of the slope would in places cause a dark and undesirable shadow on the water on the west side of the canal, and the lights would be more liable to damage by mischievous prowlers. At the height chosen, the lamps light the opposite bank over the middle part of the ship's deck, which some of the navigators thought was a desirable feature. The lighting units are placed on every fifth pole (i.e., 450 feet apart) on the straight part of the canal prism, and on every fourth pole (i.e., 360 feet apart) on the curves, in order to compensate for the greater width of the canal at the curves and to give a little more light where it is most needed. Fig. 13 shows a typical cross section of a canal reach or prism and shows various other features of the prism lighting.

From early experiments made by the canal engineers it was found that ordinary searchlights were open to several objections, there being too much glare and unsuitable distribution of light. The commercial types of street lighting units were shown to be entirely unsuitable for the purpose and it was evident that something different would have to be used. It was imperative that the lighting unit be such that the light would be spread out in a wide horizontal fan and that the beam would be depressed from the horizontal so that it would just cover the opposite bank, and so that the navigator in his wheelhouse when near the centre of the canal would be above the useful beam of light projected on the far side, thus greatly reducing any chance of glare in his eyes. This meant some sort of flood lighting such as that now being used for airports.

After making trips up and down the canal, the conclusion was reached that an illumination the equivalent of full moonlight on the far bank would facilitate navigation on the reaches, and since the Welland canal had a 7.5 ampere series lighting circuit in use along the canal, it was decided that manufacturers of lighting equipment would be given an opportunity during the navigation seasons of 1927 and 1928 of installing a trial installation of lighting fixtures of the type they recommended, in order to find out what was available and to give practical demonstrations to canal engineers and to ship captains of lighting which they considered best suited to navigation conditions. The experimental installations included various types of street lighting units and one using a Fresnel type of lens with reflector.

In a study of the trial installations the following conclusions were reached:—

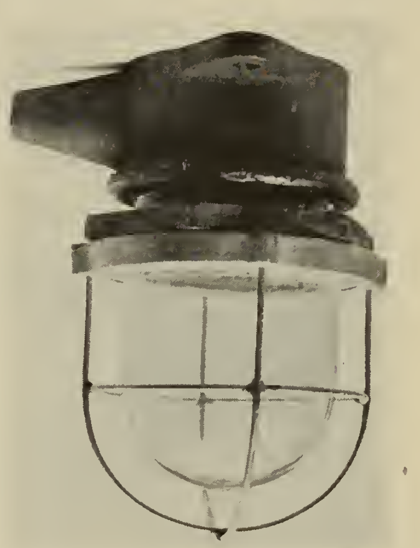


Fig. 12—Mooring Gallery Lighting Unit.

1. That too brilliant lighting was neither necessary nor desirable.

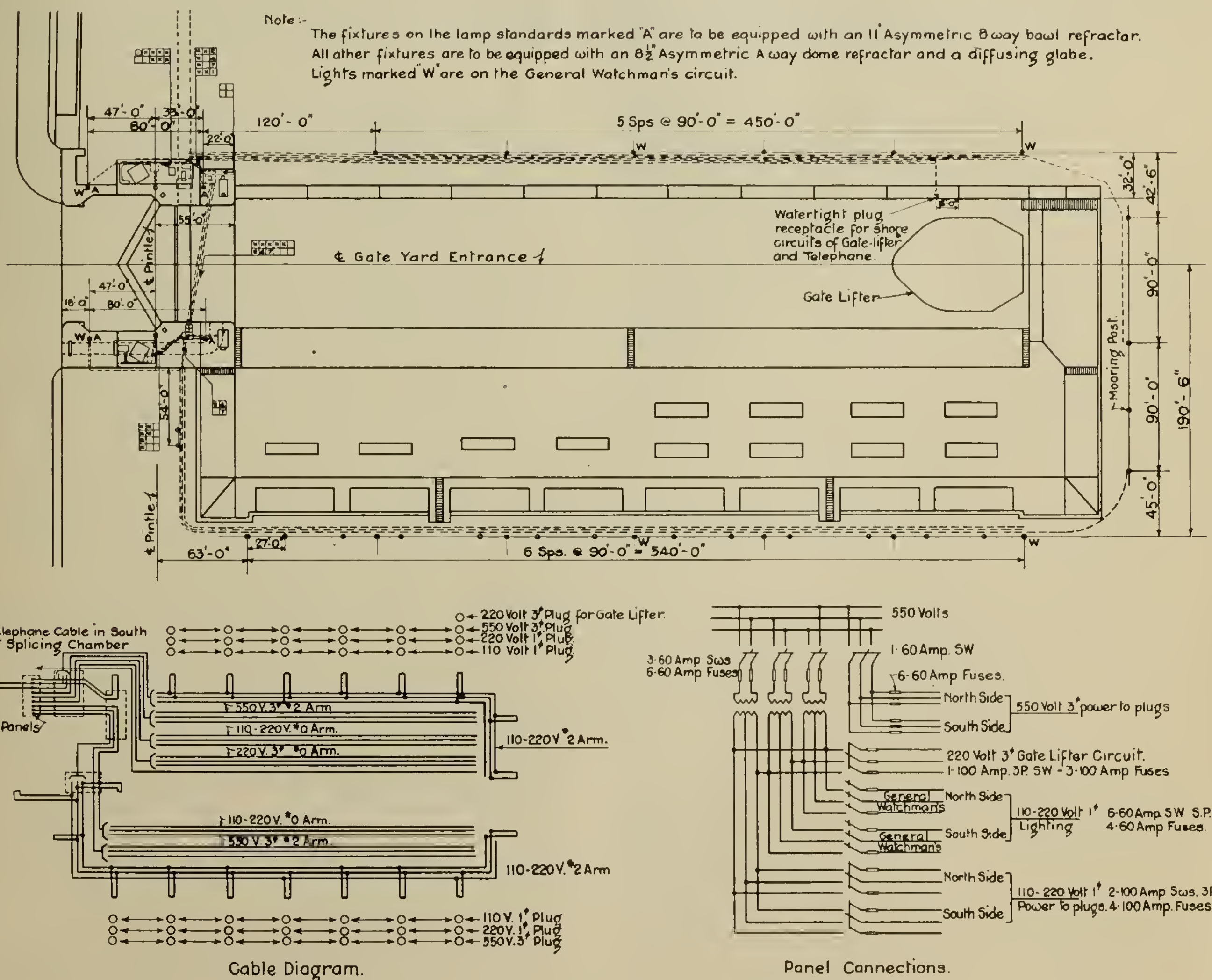


Fig. 11—General Arrangement of Lighting and Circuits for Gate Yard.

2. That the opposite bank and wash wall should be illuminated.

3. That the whole of the water surface should be flooded with light.

4. That a fairly uniform illumination of the opposite bank was preferable to a silhouette effect.

5. That so far as the distribution of light was concerned, the best lighting could be accomplished by using a lens of the Fresnel type and that these units using a 400-candle power lamp appeared to give sufficient illumination on the straight reaches of the canal.

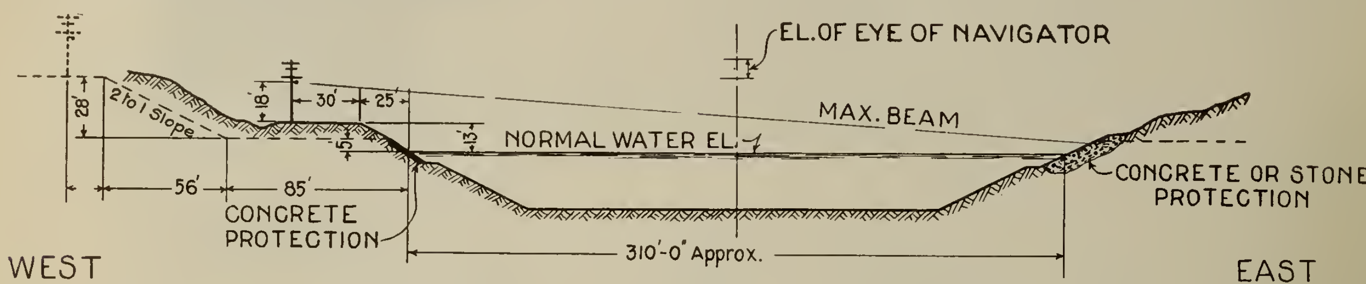


Fig. 13—Typical Cross Sections of Canal Looking North.

The result of the experiments was the adoption of a lighting unit using a 180 degree Fresnel type of lens in which lamps of from 400 candle power to 1,500 candle power could be used. Four hundred candle power lamps have been adopted as standard for ordinary conditions of the prism lighting, the larger lamps being used to meet special conditions when the lamps are at a greater distance from the canal or where increased illumination is required.

After careful investigation and in collaboration with the manufacturers of lighting equipment, it was decided to specify that when using a 400-candle power 20-ampere 226-watt (4,000-lumen) lamp in the fixture, and under normal rated operating conditions, the illumination effect produced, over a surface 400 feet long horizontally and 25 feet wide vertically and at a distance of 400 feet from the light centre of the unit, should not be less than 0.03 foot candles, also that the fixture should maintain high illumination efficiency in use, and that after one year's operation, provided that the outside of the glassware was clean and the lamp operating at normal rating, the illumination produced should not be reduced below 80 per cent of the illumination specified above. Also that in the fixture furnished, when using lamps of any rating other than 400 candle power but between 250 candle power and 1,500 candle power inclusive, the illumination results obtained should be not less than directly in the ratio that their candle power bears to 400 candle power. Fig. 14 shows the vertical and the lateral distribution of light of the 400-candle power unit.

The optical system of the lighting unit consists of a 180-degree Fresnel type lens and a spherical reflector made of brass or copper accurately formed and chromium plated. The lens is made of good quality heat-resisting glass having an inside diameter of approximately 7 inches and a clear height of slightly over 6½ inches. The lenses have a light amber colour and absorb somewhat less light than clear glass.

The body of the lighting unit is made of cast iron heavily hot-galvanized. The lamp socket inside the body is on an adjustable support which permits vertical movement of the lamp for the purpose of raising or depressing the beam of light. Means are provided for locking the socket holder in position. The lens is cemented into the body of the fixture. To facilitate relamping, cleaning, etc., there is a hinged door at the bottom of the unit that can easily be unfastened or fastened. In this door is a diffusing glass which permits the lighting of the ground beneath the unit. The body is mounted on a bracket that allows the unit to be rotated about its vertical axis and also to be tilted in a vertical plane to and from the pole on which it is mounted. The leads enter the unit through porcelain bushings. The wire inside the fixture is insulated with asbestos in order to withstand the high temperature inside the fixture. The whole fixture is proof against the entrance of water, dust and snow. The unit is shown by Fig. 15.

The series line current is 6.6. amperes and the lighting units are connected to this line through series line insulating transformers that step up the current to 20 amperes for use in the lamp. The series system for the entire canal is divided into two parts, one for the north and the other for the south half of the system, and is fed from station type constant current regulators, three of which are installed at lock No. 2 substation to feed the north section of the canal and three at lock No. 8 substation to feed the south section; one spare regulator is also installed at each of the above substations. The lamps alternate on the three circuits so that in case a circuit goes dead every third light only will be out.

6. Lighting for Bridges

Considerable pains were taken to make sure that adequate illumination was secured in the machinery, switchboard and operating rooms of the bridges. All walks and stairways are well lighted. Plug receptacles are provided at useful points in the rooms. All instruments on the switchboards or elsewhere have ample light on their scales. All lights are controlled from a lighting panel in the operator's room. The lights in each room or in each group can be switched on or off as desired. One hundred and ten-volt lamps are used for all bridge lighting.

All vertical lift bridges have lamps to light the upper platform and the counterweight rope sheaves at the top of the towers. Each vertical lift bridge has a scale of heights painted on the right hand front tower leg facing on-coming navigation, to show the navigators the height of the span at all times, which is illuminated by a light equipped with a reflector so that the light is thrown on the scale only. Auxiliary oil lamps are provided for bridge navigation and scale lighting and for the operator's use in case of failure of the electric power service.

The floor of the bascule bridges at the canal locks is not lighted, adequate lighting being provided by the general lock lighting. Each floor and approach span of the double leaf rolling lift bascule bridge No. 4 is lighted by four 300-watt lamps in 8-inch two-way bowl refractors. The eight lighting units are of the pendent type and are approximately 28 feet above the floor of the bridge, four being placed on each side of the fixed part of the roadway. Since most of the light from each unit is projected along the roadway there is no glare in the eyes of the navigators approaching the bridge. This lighting is very satisfactory and the height of the units is such that no trouble from glare is experienced by automobile drivers.

On the vertical lift highway bridges over the reaches of the canal and where the bridge does not form part of a main street in a city or town, the bridge floor is lighted by a row of lights placed above the centre of the roadway and suspended underneath the upper arch of the moving span and at the lower chords of the towers. The lighting units are porcelain enamelled steel reflectors designed for outdoor service. The lamps are set well up in these reflectors and the reflector is so designed that the angle of cut-off is such that there is no glare in the eyes of navigators approaching the bridge or in the eyes of motorists and others using the bridge. Fig. 16 shows a night picture of bridge No. 11.

In the case of bridges at the main streets of towns and cities, special care was taken to select a lighting that would harmonize with the street lighting. The lighting units are approximately 22 feet above the floor of the bridge. These lighting units project most of the light along the roadway and also cause no glare to the navigator approaching the bridge. The amount of light on the floor of the bridges is approximately one to one and a half-foot candles measured at the floor.

7. Buildings

An attempt has been made to provide illumination in the buildings that will contribute materially to safe and speedy operation, fewer mistakes, good appearance and working conditions and the tendency for cleanliness and better keeping of the building and equipment on the part of all concerned.

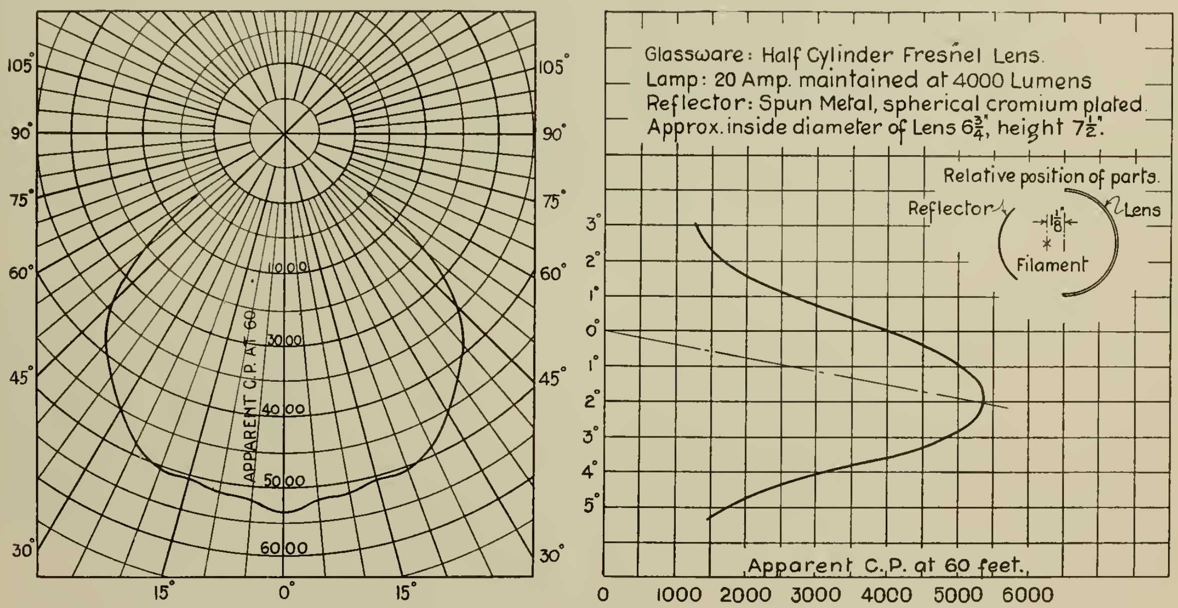
Power House.—The generator floor is approximately 30 feet 6 inches wide, 117 feet long and 39 feet high and is lighted by ten Holophane high bay lighting units with a concentrated distribution of light which with 500-watt lamps produces a little over 10 foot-candles at the floor line. The switch gear room is approximately 16 feet wide, 51 feet long and 24 feet high and is lighted by four 21-inch porcelain enamelled glass steel diffusers with 12-inch diffusing glass globes with 500-watt lamps. The control switchboard room is the same width and height as the switchgear room and is 34 feet long and is lighted so that all instruments on the switchboard are well illuminated and free from shadows.

In the houses on the locks porcelain enamelled reflectors are used. The illumination intensity is approximately 4 foot-candles. In some of the control houses small shaded bracket lamps are provided over the lock control desk so that the operator can turn off the room lighting and manipulate the controls by the aid of the directed light on the control board only.

8. Navigation Signal Lights at Locks

Signal lights are mounted in a prominent position near the upper and lower ends of the locks so that each signal will be visible to mariners navigating in the section of the canal leading to the lock entrance near which the signal is mounted. Each signal shows a green light when the lock is ready to receive a ship and a red light at all other times. Both lamps will never be lighted at the same time and each signal is manually controlled by means of a two-way switch on the lock control desk.

Fig. 15—Prism Lighting Unit.



Lateral C.P. Distribution

Vertical C.P. Distribution

Fig. 14—Distribution Curves of the Prism Lighting Unit.

Each signal consists of a weatherproof casting of aluminum alloy enclosing two incandescent electric lamps mounted one above the other. Behind each lamp there is a reflector and in front of it a lens of coloured glass so that one lamp will project a beam of red light and the other a beam of green. A hood or visor of cast aluminum alloy is provided over each lens to shade it from the rays of the sun. The length of the visor is about 75 per cent of the diameter of the lens and surrounds the upper semi-circumference of the lens. Each lens with its visor is mounted upon a door, hinged so that it can be swung open to give access to the interior of the casing for cleaning the reflector and lens and for replacing the lamp. The doors, when shut, are fastened by means of thumb nuts and make a thoroughly weatherproof and dust-tight closure with the casing. The whole casing is designed to have sufficient radiating surface to carry off the heat of the lamps without ventilation.

Fig. 16—Bridge No. 11 at night.

The lamps are 400-watt capacity and have a concentrated filament so as to give a narrow beam spread. The lamp and its socket is so made that when a new lamp is screwed home in the socket it will be in the proper focus without further adjustment. The lamps operate on 110 volts.

The reflector and the lens are so designed and the lamp so focused with reference to them that the signal throws a narrow concentrated beam of light of not less than 13 degrees spread. The specifications stipulated that the light flux of the beam within a circular cone having an angle of 13 degrees at the focus should be not less than 1,150 lumens and that the light should be distributed as uniformly as possible over the cross section of this cone and should give an illumination of not less than 0.001 foot-candles at a distance of one mile from the signal at any point within the 13-degree cone, all calculated upon the assumption that the lens is colourless.

The reflectors are made of metal, cadmium plated, and are non-rusting and non-tarnishing. They are so fastened to the casing that they can be easily taken out and replaced without requiring adjustment to obtain proper focus.

The lens is made of a strong heat-resisting glass, which is of such a shade and quality that it transmits the maximum amount of light consistent with giving to the beam a distinctly red or green colour as the case may be. The lenses are also so mounted that they can easily be taken out and replaced without requiring adjustment to obtain proper focus.

In order to increase the visibility of the signal against the sky, the face of the signal is surrounded by a target painted black to form a background for the light. The target is of metal and forms part of the casing and is made in such a manner that the doors in the front of the signal can be opened without disturbing the target.

Each lock operator is stationed within 300 feet of the signal that he controls; he is behind it and at most locks considerably to one side or below it, or both. The position of the operator relative to the signal is different in nearly every case and is such that he is unable to see the light from the lenses on the front.

It is desirable that he should be able to see what light the signal is showing, so that the operation may be checked and that be may receive prompt warning of any failure. To enable him to do this, each signal is equipped with rear sights, one for the red lens and one for the green. Each rear sight is adjustable and can be set to throw its beam to any position behind and below the signal within an angle of 180 degrees horizontally and 90 degrees vertically. The adjustment is provided by means of two elbows each containing a mirror set at 45 degrees so as to deflect the beam to any desired point by rotating the elbows with reference to each other and to the signal casing. Light for the rear sight beam is taken from the signal lamp through a small hole in the reflector. The specifications stipulated that each rear sight beam should illuminate a circle at least six feet in diameter at a distance of 300 feet with an intensity of at least 0.001 foot-candles, calculated on the assumption that the lens through which it is transmitted is of clear glass. The lens of each rear sight is, however, of the same colour as the signal lens of the lamp from which it takes its light. The lens is shaded by means of a hood similar to the hood provided for the signal lens. The hood is adjustable and can be set to enclose the upper semicircle of the lens in any position of the mirrors.

All joints in the rear sights are dust tight and weatherproof and are provided with suitable clamps to hold the adjustable parts in position after they have been adjusted. The mounting is made so that it can be readily taken apart and assembled again for cleaning the mirrors, etc. Mirrors, lenses, etc., are so mounted that if taken out they can be easily replaced in their proper positions. The signal is shown in Fig. 17.

9. Harbours

The lighting for the east side of Port Colborne harbour is an extension of the lighting system for the east approach of lock No. 8. The distribution system is fed from the 550-volt bus of the substation for bridges No. 20 and No. 21 and is controlled by the lighting circuits of lock No. 8, as indicated in Fig. 9. On the west side of the harbour the lights extended from bridge No. 20 to the government elevator at the entrance to the harbour and formed a part of the Welland canal series lighting that was taken over by the Welland Ship canal, being fed from two outdoor type constant current transformers mounted on a pole near

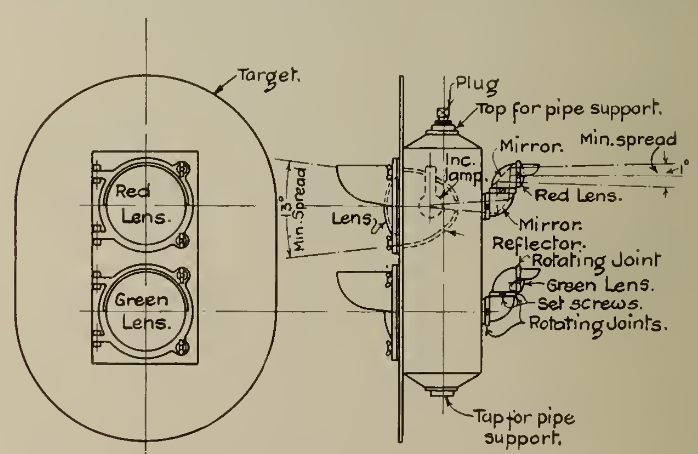


Fig. 17—Colour Light Signals for Locks with Adjustable Rear Sights.

the west approach to bridge No. 21. The transformers are energized from the 550-volt bus of the bridge substation by means of a buried cable.

The harbour at Port Weller is approximately 1,200 feet wide between the tops of the east and west slopes and 800 feet wide at the bottom. The entrance is 400 feet wide. The length of the harbour is a little over one mile, and it is lighted on the west side from the entrance wall of lock No. 1 to the entrance of the harbour. The lighting units are at present spaced about 500 feet apart, but can be spaced 250 feet apart if desired, and are approximately 30 feet above normal water level and from 50 to 70 feet from the top of the slope. The lighting units are identical with those used at the locks, except that a 1,000-candle power 20-ampere series lamp is used, the bracket is made for mounting on a wooden pole, and the refractor has a symmetric distribution. This was decided to be best for lighting the roadway to the navigation range lights and light house on that side, and at the same time would give sufficient illumination on the west slope so that navigators can clearly see the west bank and both sides of the harbour entrance. No pretence is made to light up the whole surface of the harbour or the east slope.

The Port Weller lighthouse, the foghorn and the light on the west side at the entrance to the harbour are supplied with power from Lock No. 1 substation by means of a 2,200-volt three-phase line.

The berth for the 500-ton gate-lifter pontoon is on the east side of the canal and below lock No. 1 at the place where the canal channel widens out into the harbour. The east and west concrete wall from lock No. 1 ends at this area. The area around the gate-lifter berth is well lighted by multiple 110-volt lights in lock lighting units. These lights are fed from a 550-volt three-phase pole line extending from the foot of lock No. 1 to the gate-lifter berth. On the opposite side the end of the west concrete wall is lighted by three 20-ampere series lamps in lock lighting units fed from the series system.

There are various docks along the canal such as those at Welland and St. Catharines. The general illumination for docks on the west side is taken from the canal prism lighting circuits and is furnished by lighting units similar to those used at the harbours. Lighting for the sheds and buildings is by means of the standard multiple lighting system.

Acknowledgments

From the foregoing narrative and descriptions, it can be seen that the problem of designing and installing the lighting for the Welland Ship canal has occupied the attention of many engineers in various lines of work. It would be impracticable for the author to give in this paper a list of the personnel concerned, but he does wish to record his appreciation of the kindly aid extended to the departmental engineers by other engineers in various cities of Canada and especially by G. F. Mudgett of the Canadian Westinghouse Company, R. M. Love of the Canadian General Electric Company, and M. B. Hastings of the Powerlite Devices Limited, also by the steamship companies and ship's captains for their aid during the experimental tests of the lighting.

The construction of the Welland Ship canal is under the jurisdiction of the Department of Railways and Canals, Dominion Government of Canada, of which the Hon. Dr. R. J. Manion is Minister, V. I. Smart, Deputy Minister, and Colonel A. E. Dubuc, D.S.O., M.E.I.C., chief engineer, with Alex. J. Grant, M.E.I.C., engineer in charge.

Hydraulic Stability

The Interaction of the Speed Governor and Surge Tank in Hydro-Electric Plants and the Effect of This on Surge Tank Design

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Paper to be presented at the General Professional Meeting of The Engineering Institute of Canada, Ottawa, Ont., February 7th and 8th, 1933.

SUMMARY.—A general discussion is given of the functions of the governor and surge tank in a hydro-electric plant, as regards the oscillations of level in the tank, and conditions under which they tend to increase or die away. The effects of synchronous machinery on the line and parallel operation with other plants are noted, and a mathematical analysis follows, leading to expressions for the position of the water level in the tank at any instant, for the requirements for damped movement of the water surface in the tank, and for the critical area of the tank water surface under different conditions.

In any electrical distributing system the amount of power that is being used is continually fluctuating because consumers are constantly increasing or decreasing their power requirements. In order to keep the entire power system in equilibrium, therefore, it follows that the amount of primary power fluid used must be varied in the exact proportion as consumption of electrical power is changed. If this balance were not maintained, it would be necessary to absorb the excess or supply the deficiency in primary power in some fashion not inimical to the satisfactory functioning of the system. In a hydro-electric station, power generated by the turbines, in excess of requirements, can only be used in speeding up the rotating parts, not only of the generating units but also of the entire connected synchronous load. In other words, hydraulic power which is not being transformed into electrical power, is changed into kinetic energy. On the other hand, if the system power requirements are in excess of generated power, the reverse process takes place, kinetic energy is abstracted from the rotating parts of all connected synchronous machinery and there is a decrease in their speed. If these speed changes are greater than the degree of sensitiveness of the hydraulic governor usually installed with each turbine, then the governor functions, and, by operating the turbine gates, varies the water supplied to the runner by an amount sufficient to meet the new condition.

When a surge tank forms part of the installation, the phenomena occur which form the subject matter of this paper. For purposes of illustration, let it be assumed that a portion of the load has been dropped, for some reason that it is not necessary to specify here, and that because of the increase in speed of the generating units, the turbine gates, in response to governor action, have moved toward the closed position. The turbines are now using less water than is flowing in that portion of the waterway upstream from the surge tank and because at first there is no unbalanced force to oppose the excess flow of water, the latter enters the tank. The level of the water in a simple surge tank, or in the riser of a differential tank, at once becomes higher than the hydraulic gradient at the point of connection of tank and waterway. This difference in level between water surface and hydraulic gradient constitutes an unbalanced force which is transmitted to the water in the conduit and so decelerates it.

Effect of Governor Operation

This, of course, is part of the normal functioning of the tank for which it was designed and installed. However, the increase in level in the tank corresponds to an increase in head on the turbines and consequently an increase in power beyond the amount required. The turbines speed up, the governor acts to move the gates still further towards the closed position, additional water is rejected which flows into the tank, and this cycle repeats itself as a continuous process until a condition is reached such that the decreased flow of water in the conduit acting under the increased head will generate the required amount of power and no more.

This condition is an unstable one. The level of water in the tank is far above the level of the gradient at the tank connection and the excess pressure corresponding to this difference in level will continue to decelerate the flow in the conduit. There is now less water being supplied by the conduit than is required, and the deficiency must be drawn from the tank, decreasing the level therein. The head on the turbines is correspondingly decreased, the power generated decreases and a cycle of events ensues the reverse of that described in the preceding paragraph.

This phenomenon may be visualized as an oscillation in the level of the water in the tank, above and below the level for steady flow conditions, set in motion by the action of the governor in response to a load change, and thereafter influenced by the governor as the latter attempts to maintain the power generated at a fixed value.* As will be shown later, this oscillation may increase in amplitude (up to a point), or it may remain at a constant amplitude, or it may die away, depending entirely upon the relation between certain of the physical and hydraulic elements of the installation. It will also be shown that, given a certain installation, the characteristic of this oscillation is determined by the area of the surge tank, and that there is a tank area, called the critical area, which will cause any oscillation set up to be sustained at a constant amplitude. If the area provided is less than the critical area, the oscillation will increase in amplitude, but if it is greater than the critical, the oscillation can only die away.

That such occurrences will happen is amply evidenced by a plant at Heimbach which was placed in operation in 1904. What happened has been described as follows†:—

"From the moment the plant was placed in operation governing lacked stability despite the fact that both the turbines and their governors had been supplied by a reputable manufacturer. Finally, at the end of the summer, when the level of the head pond was low, the turbine gates started to open and close in a perfectly established rhythm even while there was a steady demand from the system. This to and fro movement of the gates, once set up, *continued indefinitely*.

By the aid of manometers attached to the penstocks, which allowed ten readings to be taken in ten seconds, it was found that the movements were caused by variations in pressure in the penstocks and finally by an oscillation of the level of the water in the surge tank. A float, installed in the tank, disclosed a perfect synchronism between the oscillation of the water level and the oscillation of pressure in the penstocks in service."

It was further discovered that these oscillations were sinusoidal in character and their amplitude varied with the quantity of water used by the turbines.

The trouble was remedied by installing, in addition to the already existing synchronous pressure regulators, a compensating valve designed to absorb the energy which gave rise to the sustained pressure oscillation.

If the power plant under consideration is the only one delivering power to a distributing system, then, under the conditions just described, operation would be confronted with two extremely undesirable results. The constant see-sawing of the regulating mechanism would subject it to undue wear and more deplorable than this, since service rendered to customers would be detrimentally affected, there would be a continuous change in frequency. The speed of all synchronous machinery would vary continuously and voltage regulators would be in constant operation.

If the physical and hydraulic elements of the installation govern the type of oscillation that is set up, it is evident that no matter how small the initial change in tank level may be, the oscillation will be damped, sustained at its initial value, or amplified depending entirely upon the relation among the controlling elements. In order that any installation may be stable, the rapid damping of even the most feeble oscillation is a prime necessity. In the mathematical analysis which will subsequently be undertaken, it will be found that this requirement simplifies the procedure to a considerable degree.

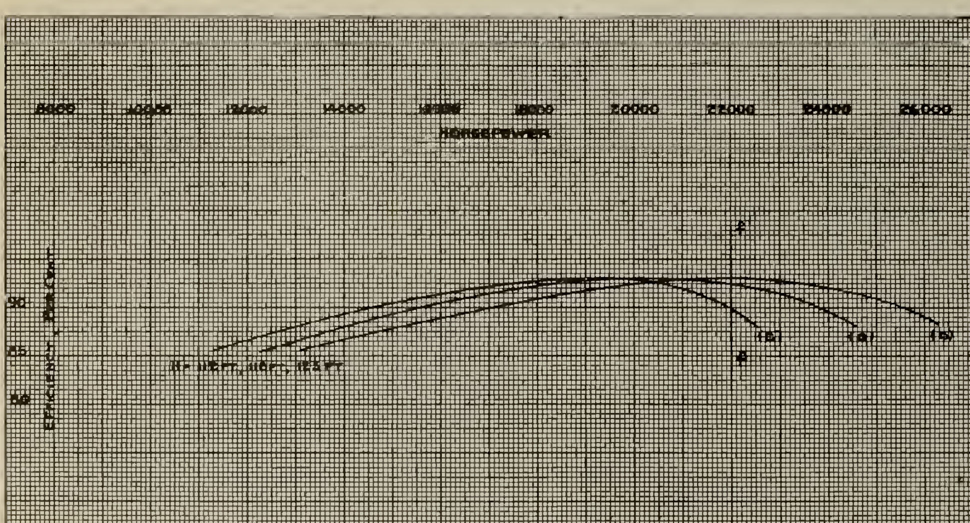

Fig. 1—Performance Curves of Hydraulic Turbine at Heads of 112 feet, 118 feet and 123 feet.

Effect of Turbine Efficiency Characteristics

So far no mention has been made of the effect that changes in the efficiency of the turbines due to changes in the head, may have on the hydraulic stability of the plant. Three typical efficiency-power curves at constant head for the same turbine are shown in Fig. 1, the curve (*b*) being drawn for a head slightly greater than curve (*a*) and curve (*c*) for a head slightly less. Let it now be supposed that, due to a load change, a small surge has been set up in the tank and that at the moment under consideration the water level in the tank is rising. Further, let it be supposed that the turbine is operating somewhere on the drooping part of the efficiency curve beyond the point of maximum efficiency. The line *f-f'* has been drawn to represent the operation of

*It is assumed throughout this paper that, once the load change has occurred, the system power requirements remain constant at the new value for a period of time at least of sufficient length to allow a stable hydraulic condition to be attained. When this condition has been reached there will be a new gate-opening position and a corresponding new speed. Whatever generated power and speed variations may occur during the period of regulation, due to the changing head, the governor mechanism will not be satisfied until the new steady gate-opening position and the corresponding new speed have been reached under the final steady head. In other words, the governor tries to maintain an exact balance between generated power and demanded load. Since the latter is assumed constant, it is quite permissible to describe the governor action, during the period of regulation under the assumed conditions, as attempting to maintain the power generated at a fixed value.

†Theorie des Chambres d'Equilibre, by Calame et Gaden, p. 211. (Translation made by A. W. F. McQueen.)

the turbine under these conditions with the governor adjusting the gates to keep the power output at a constant value. It will be seen that as the head increases, the efficiency of power generation increases and hence less water will be required than if the efficiency remained constant. The result is that the turbine gates are closed a little more and additional water is forced into the tank. On the other hand, if the water level in the tank is falling, the turbine efficiency decreases as the head diminishes, the governors are under the necessity of opening the gates beyond the position that would be necessary if the efficiency remained constant, and an increased supply of water is drawn from the tank. Under these conditions it is evident that the surge in the tank will have a greater amplitude than that set up by any supposed condition of operating at constant turbine efficiency and therefore the critical size of the tank will be increased.

On the other hand, if the turbine is operating at loads smaller than that at which the efficiency curve peaks, the opposite effect is produced; increasing heads mean decreasing efficiencies and vice-versa and the critical size of the tank becomes smaller.

It is a general characteristic of the efficiency-power curve of any Francis turbine to have a sharper peak as the head is decreased. In other words, the slope of the curve, over the operating range, varies inversely as the head, and therefore the rate of change of the efficiency with respect to the change in head, at constant power, increases with decreases in the head. It is the value of this rate which will determine how much larger or smaller the critical size of tank becomes as compared with the critical size that would be calculated for constant efficiency conditions.

In practice it is usually necessary to design for operation on the drooping part of the efficiency curve, and therefore low head developments are unduly penalized when it is necessary to provide a surge tank to prevent excessive water hammer in the penstock and excessive speed changes in the generating unit. If, under these conditions a very large tank is indicated, it then becomes necessary to inquire whether it would not be more economical to omit the tank and to enlarge the penstock and provide additional "fly-wheel effect" to stabilize the turbine.

There are, however, two compensating factors. The conduits for low head developments are usually comparatively short and thus tend to decrease the critical size. (This point will be demonstrated mathematically later.) The other factor is that for high-specific speed turbines (low head) the efficiency curve peaks relatively closer to the full gate point than for lower specific speed turbines. If the plant is not operating in parallel with other plants, then only rarely will the entire power capacity be demanded and it has been considered justifiable in fixing the point for which the slope of the efficiency curve is to be used in calculating the minimum tank area (see mathematical analysis) that a point be chosen approaching, but not at, the full gate position. In doing so, of course, cognizance is taken of the fact that it is necessary to provide a tank with an area in excess of the critical area in order that any surge may be rapidly damped.

On the other hand, if the plant may be considered as always operating in parallel with one or more other plants, other factors are introduced which may materially decrease the critical size. This will be demonstrated in succeeding sections.

In the discussion of the previous paragraphs relating to low head developments, only those with Francis or propellor type turbines are included. If the turbine is provided with blades automatically adjusted with the load by a mechanism controlled by the governor and acting in synchronism with the turbine gates, then quite different

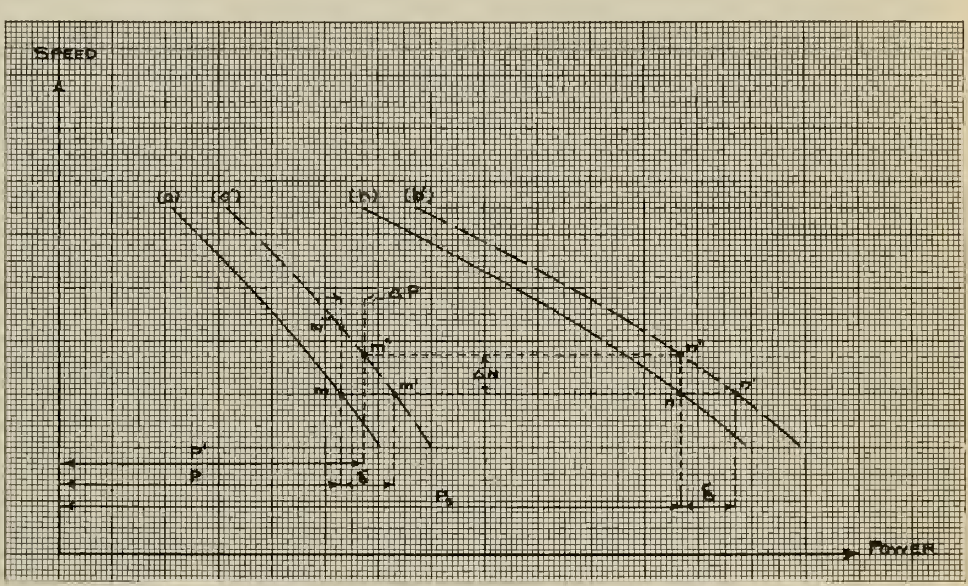

Fig. 2—Parallel Operation of Units.

conditions will obtain since the efficiency curve for these turbines is very flat and compares favourably with that of a medium or low-specific speed Francis turbine.

Operation in Parallel with Other Plants

From what has already been said, it is clear that the measure of the hydraulic stability of the conduit-surge tank system is the relation between the velocity in the penstocks at any instant during the surge following a load change and the steady velocity when the level of the water in the tank has finally become perfectly quiescent. The effect of two characteristics of the turbine and governor modifying this relation has already been analysed. The first of these was the primary functional characteristic of the governor, adjusting the turbine gates to counteract the effect of pressure changes in the water, in its endeavour to keep constant at unity the ratio of power generated to power demanded. The second was the inherent changes of efficiency of power generation by the turbine when operating under the condition of constant power output and variable head.

There now remains to be considered what effect parallel operation with other plants may have on the hydraulic stability. The assumption is made that only the plant under consideration has been provided with a surge tank and also, for simplicity, that all the governors in the system have been adjusted for the same inherent speed change. It will be easier to follow in imagination what is happening in the various plants if reference is made to the diagram of Fig. 2. Here (*a*) and (*b*) each represent portions of the curve giving the relation between speed and power under the final quiescent head; the former of these refers to the plant with the surge tank and the latter to the system as a whole. In what follows it must be remembered that, due to the inherent speed change of the governor, an increase in speed corresponds to a closing movement of the turbine gates and vice-versa.

Let it now be supposed that during the disturbed conditions which are being investigated the water level in the tank has reached some position above the final quiescent gradient. The head on the turbine (or turbines, if there are more than one in the plant) is increased and, for the same gate opening, and hence for the same speed, it is evident that the power is increased. New curves must, therefore, be drawn to represent this new condition and these have been indicated at (a') and (b'). Since the increase in power is confined to only one plant, each set of curves will be separated horizontally by the same distance. Moreover, since the inherent speed change has been assumed to be the same for all units, the slope of curves (b) and (b') must be flatter than for curves (a) and (a').

The action of all the governors in the system is to keep the total power output constant, hence, operation for the system must always be upon some vertical line such as n-n'' in the figure. Also, since the slope of (a') is greater than (b') and the same relative speed must be maintained for all units, operation for the plant with the surge tank is along some line such as m-m'' *slanting* to the right. In other words, instead of *constant* power being required of the plant under consideration, there is a *constant interchange of load* between it and the other plants of the system. During the period when the water level in the tank is above the final quiescent gradient, this plant takes a small part of the load from the other plants, while during the period when the water level is below this gradient elevation the exchange of power is reversed. On the diagram this is represented by the horizontal distance between m'' and m''' (increase in head only). A water level above the final gradient means a tendency to produce more power than is required, and this is compensated for in part by a closing movement of the turbine gates and in part by the interchange of power just described and hence the turbine gates do not move in the closing direction as far as they would have gone had the plant been supplying power to a system by itself, and vice-versa. Accordingly, the ratio of instantaneous penstock velocity to final penstock velocity is maintained, under these conditions, closer to unity and the hydraulic conditions are more stable.

Hence it is logical that under the conditions described the critical size of the surge tank is diminished and the mathematical analysis shows that this is true and gives the amount of the reduction.

However, it is necessary to be very careful in applying this correction in practice. It is probably safe to assume that, if the plant initially goes into service as a feeder to an already existing transmission system being supplied by other hydro-electric plants, it will always operate in parallel with stations having a capacity not less than the original amount. This assumption of course rests upon the observed trend of the change in size of transmission systems. On the other hand, the validity of any reduction in tank size that may be made by reason of the analysis just outlined, depends in part on the free interchange of a small amount of power between the plant under consideration and the other units operating in parallel with it.

The necessities of water conservation at plants operating from storage or the fluctuations of flow at run-of-river plants may demand that one or more of the plants in the system, other than the one provided with a surge tank, be operated at constant gate opening by means of the "gate limit" adjustment on the governor. The amount of such gate-opening will vary from time to time and from season to season. When the governor is operating under the gate-limit it is impossible for it to open the gates and it is customary to make the adjustment in such a way that only a fairly large decrease in the load and hence increase in the system frequency will cause the gates to move toward the closed position. Moreover, the shape of the efficiency curves of various units in the system may require that different units be provided with different amounts of inherent speed change in their respective governors. That is to say, if the efficiency of a unit is maintained at a high value over a wide range of gate opening, then the necessities of economical power production may dictate that some or all of such units have a very small inherent speed change in order that they may take a large proportion of the load changes. For the same reason units having an efficiency curve peaking sharply to the point of maximum efficiency may be used as base load units and operated to give maximum efficiency. To do so they would be provided with a large inherent speed change in order that they might take only a small portion of the load swings. The interchange of power that is necessary for a reduction in tank size is, therefore, under these conditions a variable amount and hence the critical size of the tank will also vary. Therefore, care must be taken to investigate this aspect of operating conditions before the correction to the critical size of tank can be applied with any assurance of safety that a stable condition will always obtain.

Nomenclature

$a = \frac{gA}{LF} \cdot \frac{(H_v + H_r)}{V_p} - \frac{V_p}{2(H + 2H_v)}$;

A = area of the conduit;

$b^2 = \frac{gA}{LF}\left[1 - \frac{2(H_v + H_r)}{H + 2H_v}\right]$;

B, C, D, G = constants;

e = base of the Napierian logarithms = 2.71828....;

E = efficiency of penstock and turbine at any instant;

E' = efficiency of penstock and turbine for final steady load;

f, f' = symbols representing unknown functions;

F = area of the surge tank;

g = acceleration due to gravity;

h = net head on the turbines, at any instant, measured at the surge tank;

h_r = total loss of head in the waterways upstream from the tank, at any instant;

h_v = the velocity head indicated at the tank, i.e., for v_c, at any instant;

$H = H' + H_v$;

H' = difference between water level in the tank and tail-water, for final steady load;

H_g = gross head on the plant;

H_r = total loss of head in the waterways upstream from the tank, for final steady load;

H_v = velocity head indicated at the tank, for final steady load, i.e., for V_c;

$i = \sqrt{-1}$;

$k = \sqrt{b^2 - a^2} = im$;

K = a constant;

L = length of conduit from intake to tank;

$m = \sqrt{a^2 - b^2}$;

M = a constant;

N = speed of the turbine;

P = power of the turbine;

P_s = total power generated by the system;

q_p = flow in the penstock, at any instant;

Q_p = flow in the penstock, for final steady load;

$r = \frac{dP}{dP_s}$;

$r_1 = -a + \sqrt{a^2 - b^2}$;

$r_2 = -a - \sqrt{a^2 - b^2}$;

$t = \frac{2\pi}{k}$ (period of the surge); also = time in general;

v_c = velocity in the conduit, at any instant;

$v_p = q_p/F$ = velocity in the penstock, at any instant, in terms of tank area;

v_t = velocity in the tank, at any instant;

V_c = velocity in the conduit, for final steady load;

$V_p = Q_p/F$ = velocity in the penstock, for final steady load, in terms of tank area;

w = specific weight of water;

y = difference between water level in tank and headpond level, at any instant; positive when the tank level is above the pond level;

Y = difference between water level in the tank at any instant and the water level in the tank for final steady load, positive when the former is above the latter;

$\delta = \frac{3}{2} \cdot \frac{Y}{H} \cdot P$.

General Equation of Motion

By applying the fundamental law of dynamics to the case where the water level in the tank is at some elevation different from that which would be assumed under conditions of steady flow we have, at any instant following such departure (Fig. 3),

$$(y + h_v + h_r)\, Aw = -\frac{LAw}{g} \cdot \frac{dv_c}{dt}$$

the negative sign, of course, denoting a deceleration of the flow in the conduit. This simplifies to

$$\frac{L}{g} \cdot \frac{dv_c}{dt} + y + h_v + h_r = 0 \qquad (1)$$

Since the sum of the quantities of water flowing in the conduit, tank riser, and penstock, taken with their correct sign must equal zero, we have,

$$Av_c = Fv_t + Fv_p$$

or

$$dv_c = \frac{F}{A}\, dv_t + \frac{F}{A}\, dv_p.$$

By substituting this value for dv_c in (1) there results

$$\frac{LF}{gA}\left[\frac{dv_t}{dt} + \frac{dv_p}{dt}\right] + y + h_v + h_r = 0.$$

Now $v_t = \dfrac{dy}{dt}$ therefore $\dfrac{dv_t}{dt} = \dfrac{d^2y}{dt^2}$.

So substituting again,

$$\frac{LF}{gA}\left[\frac{d^2y}{dt^2} + \frac{dv_p}{dt}\right] + y + h_v + h_r = 0 \qquad (2)$$

which is the general equation of motion for flow in the conduit from upstream to downstream.

This equation assumes that the volume of the tank is quite small as compared with that of the head-pond, that the tank is able to take care of any sudden changes in the demand for water, and that any changes in flow will not affect the head-pond level which will remain sensibly constant.

Effect of Governor Action

We shall now suppose that the governor, in its efforts to maintain the output of the turbine at a fixed value following the load change, is able to follow precisely the variations in head caused by the change in level in the tank. It can do so, of course, only if the duration of one cycle of the oscillation of the water surface in the tank is comparatively long, that is of the order of one minute or more. That this is so will be demonstrated later.

At any instant, therefore,

$$P = q_p wE\,(H_g + y + h_v)$$
$$= q_p wE\,(H' + H_v + H_r + y + h_v).$$

If we further assume that the efficiency of penstock and turbine remains constant during the load change, we may write for final steady conditions,

$$P = Q_p wE\,(H' + H_v).$$

Therefore $$\frac{q_p}{Q_p} = \frac{H' + H_v}{H' + H_v + H_r + y + h_v}.$$

Now $$h_v = \frac{v_c^2}{2g} = \frac{H_v v_c^2}{V_c^2} \text{ and } \frac{q_p}{Q_p} = \frac{v_p}{V_p}.$$

So substituting,

$$\frac{v_p}{V_p} = \frac{H}{H + H_r + y + \dfrac{H_v v_c^2}{V_c^2}}$$

$$= \frac{H}{H + Y - H_v\left(1 - \dfrac{v_c^2}{V_c^2}\right)}$$

Now $$\frac{v_c}{V_c} = \frac{v_p + v_t}{V_p}$$

$$\frac{v_p}{V_p} = \frac{1}{1 + \dfrac{Y}{H} - \dfrac{H_v}{H}\left[1 - \left(\dfrac{v_p + v_t}{V_p}\right)^2\right]}$$

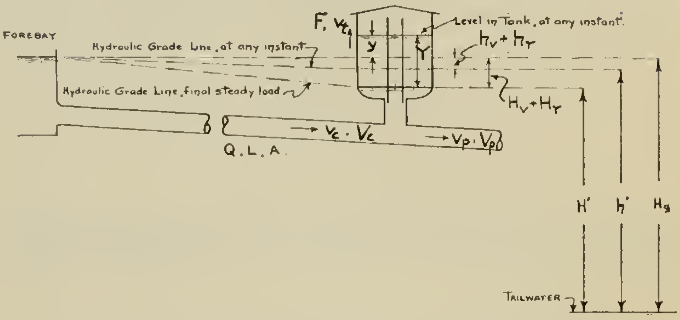

Fig. 3—Diagrammatic Layout Conduit—Surge Tank.

Now $\dfrac{Y}{H}$ and $\dfrac{H_v}{H}$ are both very small quantities and, since $\dfrac{v_p + v_t}{V_p}$ approaches unity,

$$1 - \left(\frac{v_t + v_p}{V_p}\right)^2 = 2\left(1 - \frac{v_t + v_p}{V_p}\right)$$

Substituting,

$$\frac{v_p}{V_p} = \left[1 + \frac{Y}{H} - \frac{2H_v}{H}\left(1 - \frac{v_t + v_p}{V_p}\right)\right]^{-1}$$

$$= 1 - \frac{Y}{H + 2H_v}$$

Differentiating,

$$\frac{dv_p}{dt} = -\frac{V_p}{H + 2H_v} \cdot \frac{dY}{dt} \qquad (3)$$

If we now assume that all losses of head between the head-pond and the tank are proportional to the square of the velocity in the conduit,

$$\frac{h_v + h_r}{H_v + H_r} = \left(\frac{v_c}{V_c}\right)^2$$

$$= \left(\frac{v_t + v_p}{V_p}\right)^2$$

$$= \left(\frac{v_t}{V_p}\right)^2 + \frac{2v_t v_p}{V_p^2} + \left(\frac{v_p}{V_p}\right)^2$$

If the movement in the tank is quite small, the first term of the second half of this identity will be very small compared with the other terms and it may be neglected. Substituting the value for $\dfrac{v_p}{V_p}$ found above, there results,

$$\frac{h_v + h_r}{H_v + H_r} = \frac{2v_t}{V_p}\left[1 - \frac{Y}{H + 2H_v}\right] + \left[1 - \frac{Y}{H + 2H_v}\right]^2$$

$$= 1 - \frac{2Y}{H + 2H_v} + \frac{2v_t}{V_p} \qquad (4)$$

on the assumption of a very small surge.

Substituting (3) and (4) in (2) we have, on simplifying and collecting,

$$\frac{d^2Y}{dt^2} + 2a\frac{dY}{dt} + b^2Y = 0 \qquad (5)$$

where $$a = \frac{gA}{LF} \cdot \frac{(H_v + H_r)}{V_p} - \frac{V_p}{2\,(H + 2\,H_v)}$$

$$b^2 = \frac{gA}{LF}\left[1 - \frac{2\,(H_v + H_r)}{H + 2\,H_v}\right]$$

This supplies a differential equation of the second degree in Y, that is of the movement of the water surface in the tank with respect to the assumed fixed (final) gradient level at the tank.

The complete solution of (5) is,

$$Y = Be^{r_1 t} + Ce^{r_2 t}$$

where
$$r_1 = -\,a + \sqrt{a^2 - b^2}$$
$$r_2 = -\,a - \sqrt{a^2 - b^2}$$

and the form of the solution of the differential equation therefore depends entirely upon the relation between the quantities a and b.

1. *Let* $a^2 < b^2$

For this condition $\sqrt{a^2 - b^2}$ becomes imaginary and r_1 and r_2 become complex quantities.

$$r_1 = -\,a + i\sqrt{b^2 - a^2} \quad \text{or} \quad -\,a + ki$$
$$r_2 = -\,a - i\sqrt{b^2 - a^2} \quad \text{or} \quad -\,a - ki$$

Then

$$\begin{aligned} Y &= Be^{(-a+ki)\,t} + Ce^{(-a-ki)\,t} \\ &= e^{-at}\,[Be^{ikt} + Ce^{-ikt}] \\ &= e^{-at}\,[B\,(\cos kt + i \sin kt) + C\,(\cos kt - i \sin kt)] \\ &= e^{-at}\,[(B + C)\cos kt + (B - C)\,i \sin kt] \\ &= e^{-at}\,[D \cos kt + G \sin kt] \end{aligned}$$

This is the equation of an harmonic wave having the following form:—

Increasing amplitude for $a < 0$
Constant amplitude for $a = 0$
Decreasing amplitude for $a > 0$

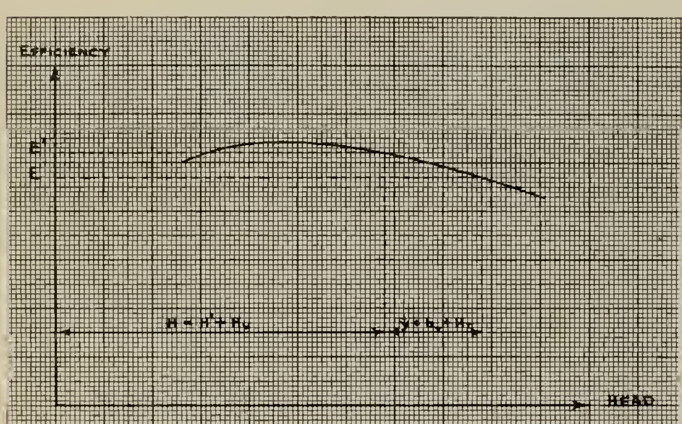

Fig. 4—Efficiency-Head Curve at Constant Power.

2. *Let* $a^2 = b^2$

It may be observed here that b^2 must always, in practice, be positive. For b^2 to be negative implies,

$$1 < \frac{2\,(H_v + H_r)}{H + 2\,H_v} \quad \text{or} \quad H_r > \frac{H}{2}$$

a condition which is manifestly not in keeping with sound principles of design.

$a^2 = b^2$ may then be written $a = \pm\, b$. The solution of (5) now becomes,

$$Y = Me^{-bt}$$
$$Y = Me^{bt}$$

two exponential functions of t with constantly decreasing and constantly increasing values of Y respectively.

3. *Let* $a^2 > b^2$

Denoting $\sqrt{a^2 - b^2}$ by m the solution of (5) is given by,

$$Y = Be^{(-a+m)\,t} + Ce^{(-a-m)\,t} \quad \ldots\ldots\ldots\ldots (6)$$

$$a^2 > b^2 \quad \text{implies} \quad a > b \quad \text{or} \quad -\,a < -\,b$$

Fig. 5—Surge Tank at Grand Falls, N.B.

It should be noted that a is always numerically greater than m so that the sign of the two exponents is always governed by the sign of a. If a is a positive quantity then (6) represents an aperiodic motion the amplitude of which finally tends towards zero. If a is a negative quantity (6) represents an aperiodic motion with a continually increasing amplitude.

The object of this study is to define the conditions for a damped movement of the water surface in the tank. The relation that will produce such a movement for each of the three cases just analysed is as follows:—

For $a^2 < b^2$ the relation is $a > 0$
$a^2 = b^2$ the relation is $a = b$
$a^2 > b^2$ the relation is $a > b$

Thus the relation $a > 0$ describes the condition for a damped movement for all possible combinations of the relation between a and b. Therefore,

$$\frac{gA}{LF} \cdot \frac{(H_v + H_r)}{V_p} - \frac{1}{2} \cdot \frac{V_p}{H + 2\,H_v} > 0$$

or
$$F > \frac{V_c^2}{2\,g} \cdot \frac{LA}{(H + 2\,H_v)\,(H_v + H_r)} \quad \ldots\ldots\ldots (7)$$

This relation was first derived by D. Thoma in the form

$$F > \frac{V_c^2}{2\,g} \cdot \frac{LA}{HH_r}$$

for an installation in which the conduit and penstock (or penstocks) are directly connected to the tank without the medium of a riser. The arrangement shown in Fig. 3 is at present much more usual and accordingly the formula has been derived for a surge tank connected to the junction of conduit and penstock by a riser pipe.

It may be noted that in actual practice a^2 is seldom equal to or greater than b^2 so that the movement of the water surface almost invariably takes the form of a sine wave. The period of this wave is, of course, $\dfrac{2\pi}{k} = \dfrac{2\pi}{\sqrt{b^2 - a^2}}$, a quantity which in an actual installation is seldom less than one minute and often two minutes or more. The gates of any modern governor will start to move within a fraction of a second after a load change has taken place so that the governor will have no difficulty in following the changes in pressure as they occur.

It is of interest to note the effect of changes in certain of the quantities of equation (7). Any increase in the amount of friction in the water passages will increase the factor $H_v + H_r$ by a greater amount than it decreases $H + 2H_v$. Therefore, the area of the tank increases with decreases in friction and in the economic design of any hydro-electric installation it is necessary to debit the increased cost of the tank against gain in power when studies are made to fix the economic diameter of the various waterways.

Fig. 6—Surge Tank at Powell River, B.C.

On the other hand, it is possible to provide a restricted section in the conduit at the junction of the surge tank. This is best accomplished by the use of correctly shaped converging and diverging cones. The effect of this is to increase the amount of velocity head registered at the tank, and so decrease the size of tank necessary for stable operation. While such a device has been employed, extreme caution must be taken in order that no objectionable results, due to the high velocities at the constricted section, may appear.

It may also be noted that an increase in the length of the conduit will cause an increase (almost in proportion as the length) in the quantity H_r, but a decrease in H. Changes in the length, however, take place much faster than changes in the product $(H + 2H_v)(H_v + H_r)$ so that the net effect of increasing the length of a conduit is to increase the size of the tank. Any hydro-electric site, therefore, that requires a long pressure conduit as a part of the structures necessary for its development, is penalized as a source of power, not only by the great expense of the conduit but also by a costly surge tank.

There is one additional point that is of great importance. The quantity $H_v + H_r$ may be taken to vary as the square of the velocity in the conduit. Hence the size of the tank is independent of the load on the plant, i.e., if the plant has been designed to be stable for one condition, e.g., full load, it will be stable for all other loads. This is not quite exact since the factor $H + 2H_v$ will also vary. Whether this increases or decreases with the load will depend upon the relation between the velocity head, the total losses of head, and the gross head. This variation, however, is quite small and in general the statement previously made remains sufficiently true that an investigation of the stability need be made for only one load condition.

Modification Due to Penstock and Turbine Efficiency

Up to the present, we have assumed that the efficiency of penstock and turbine remains constant during the load change. The change in efficiency that actually occurs may readily be included in the mathematical treatment outlined above and will be found to have a marked effect on the critical tank size.

If we denote the efficiency for final steady conditions by E', the expression for $\frac{v_p}{V_p}$ becomes

$$\frac{v_p}{V_p} = \left[1 - \frac{Y}{H + 2H_v}\right]\frac{E'}{E}$$

For constant power the efficiency curve may be expressed as a function of the head and the relation between E' and E becomes (Fig. 4),

$$E' - E = \frac{dE}{dh}(Y + h_v - H_v)$$

$$E' = E + \frac{dE}{dh}\cdot Y$$

Neglecting $h_v - H_v$

$$\frac{E'}{E} = 1 + \frac{dE}{dh}\cdot\frac{Y}{E}$$

Substituting this value in the new expression for $\frac{v_p}{V_p}$ there results

$$\frac{v_p}{V_p} = \left[1 - \frac{Y}{H + 2H_v}\right]\left[1 + \frac{dE}{dh}\cdot\frac{Y}{E}\right]$$

$$= 1 + \frac{dE}{dh}\cdot\frac{Y}{E} - \frac{Y}{H + 2H_v}$$

$$v_p = V_p + \frac{dE}{dh}\cdot\frac{V_p}{E}\cdot Y - \frac{V_p Y}{H + 2H_v}$$

$$\frac{dv_p}{dt} = \frac{dE}{dh}\cdot\frac{V_p}{E}\cdot\frac{dY}{dt} - \frac{V_p}{H + 2H_v}\cdot\frac{dY}{dt}$$

Fig. 7—Surge Tank at Chapleau, Ont.

For a very small value of Y the power P may be assumed to vary as the three-halves power of the head and since it is customary to express the efficiency as a function of the power, we may write

$$\frac{dE}{dh} = \frac{dE}{dP}\cdot\frac{dP}{dh}$$

Now $$P = Kh^{3/2}$$

Therefore $$\frac{dP}{dh} = \frac{3}{2}Kh^{1/2}$$

$$= \frac{3}{2}\frac{P}{h} = \frac{3}{2}\frac{P}{H}$$

at the point under consideration. Therefore,

$$\frac{dv_p}{dt} = \left[\frac{3}{2}\frac{P}{H}\cdot\frac{dE}{dP}\cdot\frac{V_p}{E} - \frac{V_p}{H+2\,H_v}\right]\frac{dY}{dt}$$

and the expression for a becomes

$$a = \frac{gA}{LF}\cdot\frac{(H_v+H_r)}{V_p} - \frac{1}{2}\left[\frac{V_p}{(H+2\,H_v)} - \frac{3}{2}\cdot\frac{P}{H}\cdot\frac{V_p}{E}\cdot\frac{dE}{dP}\right]$$

For a damped movement of the water surface in the tank the inequality now becomes

$$F > \frac{LA}{(H_v+H_r)}\cdot\frac{V_c{}^2}{2\,g}\left[\frac{1}{H+2\,H_v} - \frac{3}{2\,E}\cdot\frac{P}{H}\cdot\frac{dE}{dP}\right] \quad ..(7a)$$

Generating Plants in Parallel

When two or more generating plants are operating in parallel to supply the power demands of an electrical distributing system, it becomes the function of the governing apparatus to hold the power output of all the generating units at a fixed value. All units, of course, must operate in synchronism, i.e., rotate at the same or proportional speeds.

Consider the two curves of Fig. 2 representing the speed as a function of the power, i.e., $N = f\,(P)$ and $N = f'\,(P_s)$. These are labelled (a) and (b) respectively in the figure. The exact shape of the curves is not material to this discussion. The slope of the curve (a) will always be steeper than the slope of curve (b) due to the simple fact that the change in speed between no-load and full-load is the same for both curves (since all units have the same inherent speed change), while the change in power is, of course, much greater for curve (b) than for curve (a). The actual change in speed referred to above is not meant necessarily to be restricted to actual revolutions, but rather to the fact that speed changes, in the sense here considered, are representative of changes in gate opening or of the manner in which the various units of the system share the load among themselves. As stated previously, it is assumed that the inherent speed change of all the governors has been adjusted to the same value.

Since, throughout this discussion, the aim has been to establish the conditions under which even the smallest surge of water level in the tank may be rapidly damped, it will be permissible to replace the curves (a) and (b) by their tangents at the points m and n which are to be considered as representing final steady conditions.

When the water level in the tank changes from H' to $H' + Y$, it may be shown, in the same manner as above, that both points m and n will move to the right by an amount

$$\delta = \frac{3}{2}\cdot\frac{Y}{H}\cdot P$$

Since the plant with a surge tank is the only plant having a change in its operating characteristics, the same change will of course be reflected in the characteristic curve for the system as a whole which has been designated by (b). Through the new positions of m and n which we shall call m' and n' short curves may be drawn parallel to (a) and (b) which will approximate the actual new characteristic curves very closely for a very small value of Y. These new curves we shall designate by (a') and (b').

The points m' and n' are the positions which the points m and n would occupy if the action of the governors was ignored. Taking this action into account, the point n assumes a position n'' on (b') having the same abscissa as n (since P_s must remain constant); the corresponding position of the point m on (a') will be m'', a position having the same ordinate as n'' (parallel operation) but not the same abscissa due to the fact that the two curves do not have the same slope. The difference in abscissas between m'' and m''' represents a change in the power output of the plant provided with the surge tank (as has been previously described) equal to an amount

$$\Delta P = \delta - \Delta N\,\frac{dP}{dN}$$

where the change in speed is

$$\Delta N = \delta\frac{dN}{dP_s}$$

Therefore

$$\Delta P = \delta - \delta\frac{dN}{dP_s}\cdot\frac{dP}{dN} = \delta\,(1-r)$$

where $r = \dfrac{dP}{dP_s}$, that is, the ratio of the amount of the load change taken by the plant with the surge tank to the total load change required of the system.

The value of the power at any instant during the surge now becomes

$$P' = P + \Delta P = P\left[1 + \frac{3}{2}\frac{Y}{H}(1-r)\right]$$

By equating the two values for P in the same fashion as previously (p. 4) we now find that

$$\frac{v_p'}{V_p} = \left[1 - \frac{Y}{H+2\,H_v}\right]\left[1 + \frac{3}{2}\frac{Y}{H}(1-r) + \frac{dE}{dh}\cdot\frac{Y}{E}\right]$$

using the symbol v_p' to represent the velocity in the penstock under the new gate opening, i.e., for operation at m'' instead of m'''.

Differentiating

$$\frac{dv_p'}{dt} = \left[\frac{3}{2}\frac{V_p}{H}(1-r) + \frac{3}{2}\frac{P}{H}\cdot\frac{dE}{dP}\cdot\frac{V_p}{E} - \frac{V_p}{H+2\,H_v}\right]\frac{dY}{dt}$$

and the expression for a becomes

$$a = \frac{gA}{LF}\cdot\frac{(H_v+H_r)}{V_p} - \frac{1}{2}\left[\frac{V_p}{H+2\,H_v} - \frac{3}{2}\frac{V_p}{H}(1-r) - \frac{3}{2}\frac{P}{H}\cdot\frac{dE}{dP}\cdot\frac{V_p}{E}\right]$$

and for a damped movement of the water surface in the tank

$$F > \frac{LA}{(H_v+H_r)}\cdot\frac{V_c{}^2}{2\,g}\left[\frac{1}{H+2\,H_v} - \frac{3}{2}\frac{(1-r)}{H} - \frac{3}{2\,E}\cdot\frac{P}{H}\cdot\frac{dE}{dP}\right] \quad ..(7b)$$

It will now be interesting to examine the effect on the critical area of the tank of the value of r, that is, of various assumed proportions of the total load changes taken by the station equipped with a surge tank. If this station takes all the load, $r = 1$ and the expression for F reduces to the form given in (7a) which, of course, it must do to be correct. If the proportion of the load change taken by the station under discussion is decreased, the critical value for the area of the surge tank diminishes and finally becomes zero for a value

$$r = 1 - \frac{2\,H}{3}\left[\frac{1}{H+2\,H_v} - \frac{3}{2\,E}\cdot\frac{P}{H}\cdot\frac{dE}{dP}\right]$$

which will usually be just a little greater than $\frac{1}{3}$. Under this condition,

$$\frac{v_p'}{V_p} \approx 1$$

for a very small surge. That is, with the regulating mechanism functioning under the necessity of keeping the speed of its unit in synchronism with the system (not at constant power) while only sharing in one-third of the system load changes, the turbine gates are so continuously adjusted by the governor that the flow in the penstocks is maintained at a constant value during slight variations in the head resulting from the surge set up in the tank by the load change. Since there are no variations in the penstock flow, the surge must die away, and theoretically, from the viewpoint of damped oscillations, the tank may have any area whatsoever. It is only logical that under these conditions, the equation for the critical tank area reduces to zero.

Application of the Formulae

In the application of the study just completed to the design of proposed power developments judgment must be exercised in the selection of coefficients to determine losses of head in the water passages from the headworks to the surge tank. Experience and judgment are also both necessary to determine what increase in diameter should be made beyond that given by the formulae in order to approach a degree of stability that will be satisfactory in actual operation.

No general rule can be given definitely stating the conditions under which the surge tank area is determined by hydraulic stability and not by other operating characteristics or by structural facility. Experience has shown that for medium and low head plants with surge tanks hydraulic stability usually governs, and that for high head plants it may usually be ignored. This is not a fixed rule and owing to the extreme importance, both to the safety and to the satisfactory operation of the plant, that the surge tank be designed with the correct area, an investigation along the lines developed in this paper should always be carefully carried out for every installation requiring a surge tank by an experienced and competent engineer.

Figs. 5, 6, and 7 show views of the surge tanks at Grand Falls, N.B., Powell River, B.C., and Chapleau, Ont., respectively, all of which have been installed within the last few years. The designed diameter of each of these tanks was fixed by considerations of hydraulic stability.

An Engineer's Conception of Matter and Its Application to Materials of Construction

Part II*

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SUMMARY.—This paper is intended to explain for the benefit of engineers some of the fundamental ideas regarding the constitution of matter, and particularly the structure of metals, which have been developed as a result of recent investigations. These researches have thrown new light upon many of the properties of materials used in engineering construction.

V.—Solid Solutions

(References:—"Introduction to Physical Chemistry," by Maass and Steacie; "Metallic Alloys," by Gulliver; "Metals and Alloys," by Evans; "Introduction to Physical Metallurgy," by Rosenhain; Science of Metals," by Jeffries and Archer.)

Up to the present single pure metals only have been dealt with. It is now proposed to deal with mixtures of pure metals. If a molten metal is added to another molten metal the two will probably form a true solution, although this depends a little upon the temperature. Luckily in most alloy systems of commercial interest the components are mutually soluble in all proportions in the liquid state. There are, however, some systems of only partial solubility in which the liquid if left undisturbed would tend to form two layers, due to the marked differences in weight.

Certain pairs of metals also form solid solutions in all proportions. For instance, copper and gold, iron and nickel, silver and gold. In each of these instances an alloy made of the two metals in any proportion will on microscopic examination be found to consist of only one constituent. There is a marked difference, however, between a solid solution and a pure metal, in that a pure metal has a definite melting and freezing point, whereas a solid solution freezes over a range of temperature, indicating a variation in the composition as freezing continues. This variation can be seen under the microscope by the cored appearance of the crystals, but the metal can be made homogeneous by reheating.

It is evident that in a solid solution the atoms of the second metal must have taken the place of some of the atoms of the first metal, and that the two kinds of atoms have arranged themselves on one crystal space lattice. It is particularly interesting to find that if one metal is completely soluble in the solid state in another metal it can be assumed that the two when solidified separately will each crystallize in the same type of space lattice.

It should be remarked, however, that as the length of the side of the space lattice varies with the different metals the space lattice of the solid solution will be different from that of either of the two constituent metals.

Electrical Conductivity of Solid Solutions

Alloys of the solid solution type are of great industrial importance because of their high electrical resistance. The conductivity of each metal is lowered repeatedly by the addition of the other, the lowest conductivity being reached when the two metals are present in approximately equal atomic concentrations. This increase in resistance can be attributed to the difficulty which the electrons find in passing through the metal and consequent shortening of their paths under the distorted condition of the crystal lattice, and it is also possible that some of the normally easily detached electrons may find themselves fixed under the new arrangement.

Constantan is a typical high resistance alloy consisting of 60 per cent copper and 40 per cent nickel. Evidently it is a solid solution, because both copper and nickel crystallize in the face-centred cubic system.

Hardness and Strength of Solid Solutions

It is found that the addition of one metal to another increases the hardness of each, that is to say, the alloys are considerably harder than either of the constituent metals, and this applies equally to the strength of the alloy. This increased hardness may be regarded as resistance to permanent deformation, and since permanent deformation takes place largely by movement along slip planes it follows

*The first part of this paper appeared in the December, 1932, issue of The Journal.

that increased hardness must be caused by increased resistance to slip.

When two metals are crystallized in the same crystal lattice there is a certain amount of distortion due to the difference in size of the natural unit cell of each metal and, therefore, the increased slip interference due to the staggering of the atoms can be easily understood.

Partial Solution

Leaving apart those metals which form complete solid solutions in all proportions, it can be stated generally that one metal is partially soluble in another, and that usually this solubility increases with increasing temperature. This partial solubility can be regarded as the placing of occasional atoms of one metal in the crystal lattice of the other metal. These occasional atoms may either take the place of the atoms of the other metal or may also be regarded as being retained in the space in between the atoms of the other metal.

In either case a partial distortion of the crystal lattice results. Any excess metal over that which can be taken in solution is deposited independently in its own crystal form and is visible as a separate component under the microscope.

Freezing Point of Metallic Solutions—Lowering of Freezing Point

If a solid pure metal is in contact with its liquid at the freezing temperature then it is known that the number of atoms leaving the solid and entering the liquid is equal to the number of atoms leaving the liquid and entering the solid for equilibrium to be maintained.

Suppose now a small quantity of another metal is added. Usually this second metal is more soluble in the liquid than in the solid, with the result that the liquid is diluted more than the solid by the second metal. The result will be that more atoms will leave the solid and pass to the liquid than leave the liquid and pass to the solid, thus causing a gradual disappearance of the solid state. If, therefore, solidification is to be produced the temperature must be reduced, i.e., the freezing point of the liquid has been lowered by the addition of the second metal. If the added metal is more soluble in the solid state than in the liquid, then the reverse will take place and more atoms will enter the solid than enter the liquid, and the liquid state will tend to disappear so that if fusion is required the temperature will have to be raised, and in this instance the freezing point of the liquid has been raised by the addition of the second metal.

VI.—Metallic Compounds

(Reference:—"Science of Metals," by Jeffries and Archer.)

Metals combine with non-metallic substances, the metalloids, and with other metals, to form definite compounds which play an important part in determining the strength of metals and metallic alloys.

Heat of Formation

When a chemical compound is formed, heat is given out. This is called the "heat of formation." It can be accounted for by assuming that the atoms which make up the compound after being brought into a favourable position for combining are forced to give up their energy of oscillation or rotation, in order to become fixed in the position required by the compound. This energy so given up manifests itself by the emission of heat. Similarly in order to break up this same compound, heat is required in order to energize the respective atoms sufficiently to enable them to break away from their bonds.

Compounds in Solution

There seems to be a matter of some doubt whether a compound actually exists in a solution, although it is known that the solid compound may separate from the solution upon solidification. It is probable that the compound exists in the solution, because the heat of formation can be measured, but for the present purpose it is unnecessary to worry about this point.

Compounds in Solid Solution

Just as one metal may be partially soluble in another in the solid state, so a compound may be partially soluble in a metal in the solid state, and in addition the compounds usually follow the same rule as the metals in that increase in temperature increases the solubility of the compound. When a compound is in solution in a metal it is necessary to assume that the constituent atoms are in some way built in to the space lattice of the metal causing some distortion and some hardening.

When the compound separates from the metal it crystallizes in its own crystal form just as an excess of a second metal would do.

Hardness and Brittleness of Compounds

The most important characteristics of the compounds found in alloys are their great hardness and brittleness. Alloys made up entirely of such compounds are usually very hard and so brittle that they are useless for mechanical purposes.

From the mere fact that the compound forms from these atoms, it can be seen that the attraction between the unlike atoms must be very great and able to resist forces tending to separate them. The brittleness as compared with a pure metal can also be explained. In a pure metal if it is assumed that on one of the crystal planes a small amount of slip takes place, sufficient to displace the two portions by a lattice space, then the resulting condition is precisely similar to that previously existing, and the previously existing forces are re-established. If now the compound is considered to slip by a similar distance, it is possible to assume that an atom which was previously opposite to a similar or dissimilar atom will now find itself opposite to a different kind of atom and, therefore, the previously existing forces will not be re-established.

Important Compounds of Metals

Fe_3C.—A carbide of iron known as "cementite." It forms an important hardening constituent in steels.

$CuAl_2$.—The hard strong compound which forms an important constituent in the hardening of aluminum alloys.

Mg_2Si.—Another hardening constituent in light aluminum alloys.

VII.—Metallic Alloys

(References:—"Introduction to Physical Metallurgy," by Rosenhain; "Metals and Metallic Compounds," by Evans; "Handbook of Non-ferrous Metallurgy," by Riddell; "Metallic Alloys," by Gulliver; "Métaux et Alliages," by Grard and Cournot.)

It is not proposed to deal at great length with the many different classes of alloys found in metallurgy, because they are all fully described in the many text books on the subject, and any useful knowledge must include the detail. It will be sufficient for our purpose to deal with one typical family of alloys only.

Equilibrium Diagrams (Fig. 5)

In the figure the ordinates represent temperatures and the abscissæ represent percentages of the metal (A) and (B). The left hand side of the diagram represents 100 per cent of (A), and the right hand side of the diagram represents 100 per cent of (B). The point (P) represents the freezing point of pure metal (A). The point (T) represents the freezing point of pure metal (B). The curves P, Q, T, represent the commencement of freezing for alloys of different composition. For instance, an alloy of composition (X) per cent of (A) begins to freeze at the temperature (V). A point situated anywhere above the curves, P, Q, T, indicates that at that particular temperature and composition the alloy is in a liquid condition. The curves *P*, *W*, *Z*, *T*, represent the end of solidification of the alloy, thus the alloy of composition (*X*), which commenced to solidify at a temperature (*V*) completes solidification at a temperature represented by (*O*), so that the region between the lines, *P*, *Q*, *T*, and *P*, *W*, *Z*, *T*, represents a region of partially solid and partially liquid alloys. From what has gone before one would expect to find that the metal (*B*) was partially soluble in the metal (*A*), and that the solubility

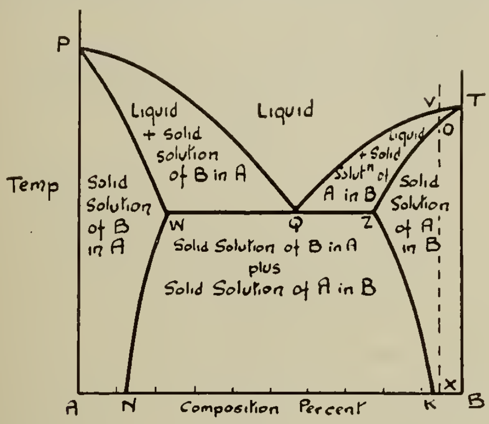

Fig. 5

decreased with decrease in temperature. This is represented on the diagram by the line *W*, *N*.

In the region *P*, *W*, *N*, *A*, there is a solid alloy which consists of a solution of metal (*B*) in metal (*A*), the proportion of (*B*) being less where the temperature is lower. Similarly, the region *T*, *Z*, *K*, *B*, represents a solid solution of the metal (*A*) in the metal (*B*). It has been seen that if the metal (*B*) is present in excess of the quantity that can be held in solution, then it separates in its own crystal form. The region *W*, *Z*, *K*, *N*, therefore, represents a mixture consisting of crystals of (*A*) with some (*B*) in solution, together with crystals of (*B*) containing some (*A*) in solution.

Presence of a Compound

If the two metals in question form between them a compound when mixed in a certain proportion, the diagram is altered and takes the form indicated in Fig. 6. In this instance the compound corresponds with a composition represented by the point (*H*), the point (*H*) being determined by the proportions of the metals required to give the compound, thus Fe_3C would correspond to 6.6 per cent carbon.

From what has gone before one would expect to find the melting point of the compound to be fairly high, and this is represented in the diagram by the point (*R*). In order to investigate the effects produced by this compound it is only necessary to divide the diagram into two parts, and consider the portions from (*A*) to (*H*) and (*H*) to (*B*) respectively as being the diagrams of two metals, except that in this case the metal represented by (*H*) is the compound.

It is thus seen that the region *P*, *W*, *N*, *A*, now represents a solid solution of the compound in the metal (*A*) and the region *R*, *X*, *M*, *H*, represents a solid solution of the metal (*A*) in the compound. Also the region *W*, *X*, *M*, *N*, now represents a region consisting of two kinds of crystals, the first crystals of (*A*) containing some compound in solution, and the second crystals of the compound containing some (*A*) in solution. These equilibrium diagrams for alloys are frequently exceedingly complicated, but by starting with a simple diagram and making sure that this is thoroughly understood, it is possible to pass from the simple to the more complicated diagrams without any very great difficulty.

Eutectic

It has been seen that when one metal is added to another there is generally a lowering of the melting point, thus in Fig. 5 the addition of (*B*) to the metal (*A*) results in the lowering of the freezing point in accordance with the line (*P*, *Q*), which represents the beginning of solidification. Similarly, the addition of the metal (*A*) to the metal (*B*) results in the lowering of the freezing point of the metal (*B*) in accordance with the line (*T*, *Q*). There is thus one particular mixture represented by the abscissa of the point (*Q*), at which the freezing point of the alloy is a minimum. This point is called the "eutectic" point, and represents the alloy of those two particular metals which has the lowest freezing point. It will be seen from Fig. 6 that it is possible to obtain eutectics between metals and compounds.

The Physical Properties of Metals

Up to the present metals have only been considered from the point of view of single crystals. Actually it is well known that a metal consists of a large number of interlocking crystals, and the size and condition of this crystalline structure plays an important part in determining the physical properties of the metals.

The determination of the most suitable crystal structure and the finding of commercial methods for producing the desired condition form important parts of the work of the metallurgist and the engineer. This part of the work is, however, generally fairly well understood, and it is not proposed to enter into any details in this memorandum, which is devoted more to a discussion of the underlying theory of the condition of the metal in the crystal.

VIII.—Hardening of Metals

(Reference:—"Science of Metals," by Jeffries and Archer.)

Hardness is usually determined by an apparatus for measuring the load required to produce an indentation in the surface of the metal. There are a number of machines for this purpose, but they are all covered by one general definition that hardness is resistance to permanent deformation. It has been shown previously that metals possess very great inherent cohesion amounting to figures which cannot be even approached by commercial materials.

The crystalline form of the metal, however, results in a regularity of the atomic arrangement, which gives rise to

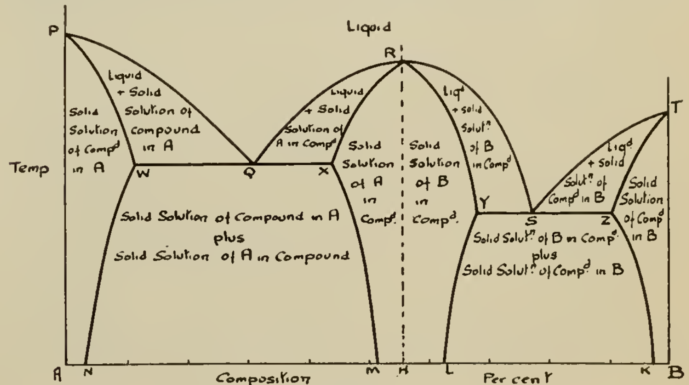

Fig. 6

certain planes of weakness or low resistance to shearing stress. When the external load produces movement along one of these planes the fragments may or may not adhere to each other in their new position. If they do not the failure of the crystal is complete, and the metal is said to be brittle. The plane of weakness is then known as a "cleavage plane."

More generally in the metals commonly used the crystal fragments adhere, and merely slip over each other. The result of such slip repeated on many planes is a measurable permanent deformation. The crystal is then said to be ductile, and the planes of weakness are called "slip planes." The first appreciable formation of slip planes indicates the passing of the "elastic limit." Anything that serves to hinder slip is a source of strength and hardness. The hardening and strengthening of metals by any of the known methods may be considered as due principally to interference with slip.

Hardness by Grain Refinement and Cold Work

Grain refinement, due to the increase of the number of grain boundaries, and increasing complexity of the structure interferes with the slip and, therefore, increases the hardness. In the same way cold working breaks up the crystals and changes their orientation, thus again interfering with slip and increasing the hardness.

Hardness of Solid Solutions

The increased hardness and strength of solid solutions are traceable directly to increased atomic forces and to a roughening of the slip planes due to the distortion of the crystal lattice brought about by the presence of unlike atoms.

Hardness of Metallic Compounds

It has also been seen that metallic compounds are hard and brittle, due to their complicated structure, and the arrangement of atoms in such a way that those of one element are not interchangeable in position with those of another element.

Hardening due to the Presence of a Free Compound

If a hard compound is present as small crystals spread through the body of a metal these hard crystals will tend to prevent slip and produce hardness, but if now it is imagined that the same amount of material instead of being present as crystals visible under the microscope is present as very small particles of sub-microscopic size, then it is possible to imagine these tiny hard particles as forming a more effective lock, preventing slip on the slip planes of the crystals.

If a piece of wood is divided up into layers ⅛ inch thick, then a ½ inch diameter ball will serve to lock five of the layers preventing slip between these layers. The material in the ½ inch diameter ball can now be considered as being more finely divided in the form of sixty-four ⅛ inch

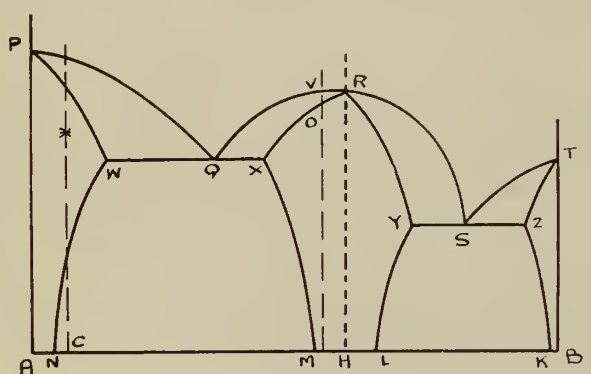

Fig. 7

diameter balls. These balls will now serve to lock sixty-five layers, thus indicating that by having the hard material in a finely divided state a very much larger number of layers can be locked. This provides a useful analogy for explaining the hardening effect of metallic compounds on metals.

Referring to the diagram for an alloy, consider an alloy of a composition corresponding with the position (*C*), Fig. 7; then it is known that when the temperature represented by the line *P*, *Q*, is reached in cooling a portion of the alloy commences to solidify. Upon reaching the line *P*, *W*, the alloy is completely solidified. At any position inside the area *P*, *W*, *N*, *A*, the alloy is a solid solution of the compound (*H*) in the metal (*A*).

Suppose now that from some position in this region the alloy is quenched, then the structure which existed at the temperature before quenching will be initially retained at room temperatures, although with time it may slowly change. In this condition the metal has the hardness to be expected from a solid solution of this composition.

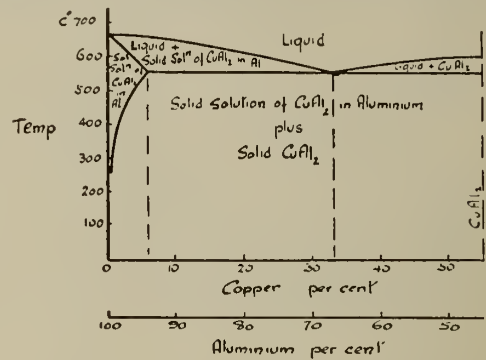

Fig. 8

It is possible by a suitable heat treatment to bring about a readjustment of the condition of this metal, and it is known from the diagram that at room temperatures the equilibrium condition of the metal would be a solid solution containing much less of the compound, as represented by *A*, *N*, so that in order to reach equilibrium there is a tendency for the compound to be released.

If the heat treatment is correctly carried out this compound can be released in an extremely finely divided state so that it acts as a locking medium on the slip planes of the metal in the manner indicated above. This process is roughly the process that takes place during the hardening of all metals by heat treatment.

IX.—Heat Treatment of Light Alloys

(References:—"Métaux et Alliages," by Grard and Cournot; "The Metallurgy of Aluminium and Aluminium Alloys," by Anderson; "The Aluminium Industry," by Edwards, Frary and Jeffries.)

Certain alloys possess the property of hardening after suitable heat treatment. The best known of these alloys is duralumin, which when heated to about 500 degrees C. and quenched in water is soft, but which hardens with time either at room temperatures or at a slightly raised temperature, depending upon the analysis. This hardening is directly attributable to the presence of a hard compound, and in alloys of the duralumin class this compound may be either Mg_2Si or $CuAl_2$.

From what has gone before it is known that the hardening effect is due to the change in solubility of the compound in the basic metal with change in temperatures. From the curve for the alloy made up of aluminium and $CuAl_2$, it is found that at a temperature of 548 degrees C. the aluminium will take in solution $CuAl_2$ equivalent to 5.65 per cent of copper, but that at a temperature of 250 degrees C. the aluminium would only hold $CuAl_2$ in solution up to a copper content of 0.5 per cent (Fig. 8).

If, therefore, an alloy containing 5.65 per cent of copper is heated to 548 degrees C. all the $CuAl_2$ is taken into solution, and if this metal is quenched it will be found to be harder than the fully annealed metal due to the compound in solution, but considerably softer than the metal in its hardest condition.

When this quenched material is heated to a temperature of about 150 degrees C. and held at this temperature for some considerable period, it is found that a decided hardening effect takes place. This hardening has been due to the gradual precipitation of very fine particles of $CuAl_2$, which interfere with any tendency to movement along the slip planes of the crystals. The $CuAl_2$ is not visible under the microscope.

If, however, metal of this same composition is very slowly cooled from the higher temperature, then the $CuAl_2$ deposited from the solution is able to coagulate and form its own crystals of visible size, which are easily apparent under the microscope, and in this condition the metal is very soft. Alloys of a similar type containing magnesium owe their hardening to the presence of Mg_2Si, which acts in a similar manner to the $CuAl_2$ except that it precipitates at room temperatures, so that an alloy which has been quenched from a temperature of about 550 degrees C. gradually hardens itself at room temperatures without further heat treatment.

X.—Heat Treatment of Steel

(References:—"Metallography and Heat Treatment of Iron and Steel," by Sauveur; "Metal Progress," September, 1930.)

As mentioned previously, the hardening properties of steel are due to the presence of the compound Fe_3C in the iron and, therefore, in studying the heat treatment of steels it is necessary to study the equilibrium diagram for the alloys formed by iron and the compound iron carbide.

The complete diagram as usually published covers only the iron side of the diagram up to about 5 per cent carbon content, this being the extent of the diagram which is of practical importance. The diagrams vary a great deal with different authorities, but a good representative diagram covering modern ideas is shown in the attached Fig. 9.

In studying this diagram it is advisable to consider it in two stages, Fig. 10 and Fig. 11.

Consider the upper part of the diagram with some simplification by omitting some of the lines at the point (A). The line A, B, represents the temperature and composition at which the metal begins to solidify, the temperature being less as the amount of carbon increases.

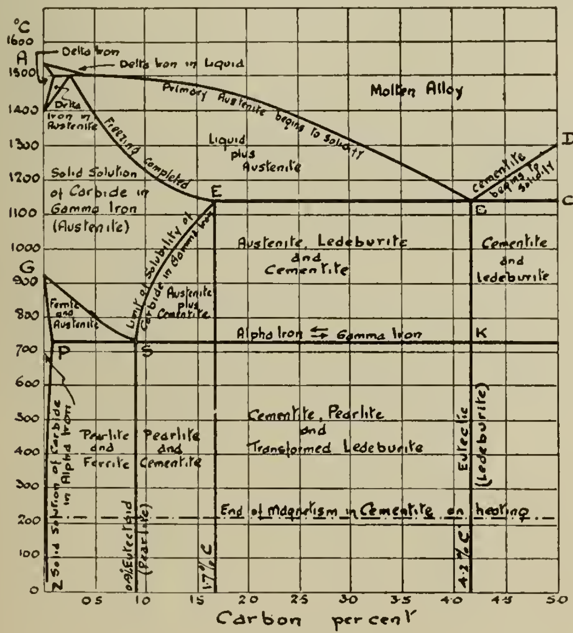

Fig. 9

The point B is the eutectic point for iron carbon alloys. In the region A, B, E, the alloy consists of a solid solution of carbide in iron with some liquid. The region between the lines A, E, E, S, and the axis O, A, represents solid solution of carbon in iron. It would, perhaps, be more correct to describe this area as the area of solid solution of Fe_3C in iron. The curve E, S, represents the limit of solubility of Fe_3C in iron. The area below the curve C, B, E, S, represents a mixture of solid iron containing some carbide in solution and solid carbide.

The area from 0 per cent to 1.7 per cent carbon represents the range from wrought iron to exceedingly high carbon steels, the region from 1.7 per cent carbon to 5 per cent carbon represents the whole range of cast irons from the white irons up to very soft irons containing large amounts of graphite. The separation of Fe_3C into iron and carbon is a complication which occurs in the cast iron portion of the diagram.

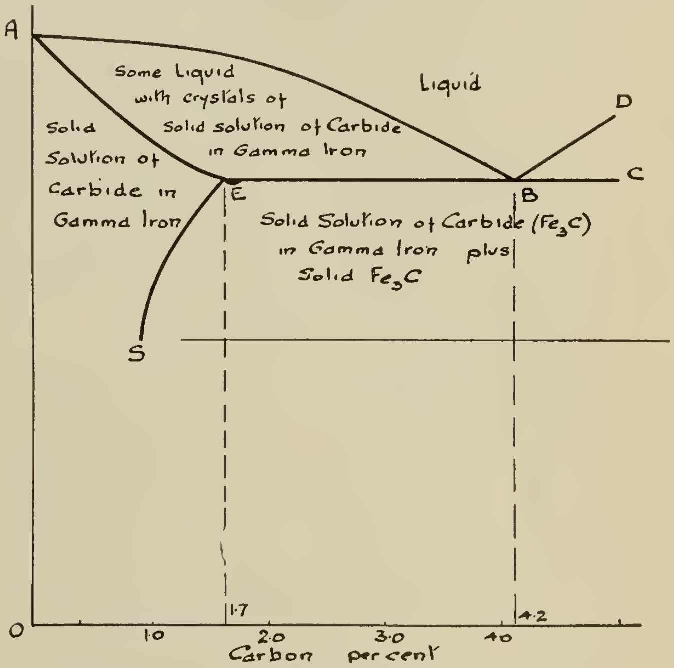

Fig. 10—Upper Portion of Simplified Iron-Iron Carbide Diagram.

The Eutectoid

The point B in the iron carbon diagram is a true eutectic. If, however, the lower portion of the diagram is now considered it is found that in the lines G, S, E, there is a construction which would appear to indicate the presence of a eutectic. It is also known that below the line A, E, B, the metal is solid, therefore the point S cannot represent a true eutectic, but must have some different characteristic. This point S is called the "eutectoid" point because of its similarity to the eutectic. It occurs at a carbon content of about 0.9 per cent (Fig. 11).

The lines G, S, and P, S, also need to be explained. Consider a steel containing 0.5 per cent of carbon, which is being cooled from high temperature, it is found that when a temperature corresponding with the line G, S, is reached the steel does not change in temperature, although it is still giving up heat, i.e., there is an arrest point in the cooling curve. This point is called the upper critical point. On further cooling, at a temperature of about 700 degrees C. a further arrest occurs when the well-known phenomenon of "recalescence" occurs.

There is also another change which occurs at a definite temperature, and that is the change from the magnetic to a non-magnetic condition, which occurs at a temperature slightly below 800 degrees C. At the higher temperatures the metal is non-magnetic, changing to strongly magnetic at the lower temperatures.

The best way to deal with the steel portion of the diagram is to consider the point S as being exactly analogous to a eutectic. Above the lines G, S, S, E, the metal consists of a solid solution of Fe_3C in iron. In the portion G, P, S, the iron has commenced to separate out in the form of ferrite. In the portion S, E, L, the carbide has commenced to separate out. The region G, P, O, represents almost pure iron, except that this iron still contains a small amount of carbide as represented by the solubility curve P, O. The region O, P, L, M, represents a mixture of iron and carbide. When the carbide separates from the solid solution during very slow cooling it does so in the form of thin plates of carbide deposited between thin plates of iron. The metallurgical name for the iron is ferrite. When these two are combined in alternate layers the combination is known as pearlite.

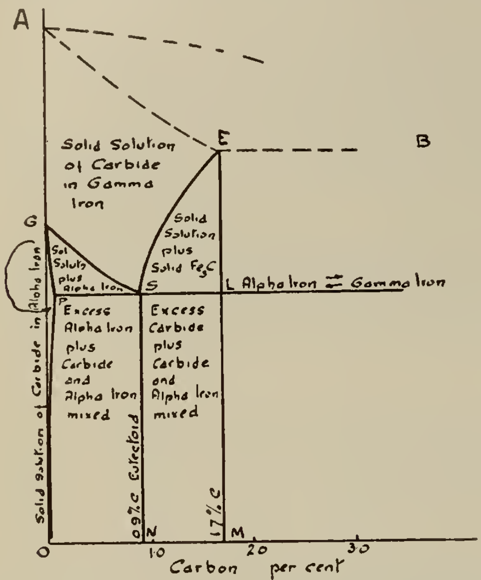

Fig. 11—Lower Portion of Iron-Iron Carbide Diagram.

At the point S the alloy consists entirely of pearlite. In the region S, L, M, N, the alloy consists of pearlite with an excess of carbide as cementite. In the region P, S, N, O, the alloy consists of pearlite with an excess of iron as ferrite. In the region G, P, O, the alloy consists entirely of ferrite, which may contain a small amount of carbide in solution.

Allotropic Forms of Iron

Above the critical points the iron consists of what is known as gamma iron, in which the atoms are arranged in the face-centred cubic lattice, which is the most closely packed arrangement of atoms.

Below the upper critical point the free iron exists as alpha iron, which crystallizes in the body-centred cubic arrangement, which is not so closely packed as the gamma iron, and consequently in passing from gamma iron to alpha iron there is an increase in volume of about 1.5 per cent due to re-arrangement of the atoms. These allotropic changes account for some of the variations in the equilibrium diagram.

The curve E, S, represents the solubility of Fe_3C in gamma iron. The curve P, O, represents the solubility of Fe_3C in alpha iron, the break in the curve from P to S being due to the change in solubility which occurs in changing from alpha to gamma iron.

Hardening of Steel

It is known from experience that if a piece of steel is quenched from an orange coloured heat it will be hardened more or less, depending upon its greater or lesser carbon content. Consider a steel containing 0.5 per cent carbon, which has been quenched from a temperature of 900 degrees C. From the diagram it is known that at this temperature and composition the steel consisted of a solid solution of carbide in gamma iron.

During quenching the structure existing at the higher temperature has been retained, but the iron has changed its crystal form from the gamma to the alpha condition, so that the whole metal is in an unstable condition. The carbide which was held by the gamma iron can no longer be held by the alpha iron. It can, therefore, be imagined to have been released *in situ*, that is as very finely divided particles, which, being of hard brittle material, form an effective obstacle to slip, and thus cause hardness in the metal. The structure of quenched steel of this kind is very complicated and does not lend itself well to microscopic examination at ordinary magnifications.

It should be noted that the steel differs from duralumin in that when duralumin is quenched the compound is held in solid solution, and is only deposited subsequently after some fairly long period. With steel there is an allotropic change which alters the crystal lattice. The compound Fe_3C is almost insoluble in the new alpha iron, and is deposited at once in sub-microscopic particles.

If now this quenched steel is slowly heated a re-arrangement will take place, in which the carbide particles will tend to assert their own individuality, and coagulate to form separate crystals, with the result that after re-heating to sufficiently high temperature and slow cooling the normal structure of slowly cooled steel is obtained. Any intermediate stage will have an intermediate amount of hardness corresponding with the well-known grading of hardness obtained by tempering steels. Increase in carbon content, of course, increases the effect produced, and for this reason a carbon tool steel will have carbon content of about the eutectoid composition. At this composition the quenched steel has nearly all the carbide deposited in a finely divided condition, producing great hardness. Any greater carbon content results in excess of free cementite, which is brittle, and any smaller carbon content results in free ferrite, which is soft.

Coinage Methods in Canada

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Paper presented before the Ottawa Branch of The Engineering Institute of Canada, November 17th, 1932.

From 1859 to 1908 all coinages required for Canada were executed at the Royal Mint, London, or, under its supervision, at the "Mint," Birmingham.

Since January 2nd, 1908, all Canadian coins have been struck at the Ottawa branch of the Royal Mint, which was formally opened on that date by His Excellency The Governor-General, Earl Grey, who struck the first coin.

Authority for the establishment of the Ottawa branch of the Royal Mint was granted by Parliament in the year 1901, under the provisions of the "Ottawa Mint Act." The work of construction was commenced in June, 1905, and was completed in 1908.

The Royal Proclamation authorizing the opening of the Ottawa Mint was published at Buckingham Palace on November 2nd, 1907, and came into force on January 1st, 1908.

On December 1st, 1931, the Mint was taken over by the Dominion of Canada and is now known as the Royal Canadian Mint.

Canadian coins of gold, silver, bronze, or other metals were to be coined as required by the Governor-General of the Dominion of Canada.

Since the opening of the Mint proper, a refinery has been added and the work of refining gold commenced in January, 1911.

As constituted at present, the Ottawa Mint consists of four principal departments:—

(1) The Mint Office, into which all bullion is received for coinage purposes and from which the finished coins are issued to various parts of Canada, on requisitions received from the Comptroller of Currency, Finance Department, Ottawa.

(2) The Operative Department, with its sub-divisions.

- (*a*) The Melting House, in which the bullion is melted with the requisite alloy into coinage bars.
- (*b*) The Coining Department, where the coinage bars are rolled into fillets, from which the coin blanks are cut, then marked, annealed, blanched, cleaned, struck and tested before delivery to the Mint Office.
- (*c*) The Die Department, where the coinage dies are made.
- (*d*) The Mechanical Department, where the power is generated and renewals and repairs to all minting machinery effected.

(3) The Assay Office, where the fineness of the ingots, coinage bars and finished coins are ascertained.

(4) The Refinery, where deposits of rough gold bullion are melted and refined, the fine gold and silver contents extracted and cast into bars for coinage or for trade purposes.

The handling of precious metal in large quantities necessitates the enforcement of certain precautions. Each workman has a locker furnished with a special key and, on arrival in the morning, changes from his private suit into his working clothes, fastens his locker and deposits the key in charge of the foreman of the room.

The strongholds, each of which is fitted with a double combination and time lock, are then opened and the day's work taken out.

The bullion to be worked on is checked out into various rooms over balances carrying up to 3,500 troy ounces and turning to the one-hundredth part of an ounce.

In each room a definite weight of bullion is given out; as this is added to by the issue of more raw material, or, as the finished work is turned in, the room is debited, or credited, with the amount involved. At the close of the day, the floors are swept, the dust burnt, and all small particles recovered and weighed in. If the accounts then balance, the keys of the lockers are released; if there is a loss, search is made for the missing metal or coin.

The various operations through which the metals pass while being transferred from ingots into finished coins have been stated in order of sequence and will now be dealt with more fully.

Melting

The ingots (of a purity of 999 parts per 1,000, or over) are placed with the necessary alloy in the crucibles and charged into the melting furnaces. There are seven of these furnaces, four of which are capable of taking a No. 60 crucible, holding a charge of 2,800 ounces of silver, and three taking a No. 35 crucible, with a capacity of 1,200 ounces of silver. Crude oil is used as fuel, in conjunction with an air blast. The oil, at a pressure of about 60 pounds to the square inch, is delivered to the furnaces by a special burner through a small hole, the diameter of which is about that of an ordinary pin; the burner is so designed that four jets impinge upon this small opening, the result being that the issuing oil is very finely atomized. The necessary supply of air for the low pressure burner is regulated by an adjustable sleeve. The flame passes through a combustion chamber and, striking upon a firebrick, is deflected so as to travel around the crucible and so to the flue.

Fig. 1—The Royal Canadian Mint, Ottawa, Ont.

The furnaces are very clean, economical, and easy of manipulation. It is usual in the case of silver, and starting with a cold furnace, for the first round to be ready for pouring one hour and a half after lighting up. After the first round has been poured, the furnaces have become thoroughly warmed up and the subsequent rounds are ready for pouring one hour after charging.

The flues are so arranged that the gases issuing from the furnaces enter a large condensing chamber, where they expand rapidly and their velocity is reduced. In passing through this chamber the gases strike against baffle-plates, by means of which their velocity is still further reduced. Any fine particles of metals which may be carried by them from the furnaces are deposited on the baffle-plates and the sides of the chamber and thus prevented from being carried away through the chimney stack.

Broken charcoal is placed in the crucibles with the metal, and, as the latter melts, floats on the surface and

Fig. 2—Weighing Ingot Silver.

forms a protective covering from the oxidizing influence of the air.

When the molten metal is ready for pouring, the crucible with its contents is lifted bodily from the furnace and placed on a stand near the mould carriages. The crucible is then taken up by a pair of tongs manipulated by two men and the molten metal poured into cast iron moulds, forming bars about 24 inches long, ½ inch thick and varying in width from 1¼ inches to 2¼ inches according to the denomination of the coin to be made. During the pouring a gas flame is played continuously on the jet and along the tops of the moulds, to prevent oxidation of the metal. The newly-formed bars are removed from the moulds as soon as they have become solid and plunged into water, washed and dried. They are then taken to the shearing machine and revolving files, the spongy ends are removed and the rough edges trimmed. They are then ready for the rolling mills.

The bars from each crucible are kept separate from those of any other crucible, and marked with distinctive letters and figures, so that their origin can readily be traced at any time. In the case of gold or silver bars, a small piece is cut from one end of the first and last bar from each crucible, and these pieces are forwarded to the Assay Department for testing purposes. The bars are not operated upon until a report from that department has been received, stating that they are within the legal remedy as to fineness. All bars which are above or below the legal standard are remelted with the necessary amount of alloy, or fine metal, to bring them within the remedy.

All worn out crucibles, covers, etc., are ground to a fine powder in a mortar mill, the powder being washed, so as to recover any metal that may have been absorbed during the process of melting. After two washings, the powder, or "sweep," is dried and thoroughly mixed; samples are then sent to various smelting firms, and the "sweep" is sold to the highest bidder.

Rolling

From the melting house the bars go to the rolling mills where they are rolled into long thin strips, or fillets. There are three of these mills, each of which is driven by its own motor: the breaking-down mill, the thinning mill and the finishing mill.

The bars are first passed some twenty times through the breaking-down mill, after which they are passed about ten times through the thinning mill and finally some eight times through the finishing mill, where they are reduced to the correct thickness for the coin that is to be made.

In the finishing mill, the distance between the rolls is varied by raising or lowering the bottom roll by means of long steel wedges, which are actuated by a hand wheel through gear wheels and fine screws. By the use of indicators and divided circles, the adjustment of the rolls can be made as fine as .0002 inch.

Adjusting

In the case of silver and of bronze, the fillets pass from the finishing mill to the blank cutting machines, but in the case of gold, it is found that further adjustment is necessary. The gold fillets are accordingly taken to the draw-bench, where they are drawn between two fixed steel cylinders by means of a dog-clutch which engages with an endless chain. The cylinders are highly polished and extremely hard and the distance between them can be adjusted to .0001 inch. By this means the smallest inequalities in the thickness of the fillets are regulated and their variations from standard reduced to a minimum. The fillets then pass to a blank-cutting machine.

Cutting

There are three of these machines, each driven by a separate motor and capable of cutting blanks for all sizes of coins at the rate of 150, 300 or 450 per minute, according as the blanks are cut single, double or triple file. The punches and beds for all different denominations are interchangeable so that little time is occupied in changing from one to another. Each machine is fitted with an automatic

Fig. 3—Pouring Molten Metal into Coinage Bar Moulds.

variable feed, which can be increased or decreased by multiples of .05 inch.

After the blanks have been cut from the fillets, the skeletons that remain, or "scissel," are cut into convenient lengths and made into bundles for remelting.

Marking

The blanks are next taken to the marking machine, where they are passed at the rate of 600 blanks per minute between a circumferential groove in a rapidly revolving hard steel disc and another groove, struck from the same radius, in a hard steel block. The distance between the disc and the block can be varied, so that any size of blank may pass between them, and adjustment is made that pressure is placed upon the edges, raising them and forming a protection for the impressions to be given to the blanks, later, in the coining presses.

Annealing

The pressure to which the metal has been subjected during the rolling, cutting and marking processes has

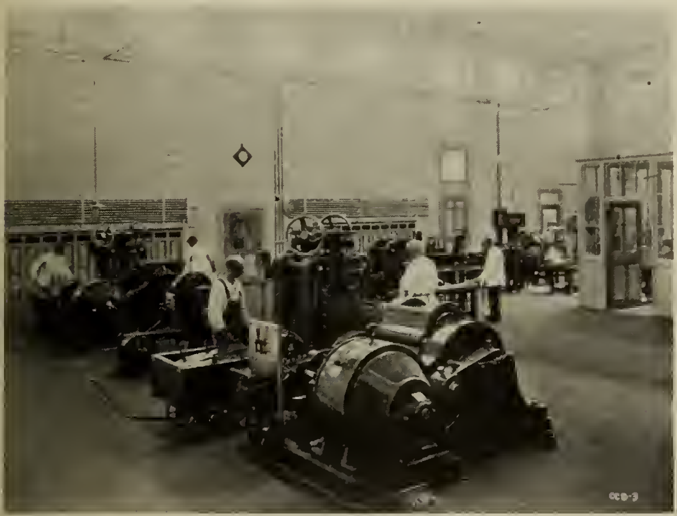

Fig. 4—Bars Passing Through Rolling Mills.

hardened it very considerably and it must be rendered ductile again, in order that the blanks, when struck in the coining presses, may take the impression of the dies. This is accomplished by heating the metal to redness and suddenly quenching it in water—or annealing.

The annealing plant consists of two oil-burning furnaces, one used for silver, the other for gold or bronze blanks.

In the silver annealing furnace the blanks are fed into the machine through a sheet iron hopper. This hopper is attached to, and revolves with, a cast iron hollow cylinder, on the internal surface of which is cast a hollow thread of very coarse pitch. The blanks follow this thread, moving forward slowly as the cylinder revolves, until they fall through an opening which communicates with a chute leading into a vessel containing water. The flame surrounds the cylinder which is kept at a red heat during the process of annealing. The time taken by the blanks in their passage through the furnace is regulated by a speed box attached to the driving motor.

The slight air current passing through the revolving cylinder is sufficient to oxidize the silver blanks slightly; this oxide is easily removed by weak sulphuric acid, leaving a fine silver surface to receive the impression from the dies.

In the case of gold or bronze, the metal must be kept free from contact with the air during annealing, as the oxidation is not readily removable by weak acid solutions. The blanks, therefore, are packed in iron cylinders with a little charcoal, an iron lid placed on top and loamed up with clay. The pots are then placed in the oven furnace and heated to about 1,000 degrees F. when they are removed and the blanks plunged into a tank of water.

After having been annealed, the blanks are cleaned in a weak solution of hot sulphuric acid, washed in hot and cold water and dried in a centrifugal drying machine. They are then ready for the coining presses.

Preparation of Dies

A matrix or master die is cut from the artist's model by a pantograph engraving machine to the required size and depth. The matrix is turned to the diameter of the coin to be produced, hardened and pressed into a mild steel ring.

From the matrix a punch is struck. The high carbon steel hub, or die block, is first coned and buffed. A brass collar is fitted to the hub and acts as a guide for the matrix to hold it in a central position while the first blow is being struck. Nine annealings and ten blows in the screw press are necessary to complete the impression on a punch for a twenty-five cent coin. The punch is then turned to size, hardened and pressed into a mild steel ring.

From the punch the working dies are made. The same process is used as in the manufacture of the punch, but the number of blows and annealings is less.

The steel for the matrices, punches and dies is of a high carbon content. Round bars or forged die blocks may be used.

Hardening:—Electric furnaces and pyrometers are used. The hubs, or dies, are packed in charcoal in plumbago pots, one to a pot, after which the pots are placed in a cold furnace and the temperature is raised to 1,550 degrees F. The dies are quenched in distilled water at a temperature of 65 degrees F. They remain in the tank for about two hours.

The matrices and punches are left glass hard but the dies are drawn on a hot plate to a light straw colour. A pair of dies will strike an average of 78,000 coins before they become unserviceable.

Coining

There are six coining presses each driven by its own motor. The speed may be controlled so that the number of blows struck per minute can be varied from thirty to one hundred. The embossing of the blank is accomplished by subjecting it to pressure when placed in a collar between dies. The collar is fixed on the plate, or table, of the press; the dies work up and down through the collar. The pressure required to emboss a blank is from 15 to 35 tons.

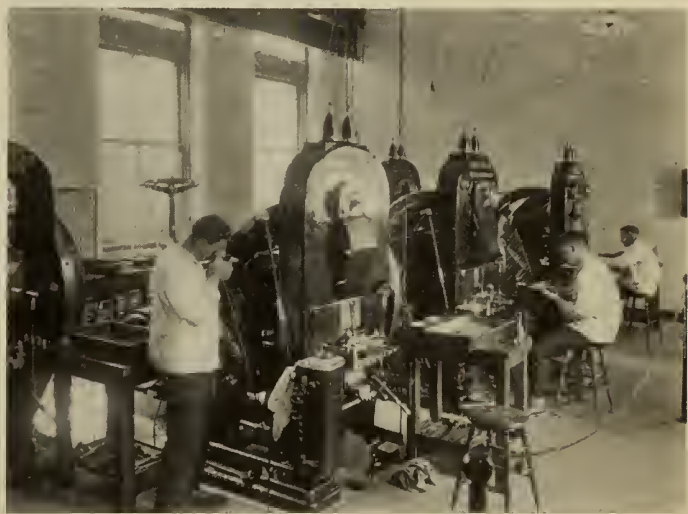

Fig. 5—The Coining Presses.

The blanks are placed in the feed tube of the press by the operator, and feeding fingers, at each stroke of the press, take a blank from the bottom of the tube and place it upon the bottom die, which is at this moment just level with the surface of the table; the bottom die then sinks to the centre of the collar, the blank resting upon it, and the top die, following down, strikes the blow, causing the imprisoned metal to squeeze out and fill all space available, thus taking the impressions of both dies and any markings placed on the inside of the collar (the milling in the case of ordinary gold and silver coins). The top die then rises and the bottom die follows, forcing the struck piece out of the collar, the feeding fingers advance, pushing the struck piece down the delivery tube at the back of the press, and placing another blank on the bottom die; the process is then repeated.

In the event of the fingers failing to carry a piece forward from the feeding tube, by an arrangement of levers, a driving clutch, between the fly-wheel and the main driving shaft, is released and the column carrying the top die is stopped instantly at its highest point, the fly-wheel continuing to run idle on the main shaft. The dies are thus prevented from "clashing," or striking each other, and being rendered useless.

Fig. 6—Automatic Weighing Machines.

The battery of six presses can strike an average of 200,000 pieces per day.

The finished coins are forwarded to the examining room, where they are subjected to various tests before delivery to the Mint Office for issue.

Testing

The coins are first "roll-sorted," that is, shaken up in trays into columns and the edges examined for burrs, cracks or notches; in the case of gold coins, and the fifty cent and twenty-five cent pieces, each piece is then weighed separately on an automatic weighing machine. The ten cent pieces are weighed against a standard dollar weight, while the five cent nickel pieces and the one cent bronze pieces are weighed against an avoirdupois pound.

The automatic weighing machines are very delicate instruments, the weighing being so accurate that the beam, when fully loaded, will turn to .01 of a grain. Each machine will weigh twenty coins per minute. The coins are fed into a hopper by the attendant. One coin is then pushed automatically on to a flat pan attached to one end of the beam, where it remains for three seconds; after which, it is pushed off by the succeeding coin. During the time it is resting on the pan, the beam is first released from, and then gripped by a pair of fingers, the position which the beam assumes during the interval, consequent upon the weight of the coin, determines which one of the three chutes it will drop into when it is pushed off. These chutes lead to three boxes; one for coins that are too light, a second for those that are too heavy, while a third receives those that are of the correct weight.

The last are taken to the overlooking machine, where they are spread on a travelling band and carefully examined. Any that are found discoloured, or otherwise imperfect, are picked out. The band travels on rollers, and, on reaching one end of the machine, the blanks are turned over automatically, so that the other side of the coin may be examined. The perfect coins are then "rung," or dropped singly upon an iron block to ascertain if they have the correct ring and to eliminate the "dumb," or cracked pieces.

Those coins which have been found to be light, or heavy, dumb, discoloured, or in any way imperfect, are destroyed in the defacing machine and remelted. The defacing machine is of a similar design to the marking machine but whereas the groove in the disc of the later is a plain one, that in the defacing machine is divided into a series of notches, so that the edges of the defective coins are notched all the way around.

The good coins are delivered to the Mint Office, where they are counted into bags by the telling machine. This machine automatically counts and delivers into bags any number of coins, as required. When the desired number has been delivered, the machine stops, until set in motion again by the movement of a lever.

The bags, each with a tag attached showing the denomination, weight and value of the contents, and sealed with a lead safety seal, are then placed in the stronghold ready for use.

The Trial of the Pyx

From each journey (720 ounces) of silver coin ready for issue, one piece is set apart, the pieces so taken without preference in the selection being placed in sealed packets. Once each year the Governor in Council, in terms of the Currency Act, nominates not less than three competent persons as Assay Commissioners and these meet as a Jury. After being sworn they have produced to them the packets containing the coins set apart, and they proceed to weigh and assay these, both individually and in bulk, in order to determine whether they are within the prescribed limits of weight and fineness, reporting their findings to the Minister of Finance.

The coins set apart are known in the Mint as the pyx, the "pyx" being originally the name given to a certain chest in Westminster Abbey in which such coins were placed. The Trial of the Pyx is a very old English ceremony and in England is conducted by a Jury selected from members of the Goldsmith's Company, one of the London Livery Companies. Both in England and in Canada the Trial is conducted quite independently of the Mint, and though in Ottawa the work may be carried out in the Mint laboratory, the balances and weights are supplied by the Department of National Revenue.

The Forty-Seventh Annual General and General Professional Meeting

to be held in Ottawa, February 7th and 8th, 1933

The Annual General Meeting for 1933 will be convened at Headquarters, 2050 Mansfield Street, Montreal, on Thursday, January 26th, 1933, at eight o'clock p.m.

After the transaction of formal business, the meeting will be adjourned to reconvene at the Chateau Laurier, Ottawa, at ten o'clock a.m., on Tuesday, February 7th, 1933, continuing with the Professional Sessions on the following day.

Programme of Meeting at Ottawa

(*Subject to minor changes*)

Tuesday, February 7th

9.00 a.m. *Registration.*

10.00 a.m. *Annual General Meeting.*
Reception and discussion of Reports from Council, Committees and Branches.
Discussion of recommendations of Committee on Development.

12.45 p.m. *Formal Luncheon:* Members, $1.25.
Local ladies, $1.00.
Complimentary to visiting ladies.
Welcome by the chairman of the Ottawa Branch (who will preside), and by His Worship the Mayor of Ottawa.
It is hoped that the members and ladies present will be addressed by Mr. E. W. Beatty, K.C., President, Canadian Pacific Railway, who will speak on the Railway Problem.

2.15 p.m. *Annual General Meeting* (continued).
Scrutineers' Report and election of Officers.
Retiring President's address.
Induction of new President.

4.30 p.m. Her Excellency the Countess of Bessborough has graciously consented to receive the visiting ladies at Government House.

7.00 p.m. *Annual Dinner of The Institute,* the President in the chair.
The Governor-General, His Excellency the Right Honourable the Earl of Bessborough, G.C.M.G., LL.D., Hon.M.E.I.C., has honoured The Institute by consenting to be present and address the members and ladies.

9.45 p.m. *Reception and Dance.*
Tickets for Dinner and Dance $2.50 per person.
Tickets for Dance only $1.00 per person.

Wednesday, February 8th

9.30 a.m. *Professional Sessions for the Presentation and Discussion of Papers.*

Room A. Chairman—G. G. Gale, M.E.I.C.
(1) *General Description of the Chats Falls Development, and Organization for Construction*—by T. H. Hogg, C.E., D.Eng., M.E.I.C.
(2) *Construction Features of the Chats Falls Development*—by H. L. Trotter, D.S.O., M.E.I.C., and Jas. Dick, A.M.E.I.C.
(3) *Electric and Hydraulic Tests at the Chats Falls Development*—by G. D. Floyd, B.Sc., and J. J. Traill, C.E., M.E.I.C.

Room B. Chairman—A. J. Grant, M.E.I.C.
(1) *The Illumination of the Welland Ship Canal*—by L. P. Rundle, B.S., M.E.I.C.
(2) *The Electrical Features of the Chats Falls Development*—by E. T. J. Brandon, B.A.Sc., A.M.E.I.C.

Room C. Chairman—G. J. Desbarats, C.M.G., M.E.I.C.
The Relations of Aeronautical Research to General Engineering—by Squadron-Leader Alan Ferrier, M.C., B.Sc., A.M.E.I.C.

12.45 p.m. *Luncheon:* Members $1.25.
Local ladies $1.00.
Complimentary to visiting ladies.
The Chairman of the Ottawa Branch will preside and an address will be given by a prominent speaker.

2.15 p.m. *Professional Sessions* (continued).

Room A. Chairman—F. A. Gaby, D.Sc., M.E.I.C.
(1) *The Hydraulic Design of the Chats Falls Development*—by Otto Holden, B.A.Sc., A.M.E.I.C.
(2) *Hydraulic Stability*—by A. W. F. McQueen, B.A.Sc., A.M.E.I.C.

Room B. Chairman—John Murphy, M.E.I.C.
(1) *The Trans-Canada Highway as an Unemployment Relief Measure*—by Jas. Sinton.
(2) *The Development of the Port of Churchill*—by D. W. McLachlan, B.Sc., M.E.I.C.

2.30 p.m. The Ladies will visit the Parliament Buildings—(Carillon Concert).

4.30 p.m. *Ladies tea* at the Chateau Laurier (complimentary to visiting ladies).

8.30 p.m. *Meeting in the Auditorium of the National Research Laboratories,* Sussex St., when a discourse on *Exploration for Ore by Magnetic and Electrical Methods,* illustrated by experiments, will be given by Dr. A. S. Eve and Dr. D. A. Keys, of the Department of Physics, McGill University.

9.15 p.m. Following the lecture, members and ladies are invited to visit the various laboratories of the National Research Council, *demonstrations* being arranged in the following among other branches of Engineering Physics:
Vibrations in Solids.
Glow Discharge.
Testing Heat Insulation.
Radium Measurements.
Standards of Light.
Radio Direction Finding and Interference.

Members of the Research Council Staff will be present in the laboratories and will be glad to explain the investigations which are being carried on.

Among these may be noted work on natural gas, asbestos, maple products, rubber, winter damage to textiles, colloids, adsorbent clay, honey and magnesite.

10.15 p.m. *Light refreshments will be served.*

The Ladies Committee is arranging for the entertainment of visiting ladies and a Ladies Programme will be issued.

Arrangements are being made for a conference of The Institute's Committee on Engineering Education, to be held on Wednesday, the 8th, at a time and place to be announced.

Hotel Arrangements. Members are recommended to make their reservations well in advance. The management of the Chateau Laurier will give the following rates (European Plan):—
Single rooms with bath $4.50, $5.00 and $6.00
Double rooms with bath $7.00
Do (twin beds) $8.00

THE
ENGINEERING JOURNAL
THE JOURNAL OF
THE ENGINEERING INSTITUTE
OF CANADA

VOLUME XVI JANUARY 1933 No. 1

The E.I.C. Engineering Catalogue—1932-33

The decision of the Council of The Engineering Institute of Canada to publish a catalogue of engineering equipment, materials and services has met with the general approval of the membership, as evidenced by a number of appreciative letters and an almost complete absence of criticism.

In undertaking the publication of this Catalogue, The Institute is definitely fulfilling one of its principal functions, the dissemination of engineering and technical knowledge, and is, indeed, enlarging a service which it has been rendering for some years in a somewhat different manner, in furnishing information to its members and those engaged in industrial and other engineering work throughout Canada.

The object of such a Catalogue is to provide in a single volume, for the use of those engaged in any branch of manufacturing or other engineering work, a list of the available sources of supply of the various types of equipment, materials, etc., which they may require, together with such data regarding these products as will assist the purchaser in determining that which is best suited to his requirements.

The Catalogue, which is now just off the press, is being distributed to those members who need it in their professional duties and who have sent in notifications to that effect, and also to those officers of important firms or organizations who can make use of its list of sources of supply and the technical information which it furnishes.

It is a book of over two hundred pages, and consists of three main sections as follows:

The Catalogue Section—contains data descriptive of the products of manufacturers; its importance to those called upon to design, specify or purchase such products is obvious.

The Index Section—or Products Index, contains some 1,800 subject headings intended to cover such equipment of an engineering nature and such materials or manufactured products as are likely to be required by industrial plants or contractors, or specified by engineers. Its entries deal with a wide variety of equipment, materials and products, ranging, for instance, from abrasive materials and bag filling machinery to ventilating systems and zinc. Under each products heading are given the names and locations of manufacturers of that particular item in Canada, Great Britain and the United States.

The third, or *Directory Section*—contains an alphabetical list of these manufacturers' names, with their full addresses, the names of their local representatives and the names of other firms which they represent, if any. The names of Canadian representatives of British and foreign manufacturers are also included. It will be noted that the Directory Section also contains the names of firms acting as sales representatives of manufacturers, with the names of their principals in each case.

The work of preparation has been for some months in the hands of a special staff working under the general direction of the Secretary and headed by N. E. D. Sheppard, A.M.E.I.C., as Managing Editor and H. G. Thompson, A.M.E.I.C., as Editor in charge of the compilation of data for the indices.

The work has involved correspondence with some three thousand firms, and it is believed that the result is the most complete and informative Engineering Index yet published in Canada, being, in fact, international in its scope and covering all principal branches of engineering work.

Recommendations of the Committee on Development

During the past two months the recommendations of the Committee on Development, as published in the October number of The Journal, have aroused widespread interest and discussion, as a result of which the committee has made several changes in its original recommendations so as to bring them in line with the expressions of opinion received. Among these changes may be mentioned the withdrawal of the proposed class of Fellows and the suggestion that for the first year the proposed increase in the annual fee payable by existing Associate Members who would become Members should be reduced by one half. These revised proposals have been considered by Council, but it has not yet been possible to place them before the membership.

It has been gratifying to Council to note the many letters, commenting on the Committee's proposals, which have been sent in by Branch Executive Committees and private members, and the reports of meetings which a number of Branches have held to consider the matter. All of these communications were submitted to Council at its last meeting, and after due discussion it was felt that the time available for study has as yet not been sufficient to warrant the proposal of any of the committee's recommendations as definite amendments to the By-laws. They will therefore not be voted upon during 1933, but will be brought forward for discussion at the Annual Meeting at Ottawa on February 7th. In this way a year's time will be available for their further development and consideration.

Results of November Examinations of the Institute

A further report from the Board of Examiners, presented to Council on December 16th, 1932, 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 C—*For Admission to Associate Membership:*

P. F. Gray.............Montreal, Que.
S. Hairsine.............St. Catharines, Ont.

Message From The President

December, 1932.

The New Year's message I desire to bring to my fellow members is one of congratulation on the maintenance, and indeed the enlargement - even under adverse conditions - of the Institute's activities. During the past year we have had to face the difficulties common to all organizations, but both at Headquarters and in the branches the work has gone on without interruption.

The immediate future holds much of interest and responsibility for the membership, especially in the proposals put forward for the development of the Institute organization on lines intended to enhance its usefulness. Institute and branch committees are dealing with unemployment, a problem of deep concern but which has not proved so widespread as was feared. The Annual Meeting will be held in February in Ottawa, and will fully maintain its reputation of providing technical sessions and other functions of interest to all.

We believe that the clouds are lifting, and that as the skies brighten every member will do his share in maintaining and increasing the effectiveness of the Institute as an organization in which local professional activities are co-ordinated for the benefit of the engineers of all branches of the profession.

With this prospect in view, I wish you all a prosperous New Year.

Charles Camsell

President.

Meeting of Council

A meeting of Council was held at Headquarters on Friday, December 16th, 1932, at eight o'clock p.m., with President Charles Camsell, M.E.I.C., in the chair, and ten other members of Council present.

Discussion took place as to the recommendations of the Committee on Development and that Committee's draft of amended by-laws, dated November 22nd, 1932, which had been circulated to all members of Council for consideration. The Secretary presented a number of letters received from members of Council and the executive committees of branches in regard to these proposals, and after further discussion it was resolved that the recommendations of the Committee on Development be not put forward at this time as proposals for the amendment of the by-laws, but be submitted to the Annual Meeting in February 1933 for discussion only.

The proposed by-laws of the Winnipeg Branch were approved, as was also an amendment suggested by the Lethbridge Branch to its by-laws.

A proposal from the Toronto Branch Executive Committee was considered suggesting the temporary lowering of the entrance fees, and it was decided to suggest that this matter be brought up for discussion at the Annual Meeting.

A proposal from the chairman of the Committee on Engineering Education to call a conference of this committee during the Annual Meeting was approved.

A. H. Harkness, M.E.I.C., was appointed as a second representative from The Institute upon the National Committee on Construction Recovery, J. B. Carswell, M.E.I.C., being the other representative.

The Secretary presented a report as to the progress made regarding the formation of Radio Sections, the names and addresses of those interested having been distributed to the secretaries of the various branches. It was noted with approval that a Radio Section had been formed by the Montreal Branch.

Twelve resignations were accepted, one reinstatement was effected, four Life Memberships were granted, and a number of special cases were considered.

A number of applications for admission and for transfer were considered, and the following elections and transfers were effected:

Elections		*Transfers*	
Member	1	Assoc. Member to Member	1
Assoc. Members	5	Student to Junior	1
Students admitted	5		

The Council rose at ten fifty-five p.m.

Forty-Seventh Annual Meeting

Chateau Laurier - Ottawa, Ont.

FEBRUARY 7th and 8th, 1933.

COMMITTEE of OTTAWA BRANCH

IN CHARGE OF ARRANGEMENTS

FOR

The Annual General Professional Meeting

Ottawa, February 7th and 8th, 1933

Dr. Charles Camsell, M.E.I.C.,
President,
The Engineering Institute
of Canada.

C. M. Pitts, A.M.E.I.C.,
Chairman,
Ottawa Branch.

O. S. Finnie, M.E.I.C.,
Chairman,
General Committee.

F. H. Peters, M.E.I.C.,
Councillor,
Ottawa Branch.

G. J. Desbarats, M.E.I.C.,
Past-Chairman,
Ottawa Branch.

Dr. R. W. Boyle, M.E.I.C.,
Chairman,
Committee in charge of Technical Events.

J. L. Rannie, M.E.I.C.,
Associate Chairman,
General Committee.

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

John Murphy, M.E.I.C.,
Chairman,
Reception Committee.

L. L. Bolton, M.E.I.C.,
Chairman,
Finance Committee.

Commander C. P. Edwards,
A.M.E.I.C., Chairman,
Committee in charge of Entertainment and Excursions.

J. McLeish, M.E.I.C.,
Chairman,
Papers Committee.

W. H. Norrish, A.M.E.I.C.,
Chairman,
Publicity Committee.

P. Sherrin, A.M.E.I.C.,
Chairman,
Registration Committee.

A. E. MacRae, A.M.E.I.C.,
Chairman,
Committee in charge of Hotel Arrangements.

OBITUARIES

Frank Matthew Preston, A.M.E.I.C.

Widespread regret will be felt at the death of Frank Matthew Preston, A.M.E.I.C., which occurred suddenly on December 2nd, 1932, at Victoria, B.C.

Mr. Preston was born at Penzance, England, on January 31st, 1881, and was educated at Rugby. He entered the Armstrong Engineering College, Newcastle, in 1897, and became a pupil of H. A. Johnson, M.Inst.C.E., Bradford, England, in 1901.

During the years 1904-1910, Mr. Preston was chief assistant to Mr. Johnson on the design of works for sewerage, sewage disposal and water supply, being resident engineer on sewerage schemes in 1910-1911. Coming to Canada, he became assistant to the city engineer of New Westminster, B.C., remaining in that position until 1913, when he was attached to the city engineer's office, Victoria, B.C. In 1918 Mr. Preston was appointed city engineer of Victoria. Among the major works conducted under his direction were the building of the Johnson street bridge and the improvement of the city's waterworks system; at the time of his death Mr. Preston had just recently seen the successful completion of the largest waterworks improvements undertaken during his service with the city of Victoria.

Mr. Preston was an Associate Member of the Institution of Civil Engineers, and belonged to the Geological Society of London and the Royal Meteorological Society.

Joining The Institute as an Associate Member on October 14th, 1913, Mr. Preston took a keen interest in its activities, and represented the Victoria Branch on Council in 1930.

Arthur Charles Tagge, M.E.I.C.

It is with deep regret that we record the death of Arthur Charles Tagge, M.E.I.C., which occurred at Monroe, Mich., on December 6th, 1932.

Mr. Tagge was born at Ann Arbor, Mich., on January 31st, 1870, and graduated from the University of Michigan with the degree of B.S. (E.E.) in 1897. Following graduation he was for a year draughtsman with the Link-Belt Machinery Company, and in 1900 joined the staff of the Osborne Engineering Company, Cleveland, as draughtsman, becoming resident engineer for that company on the construction of a plant for the Peninsular Portland Cement Company at Jackson, Mich., and being appointed superintendent of the plant in 1902. In 1903-1904 Mr. Tagge was engineer for the International Portland Cement Company, Ltd., engaged on the design and construction of a plant at Hull, Que. Returning to the United States in 1905, he was engineer for the Arnold Company, Chicago, working on the design and construction of reinforced concrete railway shops and roundhouses. In 1906 Mr. Tagge joined the Western Canada Cement and Coal Company Ltd., as engineer and local manager, and was responsible for the design and construction of the cement mill at Exshaw, Alta.; in 1908 he was again with the International Portland Cement Company Ltd. In 1909 he was for a short time engineer for the Eastern Canada Cement Company Ltd., and in the same year became general superintendent and chief engineer for the Canada Cement Company Ltd., holding this position until 1916, when he was appointed assistant general manager. Mr. Tagge subsequently became vice-president and general manager, and in 1927 assumed the post of president. He retired in 1930, and made his home in Monroe, Mich.

Mr. Tagge was a Member of the American Society of Mechanical Engineers and the American Society for Testing Materials. He joined The Institute as a Member on May 17th, 1916, and though he never served on Council, took an active interest in committee work, where his sound judgment and technical knowledge were of great service. His loss will be deplored by all who knew him, either personally or professionally.

William Stanley Vipond

Members of The Institute will learn with regret of the untimely death of William Stanley Vipond, which occurred at Montreal on December 1st, 1932.

Born at Montreal on April 30th, 1887, Mr. Vipond graduated from McGill in 1908, with the degrees of B.Sc. and M.Sc. The following year he took a post graduate course and acted as demonstrator at the same university. From July 1909 to 1914 Mr. Vipond was in charge of the engineering department of the Wire and Cable Company, and in November, 1915, joined the staff of the Northern Electric Company as assistant chief engineer. In April, 1919, he became chief wire and cable engineer for the same company, holding that position for a number of years, until he was appointed wire and cable sales manager.

Mr. Vipond was for some years a Member of The Institute, having joined on April 24th, 1923.

PERSONALS

Lieut-Colonel Arthur C. Macdonald, M.E.I.C., of Macdonald, Gibbs and Company, Engineers Limited, London, England, is at present in Bhopal, India.

F. M. Pratt, M.E.I.C., has joined the staff of the Anglo Newfoundland Development Company Ltd., and is now located at Grand Falls, Newfoundland. Mr. Pratt graduated from the University of Toronto in 1912 with the degree of B.A.Sc., and in 1912-1913 was resident engineer for the E. B. Eddy Company Ltd., Hull, Que., on the construction of a ground wood mill and power plant. In 1914-1915 he was resident engineer for the company on the design and carrying out of alterations and additions to machinery and buildings. During the years 1916-1919 Mr. Pratt was on overseas service with the 7th Field Company, Canadian Engineers and the 7th Battalion, Canadian Engineers, having the rank of Captain. Returning to Canada in 1920, Mr. Pratt rejoined the E. B. Eddy Company, Ltd., as construction engineer, and in 1925 was appointed chief engineer of the same company.

G. Lorne Wiggs, A.M.E.I.C., has resumed private practice as a consulting engineer and is located in the University Tower building, Montreal. Mr. Wiggs, who was formerly manager of the Montreal Sales Office of the C. A. Dunham Company, Ltd., graduated from McGill University in 1921 with the degree of B.Sc. He was later engaged on test work with the Canadian Westinghouse Company at Hamilton, Ont., subsequently becoming sales engineer with the Canadian Crocker Wheeler Company. During 1922-1923, Mr. Wiggs was sales engineer with the Mechanics Supply Company, Que., and in 1923 was for three months with the C. A. Dunham Company Ltd., at Chicago, Ill., on heating design work. From 1924 to 1929 Mr. Wiggs was manager of the engineering department of the Mechanics Supply Company at Quebec, being in charge of all designs, plan work, etc., in that department. In June, 1929, he entered private practice in Montreal as a consulting engineer on the mechanical and electrical equipment of buildings.

ELECTIONS AND TRANSFERS

At the meeting of Council held on December 16th, 1932, the following elections and transfers were effected:

Member

LAMBERT, Zephirin, C.E., (Montreal Univ. Polytech.), City Engineer, Three Rivers, Que.

Associate Members

BROOKS, John Kenneth, (A.M.Inst.C.E.), engr., Brodrick Contractors Ltd., West Saint John, N.B.

CRYER, Edward, engr. and bldg. inspr.,Town of Hampstead, Que.

*GRAY, Peter F., Edward Charles Street, Montreal, Que.

*HAIRSINE, Sydney, elect'l. inspr., Welland Ship Canal, St. Catharines Ont.

HEWSON, Joseph Seldon, B.Sc., (N.S.Tech. Coll.), L. G. Ogilvie & Company, Limited, Montreal, Que.

Transferred from the class of Associate Member to that of Member

JACKSON, John Herbert, general manager, Niagara Parks Commission, Niagara Falls, Ont.

Transferred from the class of Student to that of Junior

GRAVEL, Louis Philippe, B.A.Sc., C.E., (Ecole Polytech.), dept. of bridges, Dept. Public Works of Quebec, Beauport, Que.

Students admitted

MILLER, Lindsay, (McGill Univ.), 4073 Hampton Ave., Montreal Que.

MOORES, Robert V., (N.S. Tech. Coll.), 362 Robie Street, Halifax, N.S.

PETERSEN, William Edgar, B.Sc., (Univ. of N.B.), 59 Dufferin Ave., Saint John, N.B.

SHANKS, Victor, (Univ. of Toronto), 2 Le Roy Ave., Toronto, Ont.

TOY, Edwin Ledentu, B.Sc., (Univ. of N.B.), St. George, N.B.

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*Has passed Institute's examinations.

RECENT ADDITIONS TO THE LIBRARY

Proceedings, Transactions, etc.

American Institute of Electrical Engineers: Quarterly Transactions Vol. 51, No. 3, September, 1932.

The Institution of Electrical Engineers: Bye-Laws (Reprinted, 1932).

American Society for Testing Materials: A.S.T.M. Tentative Standards, 1932.

The Association of Professional Engineers of the Province of British Columbia: Comparison of Engineering Acts and the By-Laws of the Associations of Professional Engineers Throughout the Dominion of Canada, August, 1931.

British Standards Institution: Indexed List of British Standard Specifications; Annual Report, July, 1932.

Reports, etc.

Department of Marine, Hydrographic Service, Canada:
Tide Tables for the Pacific Coast of Canada for the year 1933.
Tide Tables for the Atlantic Coast of Canada for the year 1933.

Department of Mines, Mines Branch, Canada:
Feldspar.

Technical Books, etc., Received

Acoustics and Architecture, by Paul E. Sabine, 1932. *Presented by McGraw-Hill Book Company.*

The Early Years of Modern Civil Engineering, by R. S. Kirby and P. G. Laurson, 1932. *Presented by Yale University Press.*

Organizations in the Field of Public Administration: A Directory, 1932. *Presented by Public Administration Clearing House, Chicago.*

The Sanitation of Water Supplies, by Murray P. Horwood, 1932. *Presented by Charles C. Thomas [Publisher].*

Tramways: Their Construction and Working, by D. Kinnear Clark. 1878.

Water Supply of Cities and Towns, by William Humber, 1876.

Map of the Country to be Traversed by the Canadian Pacific Railway, 1876.

[Framed photograph.] The President and Council of the Canadian Society of Civil Engineers, 1887. *Presented by Alan C. Macdougall.*

American Welding Society:
[Manual of] Thermit Welding, 1927.
[Manual of] Gas Welding and Cutting. Revised 1929.
[Manual of] Resistance Welding, 1927.
Code for Fusion Welding and Gas Cutting in Building Construction, 1930.
Welding and Cutting: Nomenclature, Definitions and Symbols, 1929.

American Bureau of Welding: Report of Structural Steel Welding Committee, Sept. 1931.

American Bureau of Welding and American Electric Railway Engineering Association. Final Report of the Committee on Welded Rail Joints, 1932. *Purchased.*

BOOK REVIEWS

Metallurgy

By Edwin Gregory. Blackie & Son, London, 1932, cloth, 6 x 9 in., 284 pp., photos, figs., tables, $5.25.

Reviewed by Harold J. Roast, M.E.I.C.*

This book, as stated in the author's preface, is written primarily for engineers. In the reviewer's opinion, it is the best presentation of Metallurgy for the engineer that has yet been published. Within a limited compass it contains such fundamental, practical, and definite information relating to metals and their application as to be of real value. The book is free from "padding," and the treatment is thoroughly up to date, as is evidenced by the discussions on the high frequency electric furnace on page 48, that on "creep" on page 184, and on stainless steels in Chapter VI.

Chapter II shows in many little details the author's practical experience with steel making. The whole of Chapter III, dealing with the fundamentals underlying metal life and activity, is clear in its explanations of equilibrium diagrams, and of such terms as "orientation," "dendrites," etc. The chapter on special steels is full of information. The reference to "temper brittleness" on page 131 is illuminating and concise, while in referring to the treatment of high-speed steels definite temperatures for quenching and drawing back are furnished, as on page 152, paragraph 2, instead of giving such a statement as ". . . heat above the upper critical point and draw back to a suitable temper . . ."; this definiteness is characteristic of the information given throughout the book. The photomicrograph in Fig. 135 is the clearest example of weld history that the reviewer has met with, and, tied up with the text relative to the danger temperatures for 18/8 steels, should be most useful to engineers or metallurgists involved in the troubles encountered when such steels are used in the pulp and paper industry.

The photomicrographs throughout the book are of a high order, a fact which is the more pleasing in view of the many examples of poor technique that have been published recently.

The part of the volume dealing with non-ferrous metallurgy is as valuable as that dealing with the ferrous division, and the brief matter relating to the so called "white metals" and bearing metals is informative so far as it goes.

The excellent typography and general set up of the book make it pleasant and easy reading.

The index, while of the average standard, could be considerably amplified with advantage to the reader, if in a hurry to find specific information. Abbreviation of the index is a common failing in engineering books and it is a pity that authors and publishers of technical works do not pay more attention to this feature. Mr. Gregory's book will be found a valuable addition to the library of anyone using or interested in metals.

**Lecturer in charge of Metallography, Dept. of Metallurgy, McGill University, Montreal, Que.*

Dielectric Phenomena

Vol. 3: Breakdown of Solid Dielectrics

By S. Whitehead. Ernest Benn, Ltd., London, 1932, leatherette, 346 pp., 5½ x 8¾ in., figs. tables, 30/- net.

Reviewed by J. R. Dunbar, A.M.E.I.C.*

This volume is the third in a series being prepared by the British Electrical and Allied Industries Research Association giving a critical résumé of available information on the subject of dielectric phenomena, with particular attention to the theoretical basis. The present volume deals with breakdown of solid dielectrics. The first nine chapters set forth the experimental results as reported by different writers together with empirical rules which have been derived from the experimental data. A certain amount of previously unpublished experimental work is presented for the first time.

The matter is segregated under the following chapter headings:

In Chapter X the author gives a critical résumé of a number of theories of the breakdown of solid dielectrics which are considered in the light of the facts detailed in the earlier chapters. The theoretical matter given is grouped under the following general headings:

(a) Introduction.
(b) Conductivity, Anomalous Properties and Energy Losses.
(c) Thermal Theories (including thermal-electric theories).
(d) Ionic Theories, dealing with ionization effects.
(e) Theories based on Breakdown through Rupture in Electric Field.

In an appendix is given the mathematical treatments of a number of the theories presented in the main part of the volume.

An extensive bibliography of recent articles is included.

This volume includes a résumé of and references to practically all the experimental work which has been done in connection with the breakdown of solid dielectrics and sets forth practically all the theories which have been advanced to account for the observed phenomena. No attempt has been made to include specific information regarding the breakdown of definite insulating materials with a view to assisting engineers to choose suitable insulation for use in electrical machinery. All research workers who are studying the breakdown of solid dielectrics should have this work for reference. It should prove of great value both to research workers and to students in the field it covers.

Canadian Westinghouse Co., Hamilton, Ont.

Acoustics and Architecture

By Paul E. Sabine. McGraw-Hill, New York, 1932, cloth, 6 x 9 in., 327 pp., figs., tables, $3.50.

Reviewed by A. J. C. Paine, A.M.E.I.C.*

In his recent book, "Acoustics and Architecture," Dr. Sabine describes fully and clearly the basic principles of sound resonance and sound absorption as applied to enclosed spaces. He also records at length the results of many years of experimental research conducted in the Riverbank Laboratories, Illinois, and elsewhere, on the measurements and plotting of sound waves within walls, and upon the sound absorbing properties of materials used in acoustical correction.

The text of the book may be divided into two parts, the first dealing principally with the theory of acoustics, and the second with the design of auditoria in relation to satisfactory acoustical properties, and also with the safeguarding of the occupants of "special purpose" buildings against disturbing noises.

Introducing his subject with an historical sketch of acoustics as a branch of physics, the author refers to research work conducted by Professor Wallace Sabine at Harvard University at the beginning of the century as being the first attempt to treat the subject of acoustical correction of auditoria in a scientific and practical manner. From the foundation then laid more recent investigators have been enabled to raise the subject from the realms of "opinion and guess work" to that of a fully qualified application of scientific principles, by which the designing of an auditorium to give predetermined results becomes a question of calculations of obedience to the laws governing sound reverberation, and of a judicious selection of sound absorbing materials in the fabrication.

The section of the book on the theory of acoustics contains chapters on The Nature and Properties of Sound; Sustained Sound in an Inclosure; Reverberation—Theoretical.

The practical application of the theory is covered by chapters on Experimental Reverberation; Measurements of Sound Absorption; Sound Absorption Coefficients of Materials; Reverberation and the Acoustics of Rooms; Acoustics in Auditorium Design.

In the last-mentioned chapter the treatment of many modern buildings for satisfactory acoustics is described in detail. Special note is made of acoustical design in churches, recent examples described being the Chapel of the University of Chicago, and the Riverside Church, New York.

Descriptive chapters are included on the Measurement and Control of Noise in Buildings, examples being given of hospitals and office buildings; Theory and Measurement of Sound Transmission; Transmission of Sound by Walls; Machine Isolation in Buildings.

The appendices contain complete information in tabular form of the absorption properties of all well-known building materials, as well as other useful information on the intensity of noises, etc.

Both as a text book for the student and as a reference book for the architect and engineer, "Acoustics and Architecture" should be of great value.

Staff Architect, Sun Life Assurance Co. of Canada, Montreal, Que.

The Garlock Packing Company, Montreal, Que., announces Garlock 660, an entirely new sheet packing for gasoline, oil and water. This product is produced by a new process which combines granulated cork with tough paper fibre into an ideal gasket material. Patent has been applied for. Garlock 660 is soft enough to seal flanges or joints which may be imperfectly machined or in poor condition, and tough enough to permit its use in paper thicknesses on installations requiring very thin gaskets. It will not, it is stated, shrink, crack, curl or become brittle in stock. It is manufactured in all standard thicknesses from .010 inch to ½ inch. In thicknesses less than ⅛ inch it can be supplied in rolls 36 inches wide, or in sheets. In ⅛ inch and greater in thickness it is furnished in sheets 36 inches square. Gaskets cut from Garlock 660 sheets are styled Garlock 661. They are furnished in any size, shape or quantity to specifications.

Notes on the Tenth Annual Exposition of Power and Mechanical Engineering in New York

The tenth annual National Exposition of Power and Mechanical Engineering was held in the Grand Central Palace during the week of December 5th. In general the booths of 300 manufacturers bore out their assertions that their engineers have been busy while orders were scarce, making such improvements in design that much of the existing plant machinery of the country is now out of date.

In addition to much apparatus of interest to engineers responsible for generation, distribution, and utilization of electric power, steam, water, compressed air, and oil there were many exhibits of machine tools, products and methods.

Among the technological developments of the last year revealed to the public for the first time was copper in sheets as thin as paper, and a new alloy of beryllium and copper. These were developed by the American Brass Company. The paper-thin sheets are made possible through an improvement in the electrolytic process of depositing copper. The new alloy contains from 1 to 2¼ per cent of beryllium, and has an elastic limit which rises to 170,000 pounds per square inch. It resists abrasion and fatigue and does not corrode.

The Babcock and Wilcox Company had on display a mercury-vapour generator tube for a mercury boiler. They also exhibited a boiler drum with an integral head having no circumferential seam, and some specimens of seamless alloy tubes welded by the same process as will be used for 50,000 tons of plate steel pipe for the Hoover Dam. This company also featured a grindability testing machine which provides an index of mill capacity with different coals.

The Superheater Company exhibited a model of a new type of superheater applicable to return-tubular boilers. This superheater consists of tubular elements of steel extending around and close to the lower half of the horizontal-return-tubular boiler shell in semi-circular form, so that the superheating surface is exposed directly to the furnace heat after it passes the bridge wall. The tubes are connected by metal-to-metal ground joints to special cast-steel headers suspended one on each side of the boiler shell. Saturated steam enters one end and superheated steam leaves the other.

The M. W. Kellogg Company featured corrugated pipe bends and tangents. The flexibility of corrugated bends is from four to five times that of plain pipe bends of the same overall dimensions. In making the corrugations the metal on the outer part of the corrugations is upset to such an extent that in figuring the required wall thickness for a given pressure, no attention need be paid to the increased outside diameter due to the corrugation. Corrugated bends can be pulled on radii as small as one and one half nominal pipe diameters.

The Crane Company exhibited a complete line of welding fittings and flanges. These fittings are machine tool beveled at an angle of 45 degrees, with a flat surface left at the inner circumference approximately 1/16th of an inch wide, in order to facilitate weld depth penetration and to provide accuracy in lining up preparatory to welding. Seamless welding elbows and return bends can be obtained in any of the special alloys which can be obtained in seamless tubing regularly made to iron pipe dimensions and metal thickness, provided such alloys have physical properties suitable for fabrication.

The Chapman Valve Manufacturing Co. displayed a 6-inch, 600-pound gate valve with welding ends; a new valve known as the tilting disc valve and applicable to check valve and stop valves; a lubricated plug cock in which the plug is lifted by a threaded stem, just as in a gate valve (when sufficiently lifted to gain clearance the plug is rotated and a grease seal established between the plug and the body); a full way stop and check valve of the cone type designed primarily for use where head loss is the important factor.

The Cochrane Corporation exhibited a new pilot valve for the accurate control of fluid under high pressure and other specialties for boiler and steam turbine plants using high pressure steam.

The Walworth Company featured a lubricated plug valve in which the lubricating grooves are in the body of the valve and not in the plug. These valves are available in all types and sizes and are suitable for air, water, gasoline, steam, gases, chemicals, hot oils, hot tars, etc.

The Builders' Iron Foundry exhibited a chronoflow Venturi meter which transmits its record over an ordinary telephone wire without interfering with a conversation. This meter enables central offices to keep informed of production rates regardless of distance. One such meter was shown which will record the flow in the new Catskill aqueduct which will run to billions of gallons daily.

The Brown Instrument Company exhibited a mechanical flow meter for indicating, recording and integrating. This meter has six different ranges so that it is always possible to select the proper orifice ratio and eliminates changing the size of the orifice in the flow line. In addition, the differential range of the meter can be changed at any time by the substitution of an interchangeable range tube in the mercury manometer. Also on display was an area-type flow meter in which the head, or pressure drop across the orifice is held constant while the size of the orifice is varied. The transfer of the motion of the piston to the recording or indicating meter is accomplished by the use of the inductance bridge principle.

The Bailey Meter Company displayed their rate-of-flow type meters for measuring steam, water, gases and other fluids. In this meter the flow mechanism is operated by the difference in pressure produced between the inlet side and the outlet side of the orifice or other primary element inserted in the flow line. The inlet or high pressure side is connected to the interior of the mercury-sealed Ledoux bell, and the outlet or lower pressure is applied to the exterior of the bell. This bell responds to changes in differential pressure and moves up or down as frictionless piston, it being shaped so that its vertical movement is directly proportional to the change in the rate of flow. By means of a forked lever and spindle, motion of the Ledoux bell is transmitted directly to the recording pen and integrator.

The Sterling Engine Company had on exhibition a 45-kilowatt generator of 1,200 r.p.m. driven by a Sterling Petrel engine, 6 cylinders, 115 horsepower, to be used on the Troy-Menanda bridge.

The Dampney Company of America exhibited samples of seamless tubing during the various stages of sand-blasting and cleaning prior to Apexiorizing, Apexior being a rust-proofing and corrosion-resisting material that replaces steel as the wearing surface, the process to be used for the internal surfaces of boilers, economizers, turbines, etc.

The Sarco Company featured a temperature regulator for brine control in refrigeration. This regulator consists of a thermostat tube filled with a special hydro-carbon oil. When the large volume of oil in the tube expands on being heated, a pressure is transmitted through a flexible connecting tube to a plunger cylinder which actuates the regulator valve. This allows more brine to flow through the cooling coil, thereby lowering the temperature. Gradually the valve assumes a throttling position, maintaining accurately the temperature desired.

The American Car and Foundry Co. exhibited an application of the photoelectric cell, or "electric eye," which responds to radiant heat in an electric heater for forgings. In this machine the electric eye automatically passes the heated billet along to the forger when it reaches the proper temperature. This eliminates overheating which weakens the metal, and underheating, which breaks the die.

The American Blower Company had on display an hydraulic coupling for variable speed fan drive. This type of coupling is applicable to installations using a constant speed squirrel cage motor as the driver, and functions as a direct driving medium between the motor and the fan. It is applied where a graduated speed variation is desired, as in mechanical draught installations in power plants where definite and convenient control of fan speed is essential. A speed range of from 20 per cent to 98 per cent of that of the driver is obtainable in the driven shaft.

The Riley Stoker Company displayed a complete cross-sectional scale model of a Badenhauser boiler installation, showing the furnace, coal feeders, pulverizers, chimney, forced and induced draught fans, economizer, air heater, and the various operating and access floors.

The General Electric Company exhibited a single-stage non-condensing steam turbine designed to drive pumps, fans, compressors, pulverizers and similar apparatus. Also a combination gear-motor which is cheaper and more efficient than a separate motor and reducing gear. They also exhibited an electrically controlled centrifugal air blower with full automatic control to supply a constant weight of air to iron foundry cupolas irrespective of atmospheric conditions or the resistance of the furnace. This does away with rule-of-thumb methods used by veteran foundry men who judged by the colour of the flames or sparks when it was time to shut off the air.

The Cutter Company have adapted the use of silver-plated main contact points on their air circuit breakers, the purpose being to reduce the millivoltage drop across the contacts when the breaker is in the closed position. The main contacts of the breaker being laminated, insure perfect electrical contact by a wiping action. When opening, the main contacts are protected from damage (due to arcing) by two sets of auxiliary contacts. The first auxilliary contacts to break are of copper, the second auxiliary contacts (composed of a carbon composition) breaking last are the ones across which the arc flashes. This action by the two sets of auxiliary contacts protects the main contacts from any serious damage by arcing or gases caused by opening the circuit breaker under load.

Trevithick Centenary Commemoration

The steam engines in the Eighteenth Century applying the steam-vacuum principle invented by Newcomen and modified by James Watt, condensed their steam which was supplied to the cylinder at a pressure rarely exceeding four or five pounds per square inch. Towards the end of the century, a Cornishman, Richard Trevithick, born in 1771, was bold enough to simplify the engine by increasing the steam pressure and dispensing with the condenser, so that by 1802 he had produced quite small portable engines of the same power as the large fixed engines of his predecessors. This use of higher pressures made it possible to apply the steam engine to land transport, and it was Trevithick who designed and built the first practical steam road carriage (1801) and the first railway locomotive (1804.) He also applied his engine to deep mine pumping, dredging and threshing wheat.

In April, 1933, the centenary of Trevithick's death will occur, and it is planned to hold in England a commemoration of an international character, with a memorial service in Westminster Abbey, the delivery of a memorial lecture, and the publication of a memorial volume. This commemoration will be supported by the Institution of Civil Engineers, the Institution of Mechanical Engineers, the Institution of Electrical Engineers and by a large number of other engineering societies in England and abroad.

BRANCH NEWS

Calgary Branch

H. W. Tooker, A.M.E.I.C., Secretary-Treasurer.
J. A. Spreckley, A.M.E.I.C., Branch News Editor.

Development Report

About thirty members assembled at the Board of Trade rooms on November 17th, 1932, and the evening was devoted to an informal discussion of the Report and Memorandum on Institute Development. The subject was introduced by the chairman, Lt.-Colonel F. M. Steel, M.E.I.C., and S. G. Coultis, M.E.I.C., explained some of the proposals, asking for expressions of opinion for the guidance of the Policy Committee.

Opinion was divided on the advisability of making any changes in the present classification of corporate members, and one of the senior members expressed the gratification he had felt as a young man in being promoted from one stage to another. Others felt that the close restriction in the proposed number of fellows would be a discouragement to some deserving recognition.

There was a fear indicated that an increase in the fees now paid by Associate Members might precipitate resignations and so defeat the object of increasing the revenue and prestige of The Institute. An ex-councillor made a practical and constructive suggestion that The Institute be governed by the President and officers with the aid of one Vice-President for each province. It appeared that such an arrangement would be consistent with the spirit of the memorandum and also save expenses.

Much interest was shown in the desire to safeguard the efficiency of The Institute and appreciation was expressed in the care which had been devoted to the preparation of the advance data for the information of the members.

Annual Ball

Since 1927 the leading social event of the Branch has been a ball at the Palliser hotel, and the entertainment of December 2nd, 1932, was no exception in the amount of enjoyment afforded the one hundred and twenty members and friends who were able to attend. The guests were received by Mrs. F. M. Steel, Mrs. B. Russell and Mrs. H. J. McLean and included members of the Maurice Colbourne-Barry Jones company.

The arrangements were in the capable hands of a special committee consisting of Lt.-Colonel F. M. Steel, M.E.I.C. (chairman), and Messrs. A. W. P. Lowrie, A.M.E.I.C., G. P. F. Boese, A.M.E.I.C., M. W. Jennings, A.M.E.I.C., R. S. Trowsdale, A.M.E.I.C., H. J. McLean, A.M.E.I.C., F. G. Bird, A.M.E.I.C., R. C. Harris, M.E.I.C., and H. W. Tooker, A.M.E.I.C. (secretary-treasurer).

The main dining room was brilliantly illuminated for dancing and a substantial supper was served in appropriate surroundings with all the refinements that engineers enjoy in contrast to some of their experiences in the field. Many opportunities were taken to renew old acquaintanceship and dismiss the problems of to-day in the light of western history and optimism.

Halifax Branch

R. R. Murray, A.M.E.I.C., Secretary-Treasurer.
W. J. DeWolfe, A.M.E.I.C., Branch News Editor.

The November meeting of the Halifax Branch was held at the Nova Scotian hotel on the evening of November 17th. The meeting was preceded by a supper, and was presided over by A. F. Dyer, A.M.E.I.C., chairman of the Branch. On the completion of the regular business, H. S. Johnston, M.E.I.C., introduced C. H. Wright, M.E.I.C., the speaker of the evening, whose subject was "The St. Lawrence Waterway Project."

Mr. Johnston made some reference to recent comments in the United States on the waterway and Mr. Wright, before proceeding to his address paid his respects to Mr. Ten Eyck, of Albany, and his reported suggestion that certain portions of eastern Canada might well be ceded to the United States in exchange for the cancellation of Great Britain's war debts.

The St. Lawrence Waterway Project

The speaker pointed out that when Jacques Cartier, in October, 1535, had to leave the "Emerillon" at Lac St. Pierre on account of sandbars, he uncovered the problem of the deepening of the St. Lawrence, which remains with us to this day, over a period of 400 years.

Among the early French administrators, Dollier de Casson, the Superior of the Sulpician Order, Montreal, undertook to build the first Lachine canal in 1700, the depth of water in which was to be at least a foot and a half. He put enormous effort and all available money into the enterprise, which he was not able to complete.

The first canal at Sault Ste. Marie was built by the Northwest Company in 1798, and was 2,580 feet in length "with a raised bridge or pathway of round logs at the side of it, 12 feet wide, for oxen to track the boats."

The Great Lakes, said Mr. Wright, form the largest body of fresh water in the world. The St. Lawrence has the greatest average flow of any river in North America. As this system runs up from Montreal, over 1,300 miles to Duluth, and forming as it does, in part, the International Boundary, it has been the subject of successive treaties, some of which are in force, the last one now being debated before a committee of the United States Senate.

Some important features of the present treaty were discussed, particularly the question of the meaning of the word "free" as referring to canals, the application of tolls, the bringing of Lake Michigan under the jurisdiction of an International body, and the controlling of the abstraction of water at Chicago from that lake.

The speaker believed that whether the treaty is passed or not at this time, it will form the basis of all future discussions, and the project is likely to be completed, generally along the lines now discussed.

As regards the economics of the undertaking, Mr. Wright remarked that the prospective savings on transportation of grain have, in many cases, been greatly exaggerated.

The effect on the Maritime Provinces was discussed. It was pointed out that possibly the only commodity that would be affected directly was coal, from Sydney. Charts were used to show how the deepened St. Lawrence Waterways might improve the access of Sydney coal to Ontario markets. At the same time, there would be a similar advantage given to European coal that would come across the Atlantic on tramps that might go right to the head of the lakes.

In the speaker's opinion the final development of 5,000,000 horsepower along the St. Lawrence, with much more power adjacent, would give rise to a thickly populated manufacturing district. This might involve a change in Canada's whole economic structure, and her fiscal policies, but such a change would take place so gradually that the country would be able to accommodate itself to changing conditions in North America and throughout the world.

The address was heard with great interest by the one hundred and fifty or more members and visitors present, and active discussion followed.

Mr. F. C. Cornell, traffic manager of the Halifax Harbour Commission, dealt with traffic development as affecting Halifax and the Maritimes, which can readily be increased when, and if, necessary.

Colonel A. N. Jones, president of the Halifax Board of Trade, directed his remarks to the cost, present financial condition of Canada, and possible bad effects from competition with our railways.

Professor R. A. MacKay, professor of international law, Dalhousie University, commented on the structure of the treaty and the guarantees necessary to protect the Empire during war time.

The Rev. Clarence McKinnon, D.D., the Rev. Dean Lloyd, D.D., and other speakers expressed their pleasure at being present and congratulated Mr. Wright on his address.

A very hearty vote of thanks was tendered to Mr. Wright, after which the chair was resumed by Mr. Dyer, who brought to a close one of the most interesting and best attended gatherings in the history of the Branch.

Lethbridge Branch

E. A. Lawrence, S.E.I.C., Secretary-Treasurer.
R. B. McKenzie, S.E.I.C., Branch News Editor.

The Lethbridge Branch of The Institute met on November 12th for the regular meeting. An excellent dinner and musical programme were enjoyed, after which J. T. Watson, A.M.E.I.C., introduced the speaker, Mr. J. E. Theobald, city electrician.

Transmission Lines and Distribution

Mr. Theobald opened his talk by stating that it was now fifty years since the first electrical power plant was installed in New York city by Thomas Edison, and gave quotations illustrating the difficulties encountered in the production and distribution of power from that plant.

He spoke next of transmission lines and quoted the carrying capacity of wire at various voltages to show the reason for elevated voltages on long distance lines. He spoke of copper and aluminum wire and the relative advantages of each, of the sag, and of the various types and uses of insulators. For the transmission of power to the substation he said that it is usual to have two paths for the power, either by the ring feeder system or by two lines as in the city of Lethbridge, in order that service may not be interrupted in emergency.

Mr. Theobald then showed the method of distribution by tracing the path of power from the generators in the power plant, through the substation, feeder lines, street lines and so on to the ultimate consumer in the city. He also mentioned the method of connecting with the hydro power and described some of the devices in use on the lines. Some remarks on the street lighting system closed the talk.

Mr. Arthur Reid, former city commissioner, was present, and he started a round of anecdotes on the troubles of the first city electric light plant that added much to the interest of the evening. A hearty vote of thanks was moved to the speaker, and the meeting closed with the singing of the National anthem.

The members of the Lethbridge Branch of The Institute met on November 26th, 1932, at 6.30 o'clock, for the regular dinner meeting. A musical programme was enjoyed, after which the speaker, G. H. Thompson, A.M.E.I.C. B.Sc., chief engineer of the Calgary Power Company, was introduced by J. T. Watson, A.M.E.I.C.

Electrical Generation

Mr. Thompson's first remarks were based on the history of the subject. He mentioned that the early plants used direct current, which necessitated the placing of plants at load centres and the serving of limited areas. Reserves and equipment required for twenty-four-hour service were large. But with the introduction of alternating current, with its advantage of transformation for transmission, the area supplied was increased and the location of plants less important. This of course led to the use of hydro power in remote places as is done today. Then the introduction of the unit system of generation and the interconnection of plants, made continuous service possible under greatly diversified loads, with greater efficiencies and less costly reserve equipment.

The situation in Alberta was next considered. He said that since the load per mile of line here is small, capital and operating expenses must be kept at a minimum. In order to achieve this object, in operating expenses, the whole of Alberta, with the co-operation of the various systems, is operated as much as possible as if under one control. A slide, a map of the province, was then shown, and the lines of the Calgary Power Company pointed out, with the "backbone," the Edmonton, Calgary, Ghost-Calgary, Lethbridge, McLeod lines, and the various sub and branch lines.

The plants were next mentioned, first that at Edmonton. Mr. Thompson said that the new boiler recently installed at this steam plant makes it very efficient, but that it generates (for the Calgary Power Company) only in the winter time. There are three plants along the Bow river, which incidentally almost completes its development, the Horseshoe, the Kananaskis and the Ghost river, which feed into Calgary by three lines. In Calgary a steam plant is maintained as a stand-by only, and the city plant at Lethbridge also acts as a stand-by. The Calgary Power Company is connected with the East Kootenay Power Company, who operate plants at Sentinel, Elko, and two other places. It is interesting to mention here that sufficient flow is obtained in the rivers on which the East Kootenay Power Company operates later in the spring and earlier in the fall, than in the Bow on which the Calgary Power Company operates. Therefore a greater percentage of power is used from the East Kootenay in the fall and spring seasons.

The economical balance among the plants is an extremely interesting problem. One of the factors is of course the flow mentioned above. Another is the fact that the only storage on the Bow river is the Ghost plant and at Lake Minnewanka. This of course can be released to the three plants, but there is a time delay to the lower plants, and in the winter when this water is needed further delays are caused by ice jams, etc. And when the Edmonton plant is operated, it is operated at the point of maximum economy, excess power going to the Calgary Power Company, who conserve water at the Ghost river plant.

The Horseshoe and Kananaskis plants of the company are old, but show good efficiencies, about 90 per cent, particularly in comparison with the new Ghost river plant. The efficiency of hydro plants has not greatly increased in the last few years, but that of steam plants has, and for that reason Mr. Thompson thought that steam plants would play an important part in the supply of power in the province.

The transmission lines of the company were next discussed. He said that transformations of current were made as few as possible for reasons of economy, for small places one step only is made, in larger, two or three as required. The losses in the transmission lines are low, being 10 to 11 per cent for the line from the Ghost to Edmonton.

The showing of a number of slides closed the talk, and after a discussion, a hearty vote of thanks was moved to the speaker by J. B. DeHart, M.E.I.C., and the meeting closed with the singing of "God Save The King."

London Branch

W. R. Smith, A.M.E.I.C., Secretary-Treasurer.
Jno. R. Rostron, A.M.E.I.C., Branch News Editor.

Many of the members of the Branch attended the Convocation Exercises of the University of Western Ontario held in Convocation Hall on October 28, 1932. This was made possible by the courtesy of the Faculty and took the place of the first fall meeting.

The regular November meeting was held on Thursday, the 17th, in the County Court room of the London Police headquarters. The speaker was Mr. P. W. Harpur, criminal investigating officer, London Police Department, and his subject "The Science of Finger-printing for 'Identification'."

The Science of Finger-printing

Mr. Harpur urged the adoption of a universal system of finger-printing for identification purposes. Most people had an aversion to this as they connected it with the police but this would not necessarily be the case. The records would then be made and kept by the municipalities and the government and only those who had been convicted of crime would be kept by the police department. If this scheme was adopted it would have favourable results for everyone concerned.

Enlarged photos were exhibited showing the different classification of prints, viz.: arches, tented arches, whorls, etc., and the speaker described and showed by illustration the method—now universal—of indexing the prints. By this system it was possible by sending the necessary letters and figures to any police office in the American continent to have their reply in a few hours, or less, as to whether their files contained a similar record.

The speaker also gave an outline of the development of finger-printing, how the ridges were discovered and what they really are and their use. For identification purposes prints were taken of each finger and thumb of each hand and also a print of each full hand. In taking the prints the digit is rolled on to each side so that the direction of the ridges and their termination can be traced. He described the method of detecting prints at the scene of a crime by the use of various special powders for the purpose and a practical illustration of this was given.

An inspection of the police filing system was made and Mr. Harpur called for someone to name any convicted criminal he could remember. A name was given and in a few seconds he produced the man's prints and his record. This was done not from the name but from his classification in the indexing system referred to previously.

A hearty vote of thanks to Mr. Harpur was proposed by H. B. R. Craig, M.E.I.C., seconded by V. A. McKillop, A.M.E.I.C., and carried unanimously.

Niagara Peninsula Branch

P. A. Dewey, A.M.E.I.C., Secretary-Treasurer.
C. G. Moon, A.M.E.I.C., Branch News Editor.

Thirty-six members of the Branch met at St. Catharines on November 28th to discuss the report of the Committee on Development, as printed in the October Journal.

In order to facilitate the discussion, the Executive had delegated certain members to study and explain the major sections into which this voluminous report is divided. Chairman E. P. Murphy, A.M.E.I.C., defined the proposed changes in "objects"; Councillor E. G. Cameron, A.M.E.I.C., dealt with "membership," "qualifications" and "method of admission"; Past-Councillor Carl Scheman, M.E.I.C., was delegated to look after "management"; Past-President A. J. Grant, M.E.I.C., explained the revised scale of "fees"; Mr. B. Atkinson, M.E.I.C., handled "meetings" and "discipline" and C. G. Cline, A.M.E.I.C., looked after "ethics" in the absence of Walter Jackson, M.E.I.C.

The discussion raged from after-dinner until eleven p.m. and nearly everyone took an active part. Owing to the fact that no votes were taken it was difficult to interpret the majority opinion upon certain of the contentious issues, but practically no opposition developed to the general scheme of the new proposals.

It was expected that the chief interest would centre upon the membership clauses and some opposition was voiced to the grade of Fellow, but Mr. Cameron explained that late advice from Headquarters was to the effect that the Committee were in favour of deleting this grade.

Some arguments were advanced for the abolition of clause 16c, thereby confining the field of entrants to graduates and members of the provincial associations. This, however, was felt by many to be too limiting and contrary to the spirit of the new proposals.

Mr. Cameron stated that in his opinion the recommendation of a Branch Executive should carry greater weight than it does at present in applications for admission. He pointed out that the present system, whereby so many applications were questioned by Council, was hardly conducive towards energetic drives for new and desirable members and hence many well qualified engineers were lost to The Institute.

A suggestion was made that the proposed new western zone should include British Columbia and Alberta and that the Prairie Zone should include the Lakehead Branch.

Mr. Grant explained the necessity for increased fees and there was very little discussion on this point. However a question was raised as to the payment of transfer fees by the present Associate Members in the event of these proposals being adopted.

In discussing clauses 74 to 88, exception was taken to clause 85 on the principle that it was more important to prevent an injustice being done to a member than it was to provide for all cases of irregularites being dealt with by Council. No member is quite safe if charges can be laid against him by an accuser who is not known to him, and the Secretary should not be burdened with the task of preserving the accuser's anonymity. Also if any man is not prepared to make his charges openly to Council then he should not make any charges at all. It was pointed out that nearly all the Provincial Acts carry in substance the following clause: "The Council shall not take any such action until "a complaint under oath has been filed with the Registrar and a copy "thereof forwarded to the party accused."

The general feeling of the meeting seemed to favour this contention.

Retention or otherwise of the code of ethics gave rise to little discussion. However, E. P. Johnson, A.M.E.I.C., and Mr. Cameron said they found a certain amount of inspiration from perusing the present code at frequent intervals.

The meeting closed with a very sincere expression of appreciation for the care and thought which had been given to the preparation of this valuable report by Chairman J. L. Busfield, M.E.I.C., and his associates.

Ottawa Branch

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

The Art of Making Money

J. H. Campbell, I.S.O., Master of the Royal Canadian Mint, spoke at a noon luncheon address at the Chateau Laurier before the local Branch on November 17, his subject being "The Art of Making Money." Mr. Campbell is a native of Northern Ireland, and was engaged from 1884 in the service of the Royal Mint in Australia until he attained the position of Deputy Master. He came to this country to be Deputy Master of the Royal Mint in Canada in 1926, and on the transference of this Mint to the administration of the Canadian government in 1931 he became Master of the Royal Canadian Mint. As such he has charge of all the operations for the minting of money in the Dominion.

C. McL. Pitts, A.M.E.I.C., chairman of the local Branch, presided, and in addition head table guests included: Hon. Geo. Black, Dr. Chas. Camsell, M.E.I.C., Dr. O. D. Skelton, W. C. Clark, Watson Sellar, R. M. Gemmel, W. R. Creighton, J. A. Machado, C. G. Cowan, C. A. Gray, T. P. Mackenzie, Dr. G. S. Whitby, Dr. W. H. Collins, W. B. Timm and H. E. Ewart.

Mr. Campbell traced the history of coinage methods from the time when the first coins were made, somewhere around 700 B.C., up to the present day, illustrating by means of lantern slides the methods in use at the Royal Canadian Mint at Ottawa. The views thrown upon the screen followed the various processes from the time the bullion is received until it is issued in the shape of the finished coin.

For the carrying out of these processes there are four principal departments to the Mint, consisting of respectively the mint office, the operating department, the assay office and the refinery.

At the mint office all bullion is received for coinage purposes and also the finished coins are issued to various parts of Canada on requisitions received from the Comptroller of Currency, Ottawa.

The operative department may be sub-divided into the melting house in which the bullion is melted with the requisite alloys into coinage bars, the coining department where the coinage bars are rolled into fillets from which the coin blanks are cut and put through various processes before delivery to the mint office, the die department where the coinage dies are made, and the mechanical department where the power is generated and renewals and repairs to all machinery effected.

In the assay office the fineness of the ingots, coinage bars and finished coins are ascertained.

In the refinery the deposits of rough gold and bullion are refined, the fine gold and silver contents extracted and cast into bars for coinage or for trade purposes.

Special Business Meeting

A special business meeting, attended by some fifty members, was held on Wednesday evening, November 23rd, in the rooms of the R.C.A.F. Photographic Section, Jackson building, for the consideration of the Interim Report of the Committee on Development. J. L. Busfield, M.E.I.C., and J. B. Challies, M.E.I.C., both of Montreal, were present at the meeting. The former, as chairman of this Committee, presented the Interim Report, and the latter led in the discussion upon it, after which a general discussion ensued. Much interest was evinced by the local members, as was attested by the fact that the meeting took up about three hours of time. Towards the close of the meeting Mr. Busfield again spoke, commenting upon points that had been raised during the discussion.

Peterborough Branch

W. F. Auld, Jr.E.I.C., Secretary.
W. T. Fanjoy, Jr.E.I.C., Branch News Editor.

Annual Dinner

Members of Peterborough Branch and their guests to the total number of approximately eighty persons gathered at the Empress hotel on the evening of November 22nd, for the 14th Annual Dinner of the Branch.

Toastmaster B. Ottewell, A.M.E.I.C., chairman of the Branch, handled the toast list and introduced a number of well-known speakers, whose addresses were without exception of unusually high calibre.

The toast of The Institute was proposed by R. C. Flitton, A.M.E.I.C., and responded to by A. H. Harkness, M.E.I.C., and J. F. Plow, A.M.E.I.C., Vice-President and Assistant to the Secretary respectively. J. R. Cockburn, M.E.I.C., of Toronto Branch, responded on behalf of the Branches.

Mr. Plow gave his audience a better insight into the recent activities of Headquarters and his remarks amplified the reports in The Journal. He also spoke of the coming annual meeting and pointed out that the success of any large organization such as The Institute depended on its members.

Ross L. Dobbin, M.E.I.C., who was last year elected President of the American Water Works Association, proposed the toast "Our Guests." He introduced three of his United States friends in the persons of Colonel Willard Chevalier, publishing director of the Engineering News Record of New York City, R. K. Blanchard, vice-president Neptune Water Meter Company, and W. J. Orchard, sales manager of Wallace and Tiernan Company, Newark, N.J. Mr. Dobbin also referred to

W. E. Ross, formerly of Peterborough, who as an old friend and former member of the Branch required no introduction.

Colonel Chevalier, in a thought-provoking address in which he touched upon the present economic situation and suggested that only by the proper investment of private capital in public works and construction undertakings in periods of prosperity could the people, particularly of the newer countries still in the era of construction, hope to build for the future on a permanent and solid foundation, left a marked impression on his audience.

Touching upon what he termed the spiritual values which had been derived by the world from the experiences of the last few years, Colonel Chevalier contended, "we have learned a new sense of values and have had restored to us in large degree our sense of proportion. We have been face to face with reality and have come to see dross as dross. Another thing we have learned to do is to work for the sake of the day's work and not to think merely of what we are going to get from our labours in the way of monetary gain."

In his reply Mr. Blanchard paid high tribute to the worth of Mr. Dobbin whom he described as one of the best known engineers on the continent.

Mr. Orchard replied to the toast briefly and regaled the gathering with a fund of stories mainly told on members and guests.

"Sister Professions" was the toast proposed by H. B. Hanna, which was responded to by the following guests: Dr. J. E. Middleton, Dental Association; J. A. O'Brien, Peterborough Bar Association; Dr. F. O'Reilly, Peterborough Medical Association; Rev. R. D. Wright, vice-president Peterborough Ministerial Association, and V. R. Henry, Teachers' Federation.

NATIONAL RESEARCH COUNCIL

Outlining the four great avenues of service which the National Research Laboratories at Ottawa afford Canada, Dr. R. W. Boyle, M.Sc., M.A., PhD., F.R.S.C., M.E.I.C., director of the Division of Pure and Applied Physics in the National Laboratories, addressed the Branch at the December 8th meeting. Dr. Boyle was introduced as a physicist and scientist of world repute, particularly known for his work with the British Admiralty during the Great War and his associations with McGill University and the University of Alberta.

The first of the avenues, Dr. Boyle gave as "standardization." "Any nation of significance establishes and supports financially some national institute or system of laboratories wherein are maintained, with the highest precision of which human mind and skill are capable, all those standards of time, lengths, weights, pressures, electrical currents, electrical voltages, luminous powers and other qualities, on which are founded justice and exactitude in national and international trade and commerce."

Proceeding to the second field of service, the research assistance for Canadian industry, Dr. Boyle said "In all the great nations there have been founded institutes of research for the deliberate purpose of advancing and assisting industry. The Canadian industries are relatively young and it must be expected that for many a year only a few would be able to investigate the problems arising from their activities which a collected assembly of competent scientists and technicians may be able to investigate in their behalf and to their assistance in the National Research Laboratories. This is the function of the laboratories which the Canadian government has justly decided to support."

"Most countries have in their populations a goodly number of people called inventors," Dr. Boyle said, speaking of the third division of the laboratories' operations—the field of invention. "Their existence is fortunate, for without them all industry would be laggard. They take the findings of pure science and transform them to devices for our comfort, happiness and convenience."

Speaking of the fourth avenue of the National Research Laboratories' work—the avenue of pure science—the speaker declared: "In any aspiring research institute pure science must be fostered, for without it there is grave danger of the institute degrading into a rut of dull and lifeless routine. I would say that one of the most important functions of the National Research Laboratories is to prosecute pure science. I know that the staff of the physics division will need it to keep themselves up to date in their special sciences and abreast with the personnel of similar institutes throughout the world."

Quebec Branch

Jules Joyal, A.M.E.I.C., Secrétaire-Trésorier.

"COCKTAIL" EN L'HONNEUR DE M. W. G. MITCHELL, M.E.I.C.

Mercredi, le 23 novembre dernier, les membres de la Section de Québec et quelques amis, répondant à une invitation du Président et du Conseil de leur Section, se rendaient chez Kerhulu pour prendre part à un "Cocktail" en l'honneur de W. G. Mitchell, M.E.I.C., et lui exprimer, à l'occasion de son départ de Québec, toute leur reconnaissance pour l'aide efficace qu'il a donné à toutes les organisations des années passées, ainsi que leurs meilleurs vœux pour l'avenir.

Hector Cimon, M.E.I.C., président de la Section de Québec, s'est fait le porte-parole de ses confrères et en termes bien appropriés il a exprimé à M. Mitchell tout le regret que les membres de la Section avaient ressenti en apprenant son départ de la vieille Cité de Québec après un séjour de plusieurs années, vraiment trop vite écoulées durant lesquelles M. Mitchell s'est fait des amis sincères de tous ceux qui ont eu le plaisir de venir en contact avec lui.

M. Cimon assure à M. Mitchell que tous les officiers et les membres de la Section qui ont été en relation avec lui dans la poursuite d'un idéal commun, se souviendront à jamais de l'enthousiasme et de la détermination qui ont caractérisé le support effectif qu'il a toujours prêté au Comité Exécutif lorsque ce dernier prenait l'initiative de faire quoi que ce soit pour le bénéfice des membres, de l'Institut ou de la profession.

Le président rappelle aussi à l'assistance la part active prise par le héros de cette fête dans l'organisation et le succès de l'Assemblée Générale Annuelle de l'Institut tenue sous les auspices de la Section de Québec en 1927, il cite aussi la valeureuse contribution apportée par M. Mitchell dans la direction des affaires de l'Institut lorsqu'il était Vice-Président.

M. Cimon termine en assurant à M. Mitchell que tous les membres de la Section de Québec et tous ses amis ressentiront bien longtemps le vide créé dans leurs rangs par son départ, lui souhaite, au nom de tous, succès et bonheur dans son nouveau champ d'action et exprime le vœu que nous aurons encore le plaisir de le voir parmi nous.

Le président invite alors l'assistance à boire à la santé de M. Mitchell puis, en chœur, on entonne le refrain: "For he is a jolly good fellow."

M. Mitchell remercie l'assistance et se dit très honoré de cette marque de considération de la part de ses amis et confrères de la Section de Québec, il exprime ses regrets de quitter la vieille Cité de Champlain et donne de sages conseils aux membres de la Section; il remercie sincèrement le président pour ses bonnes paroles à son égard et pour les bons souhaits qu'il lui a adressés au nom de la Section, puis après avoir donné à tous un vigoureux "Shake Hands" il se retire.

Etaient présents: MM. W. G. Mitchell, M.E.I.C., H. Cimon, M.E.I.C., A. B. Normandin, A.M.E.I.C., P. Méthé, A.M.E.I.C., T. J. F. King, A.M.E.I.C., L. Beaudry, A.M.E.I.C., E. A. Evans, M.E.I.C., J. A. Duchastel, M.E.I.C., A. Amos, A.M.E.I.C., J. U. Archambault, A.M.E.I.C., C. H. Boisvert, A.M.E.I.C., T. M. Déchêne, A.M.E.I.C., O. Desjardins, A.M.E.I.C., I. E. Vallée, A.M.E.I.C., E. Gray-Donald, Jr.E.I.C., L. Martin, Jr.E.I.C., P. W. Doddridge, S.E.I.C., T. C. Denis, R. Wood, S.E.I.C., J. H. A. E. Drolet, A.M.E.I.C., R. B. McDunnough, A.M.E.I.C., P. Marcotte, A.M.E.I.C., J. E. Roy, A.M.E.I.C., A. G. Sabourin, A.M.E.I.C., D. S. Scott, A.M.E.I.C., Brig.-Gen. T. L. Tremblay, A.M.E.I.C., R. Sauvage, M.E.I.C., L. P. Gravel, S.E.I.C., A. Paradis, Affil.E.I.C., C. L. Dufort, A. O. Barrette et J. Joyal, A.M.E.I.C.

Saguenay Branch

G. H. Kirby, A.M.E.I.C., Secretary-Treasurer.

On October 19th about forty members and friends of the Branch gathered in the Assembly Hall of the Aluminum Company's office building in Arvida to welcome Dr. A. W. G. Wilson, Ph.D., chief engineer of the Mineral Resources Division of the Department of Mines and L. H. Cole, A.M.E.I.C.

Mr. Cole gave a very interesting lecture on "Anhydrite, an Undeveloped Mineral Resource," which was illustrated by lantern slides. The substance of Mr. Cole's lecture has since been published in the October number of the Mining Journal.

A. W. Whitaker, Jr., A.M.E.I.C., moved a vote of thanks to the speaker, and Dr. Wilson gave an interesting talk on the work of his department and enumerated some of the problems which were being dealt with by the research workers of the Mineral Resources Branch.

The chairman thanked the members for their attendance and said that efforts were being made to obtain an outside speaker to address the Branch before the winter weather made transportation impossible.

There being no further business the meeting was brought to a close.

Saint John Branch

G. H. Thurber, A.M.E.I.C., Secretary-Treasurer.
C. G. Clark, S.E.I.C., Branch News Editor.

A meeting of the Saint John Branch of The Engineering Institute of Canada was held at the Admiral Beatty hotel on November 8th to discuss the details of the Interim Report of the Committee on Development. The meeting was well attended and the various items of the report were fully discussed. Mr. A. A. Turnbull, chairman, presided.

SECONDARY STRESSES IN BRIDGE STRUCTURES

On Thursday, November 24th, a meeting of the Saint John Branch of The Engineering Institute of Canada was held in the Georgian Ballroom of the Admiral Beatty hotel at which about 40 members of the local Branch were present to hear two papers presented by Sidney Hogg, A.M.E.I.C., and J. H. McKinney, A.M.E.I.C. A. A. Turnbull, A.M.E.I.C., chairman of the Branch, presided.

Mr. Hogg took for the subject of his address "Secondary Stresses in Bridge Structures" based on a paper written by him and published in the October, 1932, issue of The Engineering Journal.

Mr. Hogg began by discussing the margin of safety generally allowed for in steel frame structures and pointed out that in many cases the secondary stresses in a particular member caused by its eccentricity about a panel point would exceed the primary stress set up by direct compression or tension. He described the tediousness of the process by which these secondary stresses were found by the slope-deflection method, and explained how a great deal of work and time could be saved by arriving at a result within the factor of safety by means of a series of approximations, the number of approximations used depending on the required accuracy of the result.

Closing his talk, Mr. Hogg expressed his views on the desirability of devoting a section of The Journal to papers discussing in more detail various technical aspects of engineering problems instead of articles descriptive of complete jobs or installations. He also stated, as his opinion, that a reader's forum might be successfully operated through The Journal in which engineers from various parts of the country could discuss common problems.

Field Control of Concrete

The second paper of the evening was delivered by J. H. McKinney, A.M.E.I.C., and was entitled "Field Control of Concrete at the Saint John Harbour Commission Docks, West Saint John." Mr. McKinney prefaced his paper by outlining the general scheme of the new work being carried on at the west side of the Harbour. He went on to describe the making of the concrete, beginning with the selection and testing of the various sands and gravels available in this vicinity, stressing particularly the close control that was exercised to keep these materials uniform and of a constant quality as various deposits were worked out and material was taken from other beds. In this connection Mr. McKinney exhibited an interesting collection of sands taken from various deposits inland and from the Bay of Fundy shore. He continued his discussion by outlining the methods by which concrete was placed in the forms, stresing the need for caution in tamping the material, particularly near the outside faces.

Mr. McKinney had some interesting statistics showing the strengths obtained by laboratory tests on cylindrical specimens taken after seven day, twenty-eight day and one year intervals, some of these specimens having been made in the coldest part of the winter as well as during warm weather. He described the precautions taken to ensure that the concrete was not harmed by frost and gave the results of temperature readings taken over the first seventy-two hours after fresh concrete was poured in various locations with various outdoor temperatures. Mr. McKinney gave full credit to the report of the engineers on the Chute à Caron project and stated that the methods of control he had used were based on the results of their experience.

Discussion of both of the above papers then took place, after which the meeting was adjourned to the Strand Theatre, where a sound picture of the Abitibi Canyon development was shown to members of the Branch through the courtesy of Colonel H. F. McLean, of the Dominion Construction Company.

A vote of thanks to the speakers as well as to the Dominion Construction Company and Col. MacLean was moved by A. Gray, M.E.I.C., and seconded by W. J. Johnston, A.M.E.I.C. In speaking to the motion, J. N. Flood, A.M.E.I.C., gave credit to Mr. Hogg for his pioneer work in steel design.

Vancouver Branch

A. I. E. Gordon, Jr.E.I.C., Secretary-Treasurer.

A meeting of the Branch was held under the auspices of the Student Section in Room 100, Applied Science building, University of British Columbia, on Wednesday, November 16th, 1932, at 8.15 p.m.

P. H. Buchan, A.M.E.I.C., chairman of the Branch, introduced Mr. Brooks, chairman of the Student Section, who then officially carried on with the programme.

The following speakers participated: Clifford S. Lord, geologist, "Experiences of a Geologist in Northern Rhodesia"; Hedley S. Fowler, mining, "Road Construction in the Omineca"; Professor G. A. Gillies, Assistant Professor in Mining, U.B.C., "Lantern slide illustration of Engineering Practice during the 17th Century."

Messrs. Lord and Fowler both presented very interesting and instructive papers on their personal experiences, illustrated fully with slides.

Due to the inclemency of the weather there was not as full a turnout as expected, only about 50 being present. The non-attendance of the older members was especially noticeable, as this is one of the functions where the presence of the senior men is most desirable.

A very cordial vote of thanks was sponsored by W. H. Powell, M.E.I.C., and ably seconded by A. E. Foreman, M.E.I.C.

Victoria Branch

I. C. Barltrop, A.M.E.I.C., Secretary-Treasurer.
K. Reid, Jr.E.I.C., Branch News Editor.

On the evening of September 26th, 1932, the Victoria Branch of The Engineering Institute of Canada began its fall and winter series of meetings with an address by E. Davis, M.E.I.C., of the Provincial Water Rights Branch for B.C., on the subject, "The Romance of Electricity." The meeting was well attended by some thirty-five members and friends. H. L. Swan, M.E.I.C., chairman of the Branch, presided.

The Romance of Electricity

In introducing the subject, Mr. Davis spent some time in outlining the historical side of the discovery of electricity, from the time of its first conception, when it was regarded as a "mystery," through the times of the earliest experiments of Gilbert, Hauksbee, Franklin, Volta, Oersted, and others. He showed how discoveries and inventions had led up, one to the other, until in 1831 Faraday made the supreme discovery of induction of electric currents, a discovery which made subsequent electro-magnetic or dynamo-electric machines possible.

From this date practical applications followed rapidly and the next twenty years saw many large machines developed, using steam power as their prime movers. In quick succession many new inventions were announced. In 1870, Gramme improved a toothed ring winding for armatures. In 1873, the first Gramme generator was operated as a motor, opening the field for the transmission of power and the electric tramway. The first commercial incandescent lamp was produced by Sir Joseph Swan in December 1878. 1891 saw the development of the polyphase alternator, with the subsequent use of the transformer, discovered in 1883, for the transmission of power over long distances.

The speaker then left the historical side of the subject to deal with the development up to modern times of prime movers, both water and steam. The generation of electricity, other than that produced by chemical means, was dependent upon some form of prime mover, and the various types and capacities of these were described, as also were electric generators, and the transformation and transmission of electrical energy.

At this point an intermission was called in the proceedings of the evening, during which K. M. Chadwick, M.E.I.C., and K. Reid, Jr.E.I.C., performed a few interesting demonstrations illustrating some of the basic principles underlying the theory of electricity, and duplicated a few of the experiments of some of the pioneers in the science previously mentioned by Mr. Davis in his paper.

Mr. Davis then proceeded to describe the development and the high degree of efficiency that had been obtained in the various other branches of the electrical industry. Telephony, telegraphy, wireless telegraphy, the vacuum tube, electric railways, marine transport, electric furnaces, electrolysis, electric boilers, filters, and automatic control, were very ably covered during the remainder of the paper. The paper was illustrated by some sixty slides, including cuts showing some of the early discoverers and experiments, with pictures of original apparatus.

At the close of the address a very hearty vote of thanks was tendered Mr. Davis and his assistants.

The Burrard Street Bridge

On Friday, October 28th, thirty members of the Victoria Branch gathered to hear a most interesting paper presented by Major J. R. Grant, M.E.I.C., of Vancouver, on "The Burrard Street Bridge."

Major Grant is an eminent consulting engineer of Vancouver and one who has had the rather unique experience of conceiving, designing and supervising the construction to its ultimate completion of a major engineering work.

As this paper had previously been given before the Vancouver Branch of The Institute, the reader is referred to the Vancouver Branch news for its summary. This paper was very adequately illustrated with some sixty-five slides showing every phase of development, from before construction began, to the opening ceremonies of the completed structure.

A. L. Carruthers, M.E.I.C., moved a hearty vote of thanks to Major Grant, which was unanimously adopted.

On Friday, November 25th, 1932, the Branch was entertained by interesting movie films of the construction of the Burrard street bridge in Vancouver, construction of penstock for the B.C. Electric Railway Company at Jordan river, and the construction of the water works and reservoir for Ladner Municipality, B.C.

The films were introduced and described by J. P. Hodgson, M.E.I.C., of Messrs. Hodgson, King and Marble, engineers and contractors of Vancouver.

In the absence of the chairman, H. L. Swan, M.E.I.C., the speaker was introduced by A. L. Carruthers, M.E.I.C.

The films showing the construction of the Burrard street bridge were particularly interesting, following, as they did, the recent paper by Major J. R. Grant, M.E.I.C., designer of the bridge, and gave a most comprehensive picture of the methods of construction adopted from start to finish.

Two reels of pictures were also shown depicting the construction of 9,900 feet of penstock at Jordan river on Vancouver Island, for the B.C. Electric Railway Co., Ltd., showing the fabrication of the pipe at the Vancouver Engineering Works, transportation by scow to Vancouver Island, and thence to the pipe line by Leyland six-wheel truck. The pictures clearly showed the methods adopted of laying the pipe under difficult side hill conditions. Mr. E. N. Horsey, of the staff of the B.C. Electric Railway Co., gave a brief outline with regard to the necessity for the construction of this work by the company.

These pictures were followed by two reels showing the laying of a cast iron pipe line and the building of a reservoir for the municipality of Ladner, B.C. An interesting feature of the work was the digging of the pipe trench by a ditching machine.

The reservoir is unique, being the only one of its kind in Canada: circular in section and of concrete construction, the usual reinforcement was omitted, and in its place steel tension hoops were placed on the outside of the wall and tightened up in such a way that the concrete was pre-stressed prior to being filled with water, thus neutralizing the tension developed when the tank is filled.

At the close of the meeting a hearty vote of thanks was tendered to Mr. Hodgson by the fifty-two members and friends who were present.

Annual Meeting of Association of Professional Engineers of British Columbia

The annual meeting of the Association of Professional Engineers of British Columbia took place on Saturday, December 3rd, in the Hotel Georgia, Vancouver, when the officers were elected for 1933. The incoming president is J. D. Galloway, provincial mineralogist, province of British Columbia, and the vice-president, H. B. Muckleston, M.E.I.C.

About three hundred members from all parts of the provinee were in attendance.

The retiring president, A. S. Gentles, M.E.I.C., in his address, drew attention to the large number of engineers-in-training and engineering pupils attached to the Association, a condition differing from that in the old days when the majority of engineers only contemplated becoming members of recognized engineering organizations at maturity, when it was too late for them to undergo a formal system of training and education. In this way the Engineering Act in British Columbia had not only improved the standards for engineers' qualifications in the province, but had been of service to the younger men in providing a definite means of qualifying and improving their engineering ability. Mr. Gentles pointed out that while engineering unemployment was perhaps more marked in British Columbia than in some of the other provinces, a number of positions had been made available through the organized work of the Vancouver Engineers Relief Committee, and a considerable fund had been raised to assist those engineers who are in destitute circumstances. The finances of the Association had been maintained in good condition, and in his duties as president, Mr. Gentles had been ably supported by the members of Council and members of the Association.

The president-elect, Mr. J. D. Galloway, urged that engineers as a class ought to take an important part in endeavouring to restore economic conditions to something approaching normal. He paid tribute to the efforts of a number of mining companies in British Columbia who were maintaining employment and affording relief to their late employees at the expense of their profits, an example which should be more generally followed. While engineers have been largely responsible for producing technological unemployment, the engineer, as a class, had perhaps been backward in displaying public spirit and interest in matters beyond his own particular sphere of work. He hoped that eminent engineers, occupying executive positions, would not lose their professional outlook and would use their influence in giving a square deal to humanity.

At the annual banquet the principal speaker was Mr. J. W. deB. Ferris, K.C., who dealt with the characteristics of the engineer, his failure to interest himself in public problems, and the necessity of making a study of the distribution, as contrasted with the production, of goods.

Etobicoke Township Waterworks Development

A new waterworks system was recently constructed by the Township of Etobicoke, Ontario. Early in 1932 two wells were drilled for the township water supply, which on completion yielded over 1,000 gallons per minute. The water, however, while pure from a bacteriological standpoint, contained a large amount of iron and twenty grains of hardness per gallon. As a result it was decided to treat the water by the Permutit zeolite method with a view to the removal of these objectionable features.

The properties of zeolites were discovered many years ago by J. T. Way, an English chemist, and were applied to the art of water softening by a German, Dr. Robert Gans. Zeolites, or base exchange silicates, are able to remove hardness because they convert the calcium and magnesium salts to corresponding soluble sodium salts upon contact of the water with the zeolites. A similar exchange occurs when iron in the ferrous state is present in a water supply, and in fact the zeolite bed will continue to remove iron long after it has absorbed all the calcium and magnesium of which it is capable. When fully charged with these substances the zeolite bed can easily be regenerated by a reverse chemical action, by passing through it a solution of common salt.

The system installed at Etobicoke is designed to treat one and a half million gallons per twenty-four hours, the well pumps circulating the water direct from the wells through four zeolite units to a 100,000 gallon reservoir. A service pump takes its supply from the reservoir, but the system is so designed that if desired the water from the softeners can be delivered direct to the suction of the service pump, thus preventing the aeration of the supply as much as possible. The softening plant reduces the hardness of the Etobicoke well water from twenty grains to five grains per gallon and eliminates the iron entirely, and is the first application of the zeolite method of treatment to a municipal supply in Canada.

Measuring Electricity

The Beginnings of One Type of Meter

Most Americans use electricity for a number of purposes in their houses, their factories, their stores. In the main each consumer pays for the current in proportion to the use made of it, that is, on a quantity basis. This involves some way of measuring the electricity. In some communities water comes through a meter and on the reading of the meter the bills are computed. Thus numerous commodities are measured directly in some kind of quantity.

But some things for which we pay are measured indirectly by the effects they produce. Electricity, commercially considered, is a form of energy. It does mechanical or chemical work in great variety. Its effects exhibit themselves in many ways. Consequently, a number of kinds of devices have been invented for its measurement. The accidental origin of one type of electrical meter makes a good story. Observe, however, that the essential feature in the accident which led to the useful result was the presence of a highly trained, alert mind, with a purpose.

On the 20th day of April, 1888, Philip Lange, an engineer of the Westinghouse Company, who had been making experiments on an alternating current arc lamp, asked O. B. Shallenberger, chief electrician of the company, to examine the working of the lamp. While Mr. Lange was adjusting the lamp, a small spiral spring became detached and fell upon a brass flange which constituted a part of the support for the working coil of the lamp. This coil surrounded a projecting core which was made up of a large number of small iron wires.

The spring began to rotate slowly. This action immediately attracted the attention of Mr. Shallenberger, and, in order to observe the phenomenon more closely, he interrupted the engineer who was about to replace the spring. In order to assure himself that the rotation was not due to mere mechanical vibration of the lamp, Mr. Shallenberger then placed the spiral spring in a glass tube, holding it in his hand. The spring continued to revolve freely on its axis within the tube.

Having in mind the problem of an alternating current meter, Mr. Shallenberger immediately sensed that here was the demonstration of a principle which might lead to the much-desired metering device. His keen, analytical mind quickly perceived the conditions which caused this spring to rotate, and he soon deduced the fact that the relations of the magnetic coil and the projecting core in the arc lamp mechanism, were such as to produce a rotating magnetic field.

Theoretical deductions were quickly followed by experimental demonstrations, and the design of an ampere-hour meter. Intensive experiment and development quickly produced a design radically new in the fundamental principles involved and in its constructive details.

On May 18, less than a month after observing the rotation of the spiral spring of the arc lamp, Mr. Shallenberger completed the construction of a commercial meter, the manufacture of which was at once begun. So keen was his perception and so thorough his work in the steps of research, development and design that the meter came from his hands practically in the form used throughout its life, a notable achievement.

This Narrative records the most remarkable development in point of time involved and permanent results accomplished of which the writer has knowledge.

For the lay reader a magnetic field may be defined as in Murray's New English Dictionary "any space possessing magnetic properties, either on account of magnets in its vicinity, or on account of currents of electricity passing through or around it."

An ampere is a unit for measurement of electric current, named in honour of the celebrated French electrician, Ampere. The meter which originated as recorded in this Narrative measures the equivalent of the number of units of electric current used for one hour.—Dr. C. E. Skinner in *Research Narratives of The Engineering Foundation.*

EMPLOYMENT SERVICE BUREAU

The Service is operated for the benefit of members of The Engineering Institute of Canada, and 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

All notices intended for publication must be received not later than the 17th of the month for the E.I.C. News and the 25th of the month for The Journal.

Situations Wanted

YOUNG ENGINEER, B.A., B.Sc., A.M.E.I.C., R.P.E., Ont. Competent draughtsman and surveyor. Eight years experience including design, superintendence and layout of pulp and paper mills, hydro-electric projects and general construction. Limited experience in mechanical design and industrial plant maintenance. Apply to Box No. 150-W.

PURCHASING ENGINEER, graduate mechanical engineer, Canadian married, 34 years of age, with 13 years' experience in the industrial field, including design, construction and operation, 8 years of which had to do with the development of specifications and ordering of equipment and materials for plant extensions and maintenance; one year engaged on sale of surplus construction equipment. Full details upon request. Apply to Box No. 161-W.

REINFORCED CONCRETE ENGINEER, B.Sc., P.E.Q., eight years experience in construction design of industrial buildings, office buildings, apartment houses, etc. Age 30. Married. Apply to Box No. 257-W.

MECHANICAL ENGINEER, B.Sc., McGill 1919, A.M.E.I.C., P.E.Q., 12 years experience oil refinery and power plant design, factory maintenance, steam generation and distribution problems, heating and ventilation, etc. Available at once. Location immaterial Apply to Box No. 265-W.

CIVIL ENGINEER, B.A.Sc., A.M.E.I.C., Jr.A.S.C.E., age 28, married. Experience: construction, design, cost estimating on hydro-electric and storage work, also railway. Desires work in engineering, industrial or commercial fields. Available at once. Apply to Box No. 447-W.

MECHANICAL ENGINEER, B.Sc. Age 28, married. Four and a half years on industrial plant maintenance and construction, including shop production work and pulp and paper mill control. Also two and a half years on structural steel and reinforced concrete design. Located in Toronto. Available at once. Apply to Box No. 521-W.

CIVIL ENGINEER, Canadian, married, twenty-five years technical and executive experience, specialized knowledge of industrial housing problems and the administration of industrial towns, also town planning and municipal engineering, desires new connection. Available on reasonable notice. Personal interview sought. Apply to Box No. 544-W.

ELECTRICAL ENGINEER, A.M.E.I.C., University graduate 1924. Experience includes one year test course and five years on design of induction motors with large manufacturer of electrical apparatus. Four summers as instrumentman on highway construction. Several years experience in accounting previous to attending university. Available at once. Apply to Box No. 564-W.

MECHANICAL ENGINEER, B.A.Sc., '30, desires position to gain experience, and which offers opportunity for advancement. Experience in pulp and paper mill and one year in mechanical department of large electrical company. Location immaterial. Available immediately. Apply to Box No. 577-W.

Situations Wanted

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.

MECHANICAL ENGINEER, Canadian, technically trained; eighteen years experience as foreman, superintendent and engineer in manufacturing, repair work of all kinds, maintenance and special machinery building. Location immaterial. Available at once. Apply to Box No. 601-W.

MECHANICAL ENGINEER, A.M.E.I.C., Canadian, technically trained; six years drawing office. Office experience, including general design and plant layout. Also two years general shop work, including machine, pattern and foundry experience, desires position with industrial firm in capacity of production engineer or estimator. Available on short notice. Apply to Box No. 676-W.

ELECTRICAL ENGINEER, B.Sc., '29, Jr.E.I.C. Age 26. Undergraduate experience in surveying and concrete foundations; also four months with Canadian General Electric Co. Thirty-three months in engineering office of a large electrical manufacturing company since graduation. Good experience in layouts, switching diagrams, specifications and pricing. Best of references. Available immediately. Apply to Box No. 693-W.

MECHANICAL ENGINEER, B.Sc., '27, Jr.E.I.C. Four years maintenance of high speed Diesel engine units, 200 to 1,300 h.p. Also maintenance of D.C. and A.C. electrical systems and machinery. Draughting experience. Westinghouse apprenticeship course. Practical mechanical and electrical engineer with a special study of high speed Diesel engine design, application and operation. Location in western or eastern Canada immaterial Apply to Box No. 703-W.

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

MECHANICAL ENGINEER, age 41, married. Eleven years designing experience with project of outstanding magnitude. Machinery layouts, checking, estimating and inspecting. Twelve years previous engineering, including draughting, machine shop and two years chemical laboratory. Highest references. Apply to Box No. 723-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.

DESIGNING ENGINEER M.Sc. (McGill Univ.), D.L.S., A.M.E.I.C., P.E.Q. Experience in design and construction of water power plants, transmission lines, field investigations of storage, hydraulic calculations and reports. Also paper mill construction, railways, highways, and in design and construction of bridges and buildings. Available at once. Apply to Box No. 729-W.

Situations Wanted

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.

ELECTRICAL AND RADIO ENGINEER, B.Sc. '31, S.E.I.C. Age 25. Nine months experience on installation of power and lighting equipment. Eight months on extensive survey layouts. Two summers installing telephone equipment. Specialized in radio servicing and merchandising. Available at once. Location immaterial. Apply to Box No. 740-W.

CIVIL ENGINEER, graduate '29. Married. One year building construction, one year hydro-electric construction in South America, fourteen months resident engineer on road construction. Working knowledge of Spanish. Available at once. Apply to Box No. 744-W.

SALES ENGINEER, B.Sc., McGill, 1923, A.M.E.I.C. Age 33. Married. Extensive experience in building construction. Thoroughly familiar with steel building products; last five years in charge of structural and reinforcing steel sales for company in New York state. Available at once. Located in Canada. Apply to Box No. 749-W.

DESIGNING ENGINEER, graduate Univ. Toronto '26. Thoroughly experienced in the design of a broad range of structures, desires responsible position. Apply to Box No. 761-W.

MECHANICAL ENGINEER, graduate, '23, A.M.E.I.C., P.E.Q., age 32, married. (English and French.) Two years shop, foundry and draughting experience; one year mechanical supt. on construction; six years designing draughtsman in consulting engineers' offices (mechanical equipment of buildings, heating, sanitation, ventilation, power plant equipment, etc.). Present location Montreal. Available immediately. Montreal or Toronto preferred. Apply to Box No. 766-W.

CIVIL ENGINEER, S.E.I.C., B.Sc. Queen's Univ. '29. Three years experience as construction supt. and estimator for contracting firm. Experience includes general building, bridges, sewer work, concrete, boiler settings, sand blasting of bridges and spray painting. Age 25. Married. Available at once. Apply to Box No. 767-W.

WORKS ENGINEER, A.M.E.I.C. Twenty-four years experience, responsible for the design and building of extensions to mill buildings, specifying and installing of equipment and maintenance of plant of large manufacturing company. Good references. Will take position abroad. Apply to Box No. 768-W.

ELECTRICAL ENGINEER, B.Sc. (McGill Univ. '29), S.E.I.C. Married. Experience in pulp and paper mill mechanical maintenance, estimates and costs and machine shop practice. Desires position with industrial or manufacturing concern. Location immaterial. Available on short notice. References. Apply to Box No. 770-W.

ELECTRICAL ENGINEER, Queen's Univ. '24, Jr.E.I.C., age 32, married. Experience includes, student Test Course, Can. Gen. Elec. Co., four years dial system telephone engineering with large manufacturing company. Available at once. Apply to Box No. 772-W.

CIVIL ENGINEER, B.Sc., '25, Jr.E.I.C., P.E.Q., married. Desires position, preferably with construction firm. Experience includes railway, monument and mill building construction. Available immediately. Apply to Box No. 780-W.

Situations Wanted

DRAUGHTSMAN, experience in civil engineering, forestry engineering, land surveying and house construction. Good references. Apply to Box No. 781-W.

SALES ENGINEER, Grad. McGill Univ. in E.E. '26. Canadian, married, age 27. Two and a half years General Electric Co., U.S.A., including two years on Doherty's Advanced Course in Engineering. Experience also includes sales work with automobile manufacturers, and general merchandising work with building trades. Available on short notice. Apply to Box No. 782-W.

ELECTRICAL AND SALES ENGINEER, S.E.I.C., grad. '28. Experience includes one year test course, one year switchboard design and two years switchboard and switching equipment sales with large electrical manufacturing company. Three summers Pilot Officer with R.C.A.F. Available at once. Apply to Box No. 788-W.

SALES REPRESENTATIVE. Electrical engineer with ten years experience in power field interested in representing established firm for electrical or mechanical product in Montreal territory. Excellent connections. Apply to Box No. 795-W.

CIVIL ENGINEER, B.Sc., '32. Two years experience in municipal engineering. Two summers experience in highway engineering. In charge of survey party last summer. Available at once. Location immaterial. Apply to Box No. 800-W.

STRUCTURAL ENGINEER, B.Sc., Jr. E.I.C., with extensive experience in design and construction of industrial buildings and tall office buildings. Fully experienced in latest developments in steel and reinforced concrete frames for above buildings. At present located in Chicago. Available at about one to two weeks notice. Apply to Box No. 802-W.

CIVIL ENGINEER, S.E.I.C., graduate '30, age 23, single. Experience includes mining surveys, assistant on highway location and construction, and assistant on large construction work. Steel and concrete layout and design. Apply to Box No. 809-W.

CIVIL ENGINEER, college graduate, age 27, single. Experience includes surveying, draughting concrete construction and design, street paving both asphalt and concrete. Available at once; will consider anything and go anywhere. Apply to Box No. 816-W.

CIVIL ENGINEER, B.E. (Sask. Univ. '32), S.E.I.C. Single. Experience in city street improvements; sewer and water extensions. Good draughtsman. References. Available at once. Location immaterial. Apply to Box No. 818-W.

CIVIL ENGINEER, S.E.I.C. B.Sc. (Queen's '32), age 21. Three summers surveying in northern Quebec. Interested in hydraulics and reinforced concrete. Available at once. Location immaterial. Apply to Box No. 822-W.

CIVIL ENGINEER, B.Sc., A.M.E.I.C., with fifteen years experience mostly in pulp and paper mill work, reinforced concrete and structural steel design, field surveys, layout of mechanical equipment, piping. Available at once. Apply to Box No. 825-W.

ELECTRICAL ENGINEER, S.E.I.C., grad. '29, age 24, married; experience includes one year Students Test Course, sixteen months in distribution transformer design and eight months as assistant foreman in charge of industrial control and switchgear tests. Location immaterial. Available at once. Apply to Box No. 828-W.

SALES ENGINEER, M.E.I.C., graduate civil engineer with twenty years experience in the structural, sales, and municipal engineering fields, and as manager of engineering sales office. Available at once. Apply to Box No. 830-W.

Situations Wanted

CIVIL ENGINEER, B.A.Sc., D.L.S., O.L.S., A.M.E.I.C., age 46, married. Twelve years experience in charge of legal field surveys. Owns own surveying equipment. Eight years on technical, administrative, and editorial office work. Experienced in writing. Desires position on survey work, assisting in or in charge of preparation of house organ, on staff of technical or semi-technical magazine, or on publicity, editorial or administrative office work. Available at once. Will consider any salary, and any location. Apply to Box No. 831-W.

AERONAUTICAL ENGINEER, B.Sc. (McGill), M.Sc. (Mass. Inst. Tech.). Canadian. Age 26, recent graduate. Capable of aeroplane design and stress analysis. Apply to Box No. 838-W.

CIVIL ENGINEER, M.Sc., R.P.E. (Sask.). Age 27. Experience in location and drainage surveys, highways and paving, bridge design and construction city and municipal developments, power and telephone construction work. Available on short notice. Apply to Box No. 839-W.

CIVIL ENGINEER, S.E.I.C., B.Sc. '32 (Univ. of N.B.). Age 25, married. Two years experience in power line construction and maintenance; one year of highway construction; one summer surveying for power plant site, location and spur railway line construction. Available at once. Location immaterial. Apply to Box No. 840-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.

CIVIL ENGINEER, B.Sc. (Alta. '31), S.E.I.C., age 24. Experience, three summers on railroad maintenance, and seven months on highway location as instrumentman. Willing to do anything, anywhere, but would prefer connection with designing or construction firm on structural works. Available immediately. Apply to Box No. 846-W.

MECHANICAL ENGINEER, Jr.E.I.C., technical graduate, bilingual, age 30. Two years as designing heating draughtsman with one of the largest firms of its kind on this continent handling heating materials; three years designing draughtsman in consulting engineers' office, mechanical equipment of buildings, heating, ventilation, sanitation, power plant equipment, writing of specifications, etc. Present location Montreal. Available at once. Apply to Box No. 850-W.

BRIDGE AND STRUCTURAL ENGINEER, A.M.E.I.C., McGill. Twenty-five years experience on bridge and structural staffs. Until recently employed. Familiar with all late designs, construction, and practices in all Canadian fabricating plants. Desirous of employment in any responsible position, sales, fabrication or construction. Apply to Box No. 851-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.

MECHANICAL ENGINEER, B.Sc. '32, S.E.I.C. Good draughtsman. Undergraduate experience:—One year moulding shop practice; two years pipe fitting and sheet metal work; one year draughting and tracing on paper mill layout; six months machine shop practice; and eight months fuel investigation and power heating plant testing. Desires position offering experience in steam power plants or heating and ventilating design. Will go anywhere. Apply to Box No. 858-W.

Situations Wanted

MECHANICAL ENGINEER, age 31, graduate Sheffield (England) 1921; apprenticeship with firm manufacturing steam turbine generators and auxiliaries and subsequent experience in design, erection, operation and inspection of same. Marine experience B.O.T. certificate, thoroughly conversant with Canadian plants and equipment. Available on short notice. Any location. Box No. 860-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.

ENGINEER, McGill Sci. '21-'25, S.E.I.C., aerial mapping, stereoscopic contour work; lumber classification; highway, railway and transmission line locations; estimates; water storage investigations, etc. Five years ground surveys; three years aerial mapping. Bilingual. Available on short notice. Apply to Box No. 872-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.Sc., Montreal 1930, age 26, single, French and English, desires position technical or non-technical in engineering, industrial or commercial fields, sales or promotion work. Experience includes three years in municipal engineering on paving, sewage, waterworks, filter plant equipment, layout of buildings, etc. Available immediately. Apply to Box No. 891-W.

ELECTRICAL ENGINEER, grad. Univ. of N.B. '31. Experienced in surveying and draughting, requires position. Available at once. Will go anywhere. Apply to Box No. 893-W.

CIVIL ENGINEER, B.A.Sc., Jr.E.I.C., age 29, single. Experience includes two years in pulp mill as draughtsman and designer on additions, maintenance and plant layout. Three and a half years in the Toronto Buildings Department checking steel, reinforced concrete, and architectural plans. Available at once. Location immaterial. At present in Toronto. Apply to Box No. 899-W.

ENGINEER, Jr.E.I.C., specializing in reconnaissance and preliminary surveys in connection with hydro-electric and storage projects. Expert on location and construction of transmission lines, railways and highways. Capable of taking charge. Location immaterial. Apply to Box No. 901-W.

MECHANICAL ENGINEER, Canadian, age 25, B.Sc. (Queen's '32). Since graduation on supervision of large building construction. Undergraduate experience in electrical, plumbing and heating, and locomotive trades. Available at once. Apply to Box No. 903-W.

DESIGNING ENGINEER, A.M.E.I.C. Permanent and executive position preferred but not essential. Fifteen years experience in designing power plants, engine and fan rooms, kitchens and laundries. Thoroughly familiar with plumbing and ventilating work, pneumatic tubes, and refrigeration, also heating, electrical work, and specifications. Apply to Box No. 913-W.

INDUSTRIAL ENGINEER, B.Sc. in M.E., age 25, married, is open for a position of a permanent nature with an industrial concern. Experience includes three years in various divisions of a paper mill and two years in an electrical company. Apply to Box No. 917-W.

Purchasers' Classified Directory

A Selected List of Equipment, Apparatus and Supplies

For Alphabetical List of Advertisers see page 18.

A

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Canadian Tube & Steel Products Ltd.
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B

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Northern Electric Co. Ltd.
Conduit:
Can. General Elec. Co. Ltd.
Can. Westinghouse Co. Ltd.
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Smart-Turner Machine Co., Ltd.
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Dynamite:
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E

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Canadian Ingersoll-Rand Company, Limited.
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Babcock-Wilcox & Goldie-McCulloch Ltd.
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F

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G

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E. Long Ltd.
Smart-Turner Machine Co.
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Can. Westinghouse Co. Ltd.
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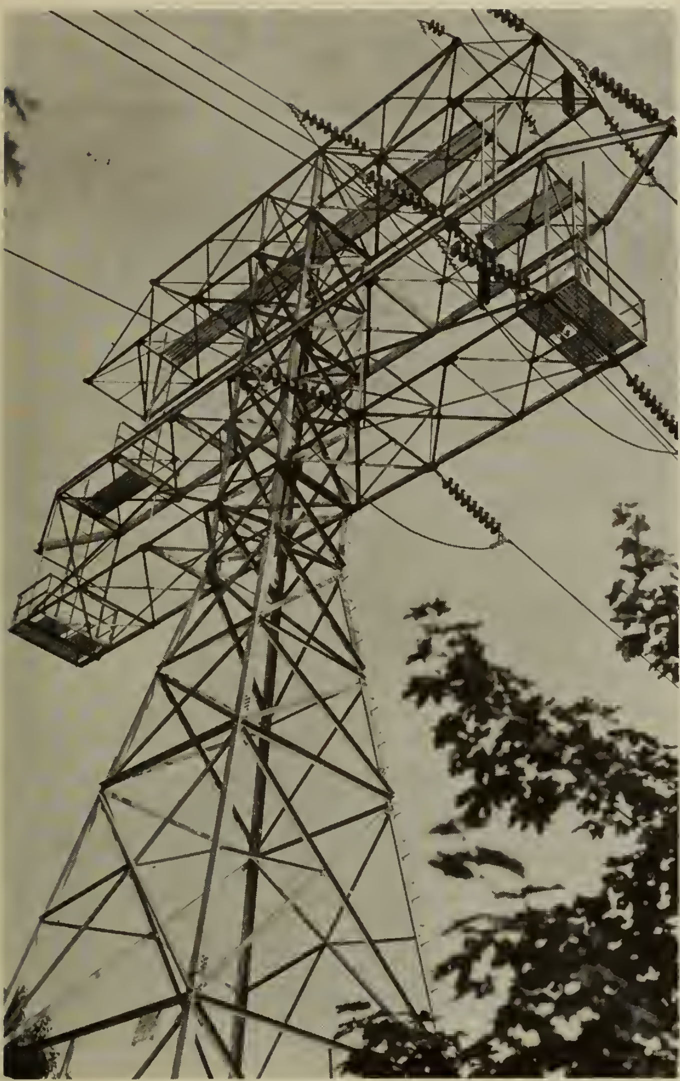

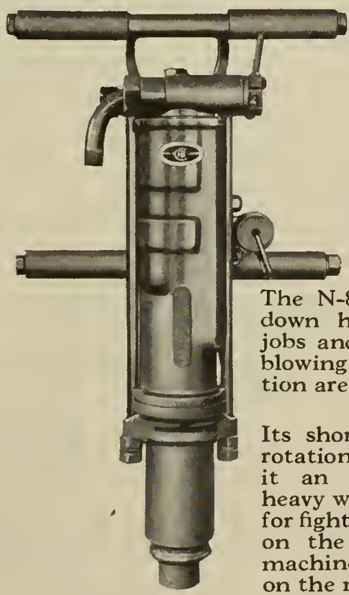

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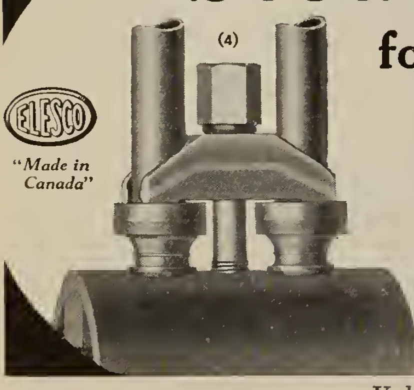

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FEBRUARY 1933

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Vol. XVI No. 2

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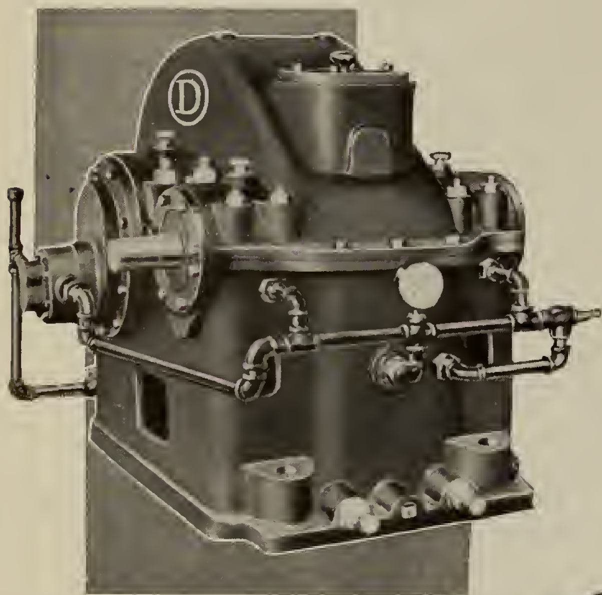

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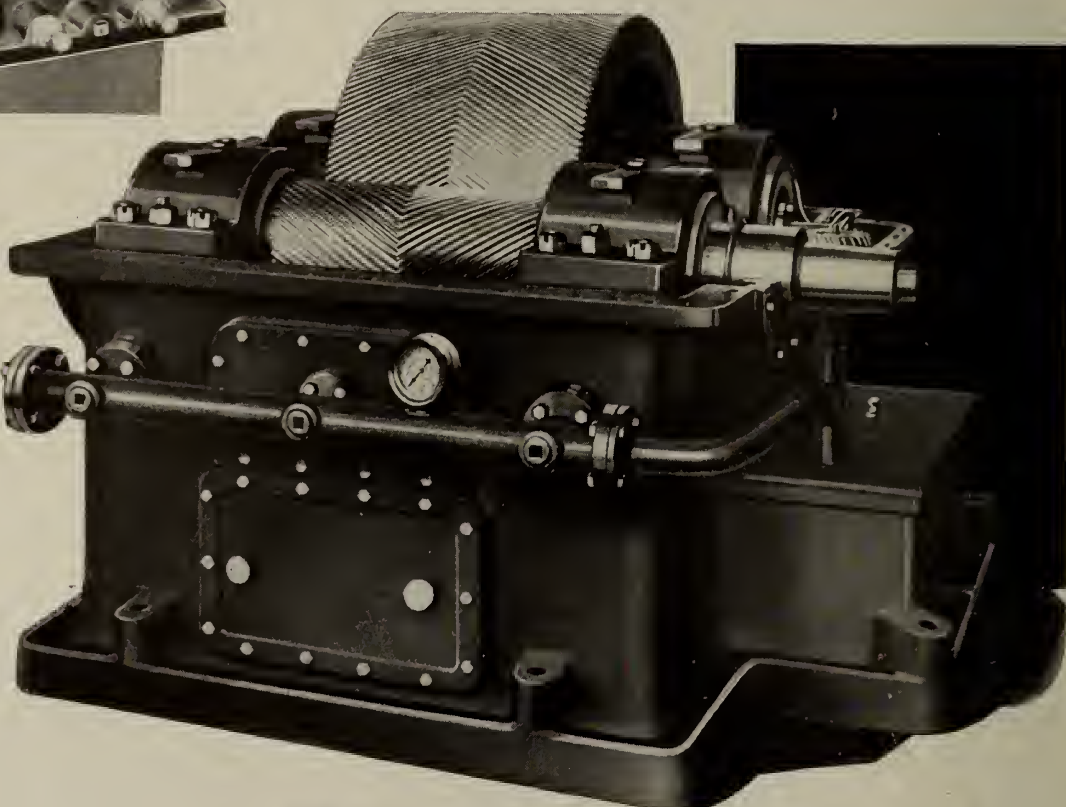

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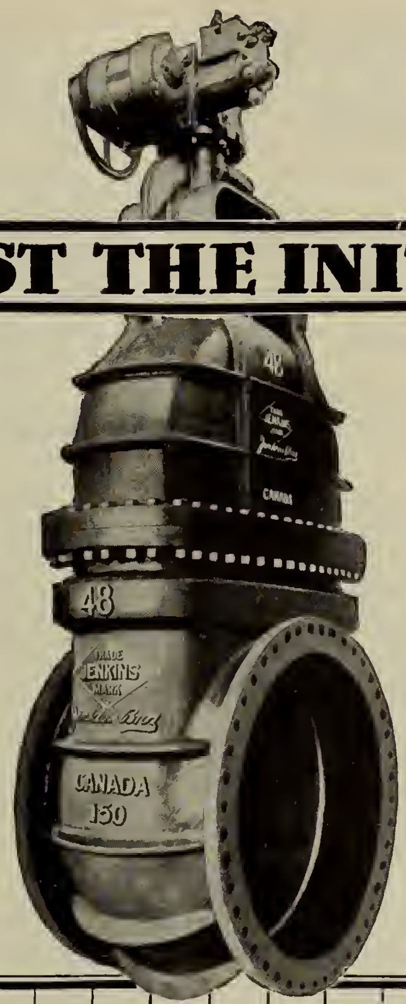

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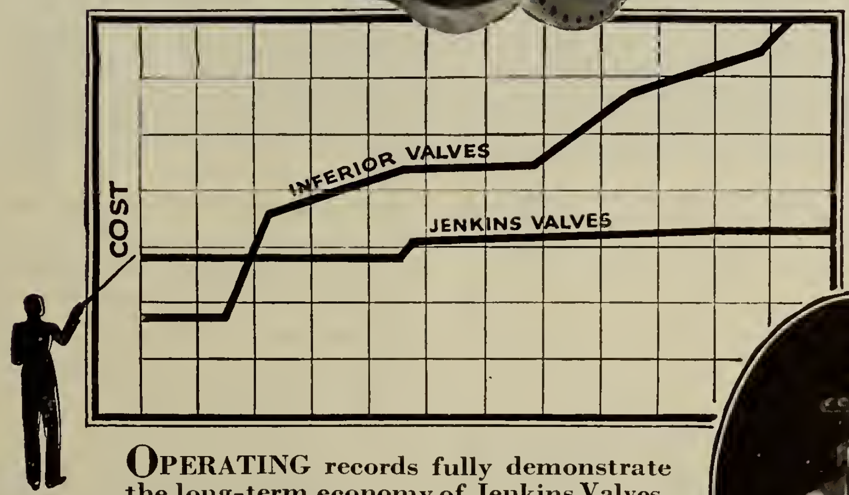

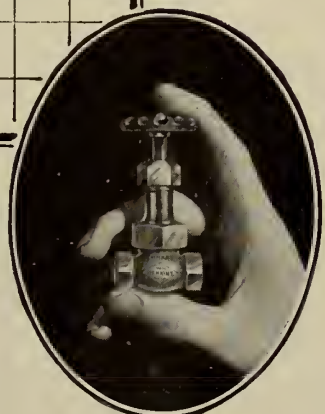

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Fig. 1—Aerial View of Chats Falls Development. —*By courtesy of Canadian Airways Ltd.*

General Description of the Chats Falls Development and Organization for Construction

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Paper to be presented at the General Professional Meeting of The Engineering Institute of Canada, Ottawa, Ont., February 7th and 8th, 1933

SUMMARY.—The Chats Falls development, of an ultimate capacity of some 280,000 h.p., utilizes one of the principal power sites on the Ottawa river, and is situated on the boundary between Quebec and Ontario. The paper first discusses the geographical and hydrographic features of the installation and then describes the interesting arrangements needed in organizing and constructing a development in which two provincial governments were concerned.

The Chats Falls development is the first major power development on the interprovincial section of the Ottawa river which constitutes a complete development of the whole flow at any site. Other important developments are those at the Quinze, Bryson and Ottawa. The first of these latter plants, which has a capacity of 40,000 h.p., is above Lake Timiskaming and consequently entirely within the province of Quebec. The Bryson development is on the interprovincial section of the river, but, as the river is here divided into two channels by Calumet island, and the interprovincial boundary follows the larger channel, the development on the eastern channel is entirely in the province of Quebec and, furthermore, is not a complete development of the river. At Ottawa, the Chaudiere dam spans the whole width of the river and controls the head-water for a number of independent plants located in either province, but only part of the potentiality of the river is used here.

There are numerous developments on the tributaries, some of great size, as on the Gatineau, Lievre, Kipawa and Madawaska rivers.

Throughout the interprovincial section of the river there are numerous undeveloped sites, many of them of great potentiality and, for the most part, capable of economical development. Remoteness of markets for the output of the larger among these had precluded development up to the present time.

The Ottawa River

The Ottawa river has had a colourful history. It was a most important route of travel as early as three centuries ago. It was for a long time the main route of trade with the Indians to districts north and west of its own watershed. More recently it has seen lumbering developments on a vast scale, and important pulp and paper manufacturing establishments are now located on the main stream and its tributaries. Extensive mining developments have taken place in adjacent territory. Important storage developments have been built for the benefit of lumbering and for water power, particularly on tributary streams.

The portion of the river developed at Chats Falls is that between Chats lake and Lake Deschenes. These lakes are formed by two expanses on the river and have areas of 27 and 36 square miles, respectively. Uniting them is a channel about three miles in length, in which there was a natural fall of 50 feet, 38 of which occurred at Chats Falls at the lower end of the 3-mile channel, and the remainder in the rapids above the falls. The rapids and falls are separated by a broad expanse in the river known as Fishery Pool, having an area of approximately one square mile, which now forms the forebay of the development. The falls discharge directly into Lake Deschenes. The river channel at the crest of the falls was divided by islands into a number of chutes extending diagonally across the main course of the stream, the chutes at the two extremities being some two miles apart.

There were obtained at various times, rights to develop power on individual chutes or on groups of chutes. Some of these rights existed fifty or more years ago, and, on account of the difficulty in obtaining complete co-operation among the various interests involved, development on a comprehensive scale was retarded. Certain properties and development rights were obtained on the Ontario side by the late Honourable Mr. Harty as early as 1883, and these, along with others held by Mr. D. O'Connor, of Ottawa, with whom Harty had become associated, were expropriated by the Hydro-Electric Power Commission in 1912. This expropriation, along with the purchase, or expropriation, of other properties and minor rights, placed the Commission in complete control of all Ontario rights of development, that is to say, as far as the interprovincial boundary.

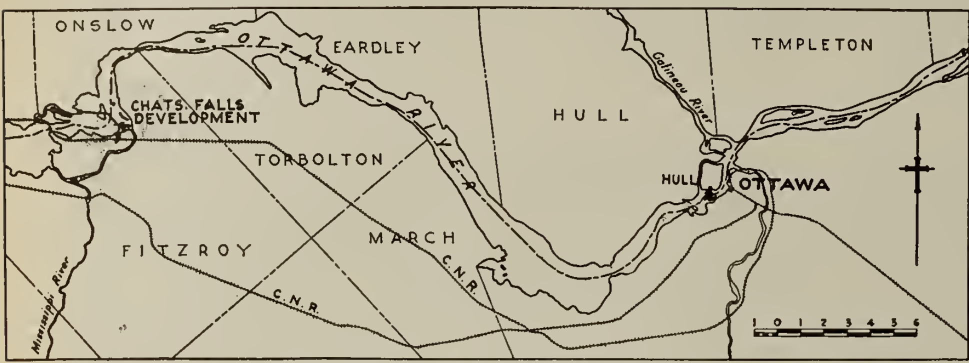

Fig. 2—Location of Chats Falls Development.

Certain proposals for development of that part of the site lying in the province of Quebec were under consideration at various times, and surveys and reports were made. In fact, on one of these, construction had proceeded to a certain extent. Prior to this, of course, all development rights on the Quebec side of the boundary had been combined and a development license obtained from the Quebec government.

Some years ago, the Chats Falls Power Company, now known as the Ottawa Valley Power Company, was formed and proceeded with surveys and plans for a development that would place a power house at Egan Chute, with a dam to a point on the Ontario shore upstream from Fishery Pool. This development would, of course, use only half the flow of the river. An agreement was made in 1928 between this company and the Hydro-Electric Power Commission for a development of the whole site in one power house. The agreement provided for the organization described later, and was followed by the completion of a contract whereby the Hydro-Electric Power Commission purchased that half of the power belonging to the Ottawa Valley Power Company. Surveys and engineering studies proceeded forthwith, and construction commenced in the fall of 1929. Four units were operating by the fall of 1931, and four more a year later. Headworks have been constructed for two additional units, the completion of which is contingent on the construction of additional storage works to further increase the minimum dependable flow.

The Ottawa river rises in Quebec about two hundred miles east of the interprovincial boundary, and thence flows westerly to enter Lake Timiskaming at its northerly extremity. The course of the river here changes to a southerly and southeasterly direction until the confluence with the St. Lawrence river is reached. From the northerly end of Lake Timiskaming to Carillon, about twenty-five miles above the junction with the St. Lawrence river, it forms the boundary between the provinces of Ontario and Quebec. The district in which it rises is a maze of rivers and lakes, not yet completely mapped. Here close together are

Fig. 3—Mosaic of Power Site, showing Location of Structures.

found the sources of the St. Maurice and Gatineau rivers the latter draining Lake Cabonga through one of its main branches, while another outlet of the lake finds its way northerly to the main river. At Chats Falls the river drains an area of 34,000 square miles, and has received the outflow of many large tributaries, the most important among which are the Kipawa, Desmoine, Black and Coulonge from the north, and the Montreal, Petawawa, Bonnechere, Madawaska and Mississippi rivers from the west and south.

The enormous number of lakes found on all the tributaries and the lake-like expanses on the Ottawa play a large part in natural regulation of the flow of the river, and serve to maintain a relatively high minimum flow. Storage dams at Lakes Timiskaming, Kipawa and Quinze, along with the many smaller reservoirs on tributaries, serve to maintain a high dependable flow. Flood flows would doubtless be greatly in excess of those experienced were it not for the regulating effect of these reservoirs, natural and artificial. The fact also that the southern tributaries come into flood in the spring before the northern tributaries, has an important bearing on the size of the spring floods. The low ratio of maximum to minimum, or mean, flow experienced on the Ottawa river is, of course, characteristic of many more rivers in northern Ontario and Quebec.

Salient data regarding flow of the Ottawa river at Chats Falls are given in the following table:

Area drained	34,000 square miles
Period of flow records	17 years
Mean flow	45,000 c.f.s.
Dependable minimum regulated flow	22,000 c.f.s.
Minimum recorded flow	11,000 c.f.s.
Maximum recorded flow	200,000 c.f.s.

In addition to the above figures, it should be noted that the dependable minimum flow may be increased eventually to 28,000 cubic feet per second by the extension of storage facilities on the main stream and tributaries. The area of Chats lake, 27 square miles, provides local pondage to care for daily and weekly variations in load.

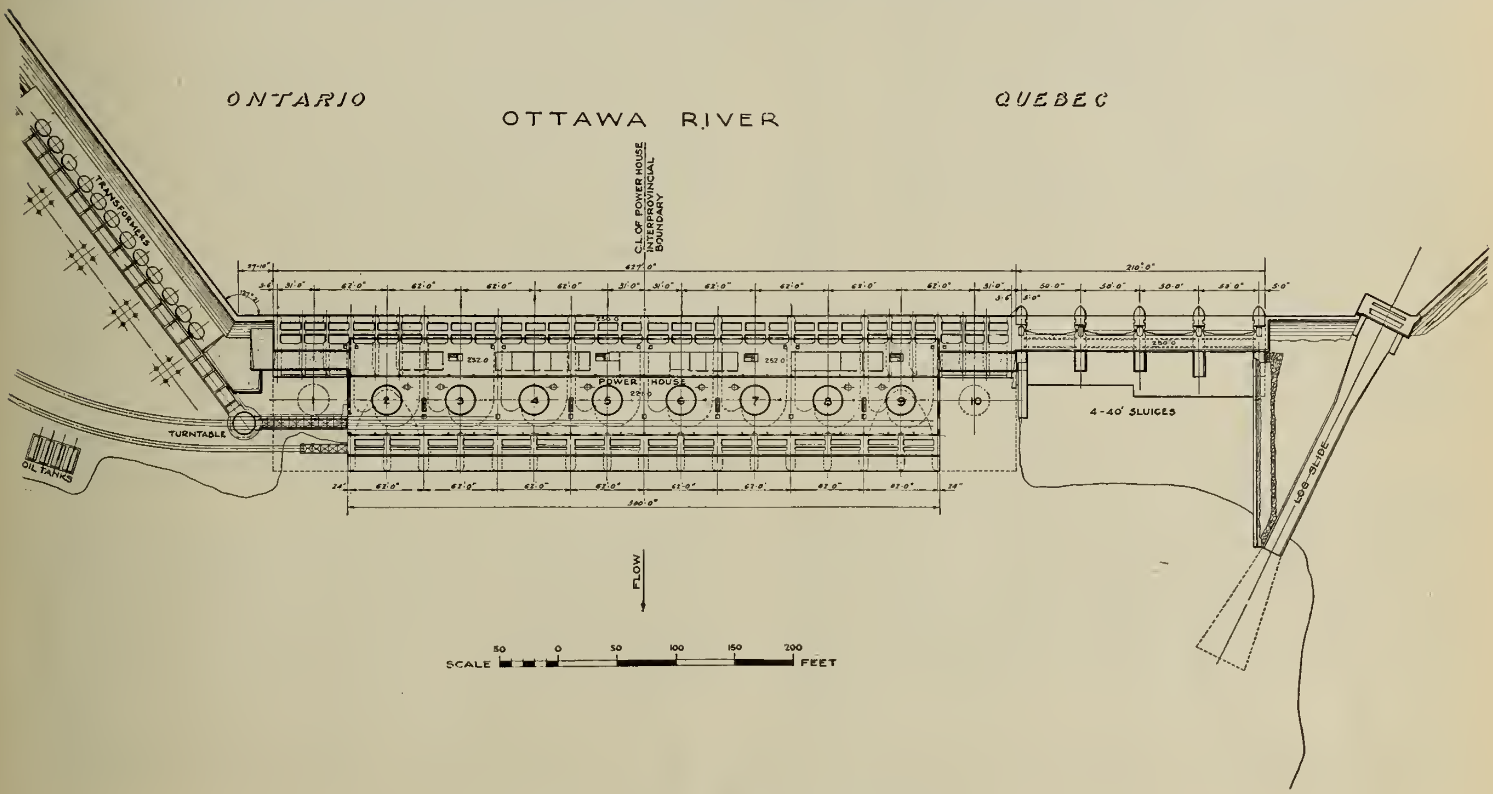

Fig. 4—Plan of Power House and Vicinity.

Description of the Development

The interprovincial boundary at the crest of Chats Falls passes through what was known as Mohr Chute. This was the most suitable point at which to locate the power house, as, with raised forebay level, a deep forebay was formed without the necessity of excavating any approach channel, and on the downstream side very little tailrace excavation was required. There was the added advantage that it was possible at this point to construct a single power house, subject to equal provincial control by the provinces of Ontario and Quebec, without requiring an officer of either province to go beyond his rightful jurisdiction. An aeroplane view of the river at the site, upon which are superimposed the principal structures of the development, is shown in Fig. 3.

To the right of the power house, that is to say on the Ontario shore, there are, in turn, a gravity section of dam some 1,200 feet in length; thirty-two stop-log sluices, each with a clear opening of 18 feet, known as the Ragged Chute sluices; a gravity section 1,350 feet long; the Victoria sluices, ten in number, also with 18-foot clear opening; and a further gravity section of 1,450 feet. Beyond this point it was necessary to continue the dam as a low earth dyke, parallel with the shore of the river, for 4,600 feet upstream. A section of the Canadian National Railway, two miles in length, which was crossed by the earth dyke, was relocated a short distance inshore.

Immediately to the left of the power house there are four sluices, each 40 feet in width, equipped with steel gates of the fixed roller type. Beyond these is a log slide, a gravity section of dam 2,000 feet long, the Wolverine sluices, ten in number, a further gravity section of 650 feet, twenty-two Merrill island sluices, and finally a gravity section 2,600 feet long, ending in a number of small disconnected sections closing low spots some distance up the Quebec shore.

The Mississippi river enters the lower end of Chats lake. A high water channel, known as the Mississippi Snye, leaves the tributary half a mile upstream from its mouth, and enters the Ottawa river below the falls. Two small concrete dams, in one of which are two sluices, were required to control the flow in the Snye.

At the control at the outlet of the lake, about three miles above the power house site, channel improvements were made whereby it is possible to maintain Chats lake levels below natural levels at high flows, in spite of raised levels at the power house. These improvements and the

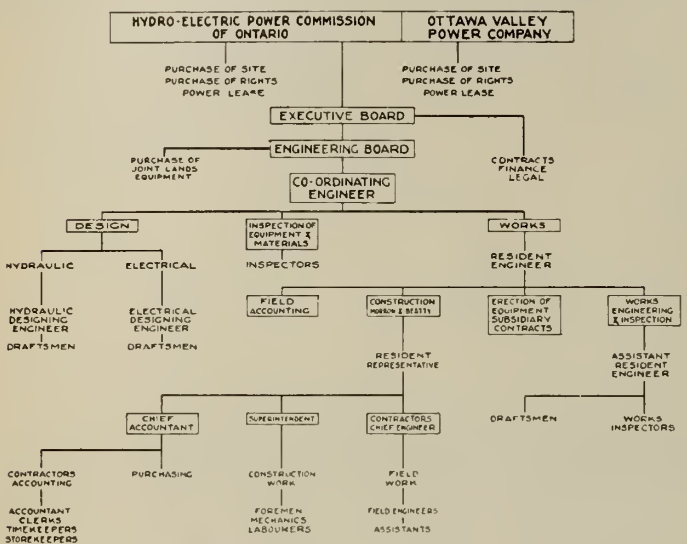

Fig. 5—Organization Chart.

dams on the Mississippi Snye are beyond the area covered by Fig. 3.

Immediately to the right of the power house, abutting on a gravity section of the dam, is a concrete platform, upon which thirteen single-phase transformers, 13.2-kv. to 220-kv., are erected, and about 800 feet from the Ontario end of the power house is the 220-kv. switching station, occupying an area about 300 feet by 360 feet. In this area are located nine oil circuit breakers and motor operated disconnecting switches. This provides for the leads from four banks of transformers, with space for leads from a fifth bank, and for two outgoing lines, with space for a third.

In Fig. 4 a general plan of the power house and the adjacent areas, including the transformer station, is shown. Descriptions of the power house layout and its equipment are given in other papers of this series.

Organization

The Ottawa being an interprovincial river, equal jurisdiction at the site is held by the provinces of Ontario and Quebec. To develop the site effectively, therefore, it was necessary that there should be cordial and close co-operation among a larger number of organizations than is usually the case in projects of this kind.

The site lent itself readily to an economic development, in which the power house crossed the interprovincial boundary, and made possible the use of a single control room and operating staff. Possible vexatious difficulties, that would arise in the operation of two independent power plants during periods of deficient water supply, were precluded. Such arrangements as to operation were more readily made because of the sale of the whole output of the Quebec half of the development to the Hydro-Electric Power Commission of Ontario.

The difficulties attendant on the construction and operation of such a joint development were not easy of solution, but the organization that was set up for the purpose functioned smoothly and effectively throughout. The general results were such that it is considered a description of the organization is warranted.

By an agreement between the Commission and the Ottawa Valley Power Company, two Boards were set up, known as the Executive Board and the Engineering Board. Each of these consisted of four members, half being appointed by the Commission and half by the company.

The Executive Board, of which Dr. F. A. Gaby, M.E.I.C., was appointed chairman, was charged with decisions on matters of policy in connection with the acquisition of properties and construction of joint works, approval of plans and letting of contracts, administration of funds for joint expenditures, employment of staffs and experts, and to supervise generally the carrying out of the joint works and to deal with all contingencies connected therewith. It was empowered also to delegate to the Engineering Board such of its powers as it saw fit.

The Engineering Board, of which the writer was chairman, was charged with the preparation of plans and specifications, and supervision of construction of all joint works, the organization of the engineering, accounting, inspection and purchasing staffs, the recommendation of all proposed contracts to the Executive Board, and other duties especially delegated to it from time to time.

The organization chart in Fig. 5 shows the relationship of the two principal organizations and their subsidiaries. All instructions from the Engineering Board were passed to a co-ordinating engineer, and thence as indicated on the chart. This concentration of responsibility in one person reporting to the Engineering Board operated very smoothly and effectively. Frequent meetings of the Engineering Board and careful attention to the transmission of information to its members in intervals between meetings enabled the Board to base its decisions on continuous knowledge and study of the problems in hand.

As the Commission had a well organized engineering and designing staff, this was used on the development, suitable arrangements being made as to compensation of the Commission by the Executive Board for these services. The inspection staff and laboratories of the Commission were also used.

Contact with the contractor and all parts of the field organization was entirely through the resident engineer at the works. The contractor's organization is also outlined in Fig. 5.

Apportionment of Costs

The Commission obtained from the Ontario government a lease of the residual water power rights in Ontario at the site, and by purchase, or expropriation, certain prior rights. The water power rental is payable to the province of Ontario by the Commission, not by the development as a whole. In the same way, the Ottawa Valley Power Company obtained a lease of the power rights in Quebec not already granted by the province of Quebec, and, by purchase, all other rights at the site. The Quebec rentals are payable by the company.

The Commission acquired, at its own expense, all necessary lands and rights in Ontario from tailwater to Chats lake, and, similarly, the company acquired all necessary lands and rights in Quebec between these limits. Lands and rights on Chats lake were treated as joint lands, and were paid for equally by the company and the Commission. By the agreement, all lands however acquired in Ontario became the property of the Commission, and those in Quebec became the property of the company.

For the purpose of construction, all works, with the exception of the transformer and switching stations and operators' cottages, were treated as joint works, and the costs were shared equally by the company and the commission.

By the agreement, on completion of construction, the dam, power house headworks, all railways and roads, are to be treated as joint works, and the power house and power house equipment as separate works. Thereafter, until the expiry of the agreement, the Executive Board will maintain and operate the joint works for the mutual benefit of both parties, whereas the company and the Commission may deal as each sees fit with its own separate works.

General Results

The estimated cost of the development and the continuity of river flow were such as to make the project appear very attractive. Unusual conditions as to river discharge and stage and favourable weather during the whole period of construction resulted in appreciable savings in some of the expected expenditures. The maximum flood flow during the year 1930 amounted to 106,000 cubic feet per second, and in 1931 to 70,000 cubic feet per second. These are less than the usual annual freshet flows. In fact, the 1931 flow is less than any during the period of record, with the exception of that in 1915. One result of the moderate floods was that the provisions for handling high flows were not taxed to anything approaching their capacity, thus favouring progress in construction. Furthermore, mild weather promoted progress also in both winters during which the work was being carried on.

Only one incident of importance occurred which had a retarding effect on the work. When the water had been lowered about nine feet on the power house site, a short section of the tailrace cofferdam failed by sliding. The cribs which moved were strengthened in their new position by steel sheet piling and additional fill, after which no further difficulty was experienced in dewatering the area. Subsequently, one 4-inch pump sufficed to handle all leakage through the cofferdam, which was about 1,200 feet in length.

Preparatory work, preliminary to construction, commenced in October, 1929, and two years later four units were in operation, and four more by September, 1932, a very satisfactory result for so large a development.

These favourable results, of course, were not due solely to advantageous conditions of river flow and weather. The close co-operation of the participating corporations and of the members of the Executive and Engineering Boards, the loyal and effective work of the engineering staff, and the efficient and aggressive contractor's organization, all played their part.

Personnel

The contractors were Messrs. Morrow and Beatty, of Peterborough, the principals of which firm, H. A. Morrow, M.E.I.C., and the late J. A. Beatty, M.E.I.C., were actively connected with the work, and were assisted by James Dick, A.M.E.I.C., as engineer and Mr. J. Barrett, general superintendent. The writer would like to take this opportunity of expressing his appreciation of the late Mr. Beatty, who played such a large part in the construction of the development, and whose high ethical standards, excellent judgment and charming personality contributed so largely to the excellent relations that existed at all times between contractors and principals. His death on March 28th, 1932, removed one who merited and received the respect and high regard of all who knew him.

Reference was made above to the constitution of the Executive and Engineering Boards. The members of the Executive Board were Dr. F. A. Gaby, M.E.I.C., chairman, and Mr. H. E. Guilfoyle, representing the Hydro-Electric Power Commission of Ontario, and Colonel C. W. Allen and J. B. Woodyatt, M.E.I.C., representing the Ottawa Valley Power Company. F. A. Robertson, A.M.E.I.C., acted as secretary to the Board. The writer of this paper was chairman of the Engineering Board, on which he and E. T. J. Brandon, A.M.E.I.C., represented the Commission, and J. S. H. Wurtele, M.E.I.C., and D. Stairs, M.E.I.C., represented the company.

On Otto Holden, A.M.E.I.C., as co-ordinating engineer, fell the duty of seeing that the directions of the Engineering Board were carried out. Mr. Holden, as assistant hydraulic engineer of the Commission, was also in charge of hydraulic engineering and design; while the electrical engineering and design was supervised by Mr. E. T. J. Brandon, chief electrical engineer, with Mr. A. H. Hull as his principal assistant. Colonel H. L. Trotter, M.E.I.C., was resident engineer.

Construction Features of the Chats Falls Development

H. L. Trotter, M.E.I.C.,
Resident Engineer, Chats Falls Engineering Board; Consulting Engineer, Montreal, Que.,
and
James Dick, A.M.E.I.C.,
Chief Engineer, Morrow and Beatty Limited, Peterborough, Ont.

Paper to be presented at the General Professional Meeting of The Engineering Institute of Canada, Ottawa, Ont., February 7th and 8th, 1933.

SUMMARY.—Describes among other construction features the building of the coffer dams, of which there were an unusual number, aggregating some 95,000 cubic yards; the excavation of some 300,000 cubic yards of rock and method of handling the resulting material; the concrete plant which placed about 240,000 cubic yards and its operation, both as regards dams and power house substructure; the handling of 11,000 tons of mechanical and electrical equipment and structural steel; and the construction of an earth dam 4,300 feet in length requiring the excavation of 186,000 cubic yards of material.

The work on the power development at Chats Falls presents a number of interesting features of construction, such as the placing of concrete in structures having a continuous length of 13,500 feet; the construction of an earth dam 4,300 feet long; the unwatering of a stream which has a large variation in flow throughout the year, and the regulating of this discharge so that there would be no damage to the work as it proceeded.

The manner in which the various parts of the construction were performed may be of interest, and, in presenting these, it has been decided to deal with them in the order in which they occurred in the course of the work.

The accompanying Fig. 1 shows the general plan of the site and the layout of the structures as built.

Operations commenced in the early part of October, 1929, with the clearing of the site, which was heavily wooded throughout; the erection of camps, and the construction of a spur from the Canadian National Railway to provide access to the work.

Living quarters were provided on the site for the employees, as the local facilities in this connection were inadequate to accommodate the large number of men ultimately engaged on the construction.

The buildings erected for camps and other temporary uses were of the usual wooden construction except that they were sheathed inside and outside with three-eighths inch plaster board, a type of construction which effected an appreciable saving in the cost of labour and material.

The complete camp establishment was in two sites, both identical in plan, and these provided sleeping and dining quarters for fourteen hundred men. Each camp comprised a main dining hall and two buildings, each divided into ten sections, for sleeping quarters. Separate accommodation was provided for staff, foremen and mechanics.

The railway spur was built from the main line of the Canadian National Railway, and was used to transport construction plant, materials and permanent equipment to the central part of the site. The first mile of the track now forms part of the permanent railway to the power house and the construction of this part involved building bridges across two channels of the river. These structures are standard deck plate girders, designed for Cooper E 40 loading, and are carried on concrete abutments.

To reach the central part of the work, at Mohr island, the temporary part of the railway was carried across the main channel of the river on a standard trestle deck supported by cofferdams, a description of which is given further on.

The total length of standard gauge tracks laid was 6½ miles, of which 1½ miles remained as the permanent railway to the power house.

Cofferdams

The number of channels through which the river passed entailed a large quantity of cofferdam work; but that feature of the topography was of assistance in the diversion of the flow.

Before any unwatering was started a careful study was made as to the elevation to which the river, with certain of these channels closed, would rise at the time of maximum flow in order to determine the height to which the cofferdams should be carried. Adequate provision was made in the permanent structures for discharge by the introduction of seventy-four sluices, arranged in four sections of stop log dams.

Until one of these sections was completed, through which the flow could be permanently passed, cofferdams were placed only in one or two channels at one time.

The first cofferdam constructed, known as No. 1 cofferdam, crossed the widest channel, and, carrying the track to Mohr island, had to serve as a railway bridge until the completion of the work. This condition, in conjunction with the fact that it crossed the channel of greatest discharge, and enclosed a sluiceway section of dam, made it necessary to provide means of passing the flow after these sluiceways were built and while other parts of the dam were being unwatered. Construction was of the usual rock-filled timber crib type closely sheathed on the up stream face. It was provided with fifty-four sluiceways 16 feet wide separated by piers of the same width. Stop logs were provided so that the area below could be unwatered during the construction of the permanent dam across that part of the river.

All other cofferdams were built of square timber, generally 10 by 10, in sections of about 20 feet in length. Rock pockets were about 6 feet by 8 feet in plan with a smaller pocket left empty of rock in each crib, for loading with explosive, wherever it was the intention ultimately to remove the cofferdam with dynamite.

Sheathing consisted of one thickness of two-inch plank with a second covering of one-inch. Divers were used to place the sheathing under water, and carefully scribe it to

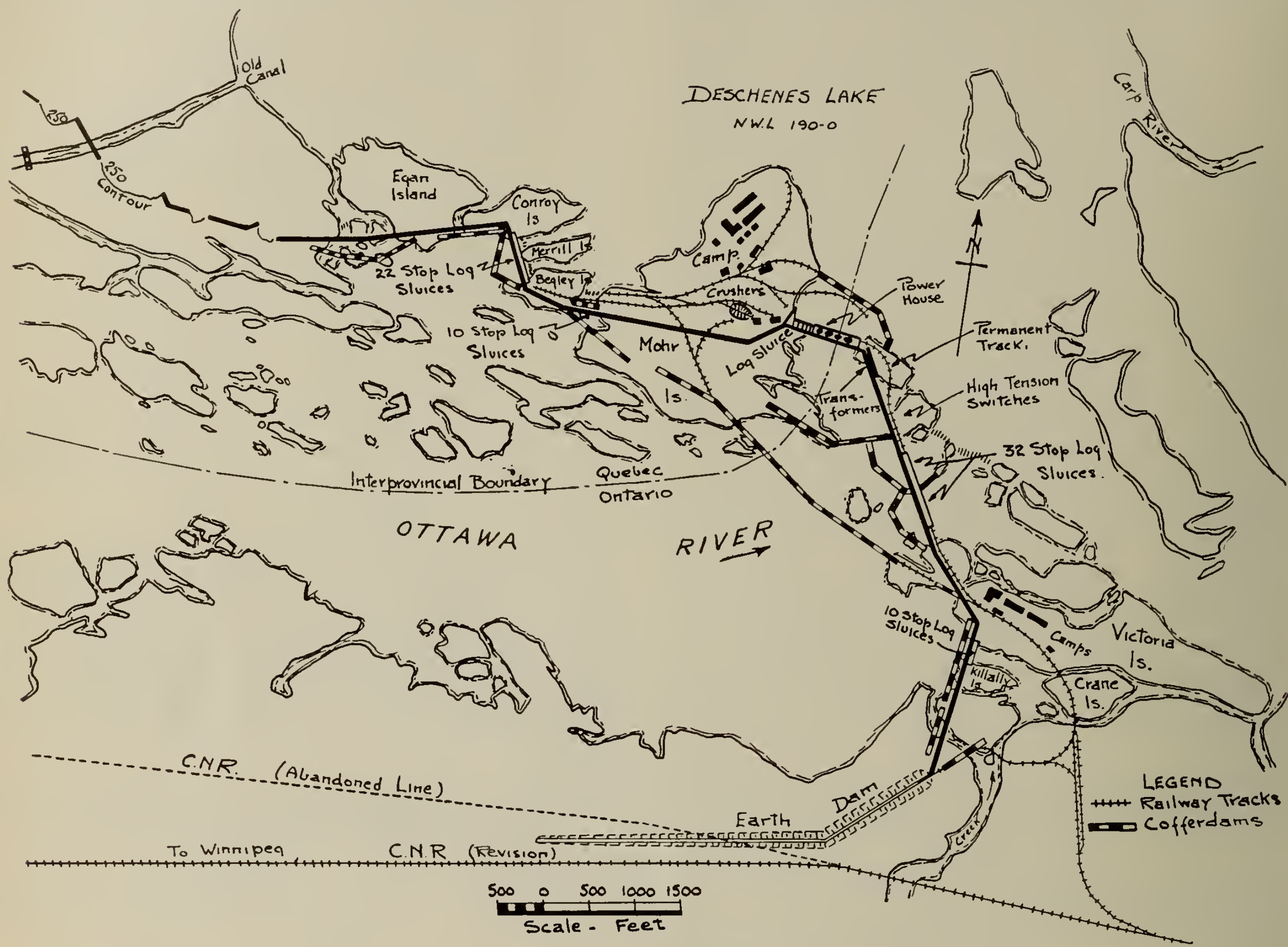

Fig. 1.—General Plan of Site.

the bottom. The usual manually operated air pumps for the divers were replaced by air service from the compressed air lines placed throughout the site and air was supplied through reducing pressure valves. The complete installation for each crew comprised high and low pressure receivers so that there was sufficient air for the diver until he emerged in case of failure in the main service lines.

The power house site, and that part of the dam lying immediately to the south of it, were unwatered by the construction of a cofferdam around the tailrace and one between Mohr and Aumond islands. The latter was so placed that it enclosed the forebay and the part of the dam mentioned without interfering with the regulation through No. 1 cofferdam sluices.

The tailrace cofferdam was on a boulder foundation overlying the solid rock to a depth of 3 to 8 feet.

The maximum head was 30 feet, and a water tight job was secured by placing a substantial toe fill, of mixed clay and gravel, along the full length of this dam to above high water level.

All unwatering structures above the dams were on solid rock so that very little toe fill was required.

Concrete, however, was used as a seal at the foot of the sheathing wherever it was above water level at the time of construction.

The construction of the permanent work across the main channel between Aumond and Victoria islands was done in two stages inside small cofferdams which diverted any leakage or discharge from the sluiceway cofferdam above.

Concrete was started on June 19th, 1930, and was confined to dry land operations until after high water, which, being late that year, reached a peak of 118,000 c.f.s. about the middle of July. With the exception of certain gaps left for passage of temporary tracks, all concrete in the dams, between Victoria island and Conroy island, was completed by December 19th, 1930, a distance of 8,000 feet.

The completion during this time of the thirty-two sluices in the main channel permitted the closing of certain channels on the Quebec side, where other sluiceway sections are located. Before the end of the 1930 season these sections were completed making available in all sixty-four permanent sluices 18 feet in width for handling the next season's flood.

Rock Excavation

The foundations of all concrete structures are on solid rock. The original surface was very rugged and considerably eroded in the stream bed and on the islands where much higher water conditions in the past had created fissures and pot holes, some of the latter having a depth of six feet. The preparation of foundations required the removal of 270,000 cubic yards of rock of which quantity 195,000 cubic yards was taken from the power house site and forebay, and the remaining 75,000 cubic yards from the dam site and other parts of the work.

The excavation at the power house was taken out in two stages. The headworks site, or upper level, was completed first. This had to be removed by sinking, in an open cut, for depths of from 12 to 25 feet, to a grade which sloped down stream from the line of the structure. The draught tube section was open face excavation and was worked from tailrace grade, 40 feet below the upper level.

Drilling was done with pneumatic hand drills using hollow hexagon steel one inch in diameter. The depth of each lift varied but did not exceed fourteen feet. The drilling was closely spaced at all abrupt changes of section, particularly at the outlines of the spaces required for the draught tubes, so that excavation was reduced to the minimum required. Compressed air was supplied by four compressors installed in a central power plant. In addition there were three portable gasoline operated compressors used as boosters to the lines at distant parts of the work, particularly on the dam excavation.

Standard gauge tracks were laid to reach all parts of the power house excavation and the rock was removed in six cubic yard side dump cars. The loading was done by three gasoline operated shovels, mounted on caterpillar traction, each with a dipper capacity of one and one quarter cubic yards. The rock is a granite gneiss and most of the quantity excavated was used for concrete aggregate, the selected material being delivered direct to the crushers or to a storage pile. Rejected rock was placed either in the tailrace cofferdam or in a waste pile from which it was later taken for use as rip rap and grading purposes.

Rock excavated from the dam foundations was wasted, or, wherever necessary, used in cofferdams. The removal was done in wheelbarrows and the rock cast to each side of the excavation. In some cases small derricks of two-ton capacity were used where the cut was deep. The foundations were grouted as the work proceeded. The grout holes were, on an average, 20 feet deep and were spaced 20 feet apart on a line from three to six feet from the up stream face of the dam.

Grouting operations, disclosing faulty rock, determined the depth to which the excavation had to be carried. This depth throughout the length of all dams averaged five feet.

Concrete

All concrete was mixed at a central plant located near the power house and about the centre of the development. The equipment installed for concrete production comprised rock crushers, mixers, batchers and belt conveyors for handling sand, stone and cement. All this equipment as well as other stationary power equipment was electrically operated.

Fig. 2 shows the arrangement of the concrete plant.

The crushing plant consisted of two crushers, the first being a 36-inch by 48-inch jaw crusher rated to give a daily production of 1,900 cubic yards of 8-inch stone, and a cone crusher of like capacity. A 36-inch belt conveyor, operating on a slope of seventeen degrees, carried the stone from the primary to the secondary crusher where it passed over a fine "grizzly" before entering the hopper. The fines resulting from the first crushing were thus removed and by-passed on a 12-inch belt conveyor to a waste pile.

The finished stone was carried from beneath the cone crusher by a 24-inch belt conveyor up a slope of nineteen degrees to the distributor above the storage pile. As the stone left this belt it passed over a vibratory screen which removed the dust caused by the secondary crushing. The removal of dust and other fine material from the crushed stone was found to be advisable because they had a tendency to assemble in the stock pile, and, passing with the stone to the mixers, would cause sudden increases of fine aggregate in the concrete. To provide adequate storage the stone was distributed at the top of the pile by the use of a shuttle conveyor, and the quantity was maintained at about 8,000 cubic yards. The stone was forwarded, from beneath the pile, to the bin above the mixing plant on a 24-inch belt conveyor which operated through a timber tunnel, 6 feet by 6 feet in section, placed underneath the full length of the storage.

This conveyor received the stone at a number of places through openings in the tunnel roof and the delivery to the belt was controlled by duplex gates.

The handling of the sand to the mixing plant was done in the same manner as the stone, using equipment of the same size and type. The sand was obtained from a deposit about 40 miles from the power site, and was shipped to the work in bottom dump gondola cars of 40 cubic yard capacity. Loading at the pit was done by a crawler crane equipped with a 1¼-cubic yard clam shell bucket. With this type of equipment it was possible to make a selection of the material. It was not necessary to create a large storage of sand at the job because the shipments were regulated to suit the demand. The unloading track was carried on a trestle placed over the conveyor tunnel and the cars were unloaded directly into the storage.

Bulk cement was used and was stored in a timber bin of ten-car capacity. This bin was divided into a series of hopper bottom pockets and at the lower end of each of these was a slide gate through which the cement was passed to an 18-inch belt conveyor for delivery to the batchers in the mixing plant.

The standard box cars in which the cement was shipped were unloaded by a power operated scraper manually directed.

No trouble was experienced by cement sticking or arching in the storage hoppers, nor was there any leakage at the slide gates, as these were effectively sealed with rubber packing. A small air operated vibrator was, however, placed on the side of each cement weighing batcher to assure that these emptied completely for each batch.

Light railway equipment was used for the movement of concrete and the tracks were laid throughout the length of the dam and power house on a light wooden trestle placed on the up stream side of the structures, with the base of rail slightly above the level of the top of the forms. Concrete was transported in one yard, V-shaped, side dump cars, of 24-inch gauge, hauled in trains of eight to ten cars by a gasoline locomotive. These trains operated each way from the mixing plant as the formwork proceeded. To permit the work to proceed at a number of places at one time, the concrete was also transported in standard gauge 6-yard side dump cars from the mixing plant to two distributing points, one near the south end of the work and the other some distance to the west. A large hopper was placed at each of these distributing points and from these the concrete was hoisted to above the level of the dam, and taken away in the small equipment on the trestle which paralleled the dam.

The location of the light railway trestles permitted placing the concrete directly into the forms, and the hoppers through which it passed were fitted with flexible metal spouts, made up of detachable tapered sections, to facilitate

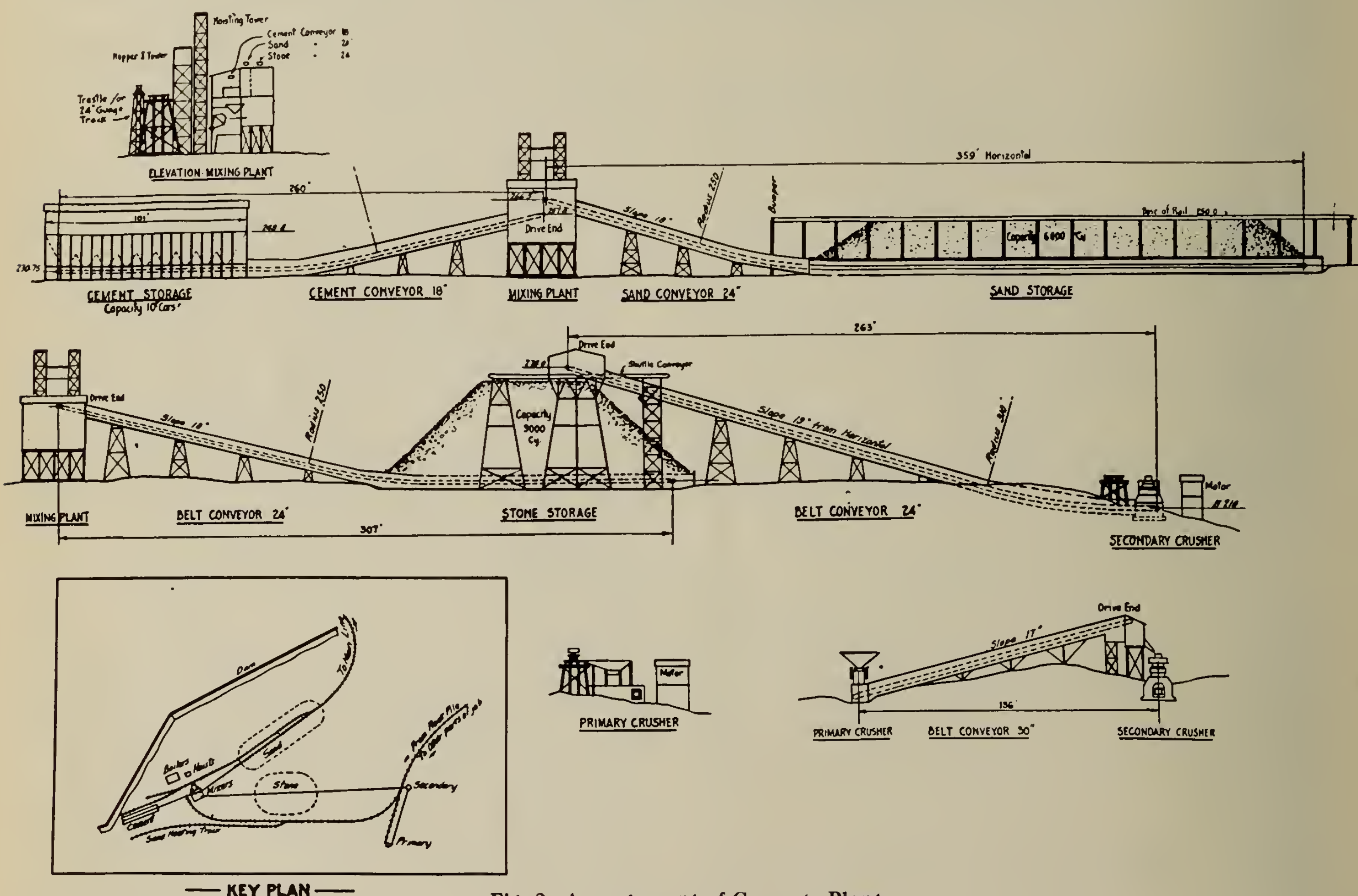

Fig. 2—Arrangement of Concrete Plant.

The mixing plant consisted of two 2-cubic yard tilting mixers. The sand and stone stored in a bin above the charging floor were delivered to the mixer hoppers, by gravity, through short chutes controlled by lift gates.

All materials and water were weighed; and the mixing time was set at two full minutes in the mixing drum.

The establishing of a central concrete mixing plant was necessary for economy of production, but it entailed the transportation of concrete to the forms of the dam for distances which reached a maximum of nearly two miles.

the distribution. All concrete was placed in this manner except the mass surrounding the draught tubes and scroll cases.

This mass concrete was placed by dumping from the cars on the trestle into inclined chutes, having a slope of 5 in 12.

The concrete passed down the chutes by gravity to hoppers leading to vertical flexible spouts, and through these it was conveyed to its required location in the forms.

Concrete placed in the dams and headworks was done continuously from rock foundations to the finished level without horizontal joints, thus eliminating leakage in dams and breastwalls. Gravity dams were built in sections 40 feet in length. Stop log dams and sluice gate dam were formed in three operations; first the aprons were placed, leaving the pier section out down to the rock; then the piers were formed, after which the decks were placed. Construction of the power house headworks was carried out in placed, and stopped about nine feet below the level of the floor of the scroll case to permit of placing the draught tube liner and speed ring anchorages.

This section was also bulkheaded midway between centre line of units. In the next operation the concrete was carried to the scroll case floor level and the outline of this mass conformed neatly to the plan of the scroll case.

After the speed ring of the turbine was installed the forms with the pit liner were placed and the concrete was

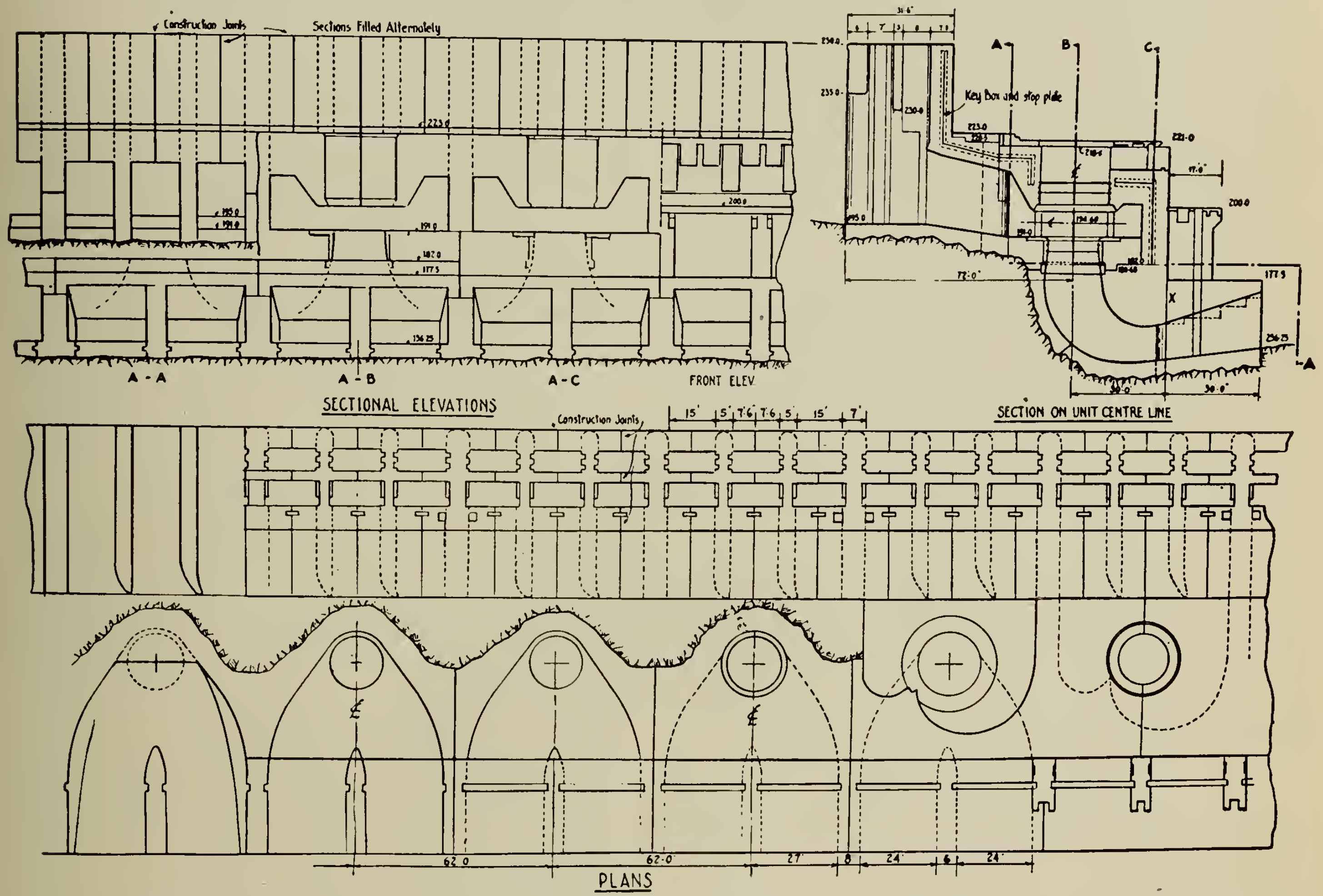

Fig. 3

Note: All construction joints are provided with key boxes and, at sections under hydrostatic pressure, with stop plates. Joint X has coating of emulsified asphalt.

a similar manner, except that each pier with curtain wall, intermediate wall and breast wall extending to the centre of the span on either side was built as a unit, thus making a vertical construction joint at the centre of each span of the intake passages.

The power house substructure may be divided into three sections; the headworks, the part surrounding the draught tube and scroll case, and the extension to the draught tube with tailrace piers lying outside the line of the power house proper. These main divisions are indicated by vertical joints which are continuous for the full length of the structure. The concrete in the latter two divisions mentioned was placed continuously between horizontal construction joints as shown on Fig. 3.

In the power house substructure the initial operation was that of placing a concrete base to receive the draught tube form of each unit. The piers and walls separating the units outside the down stream line of the building were then built, closely followed by the slab above, which was bulkheaded at the centre of the piers separating the units. The concrete surrounding the draught tube proper was then completed to the generator floor level. The construction joints of this section are at the centre line of units.

In the superstructure of the power house, which has a structural steel frame, the roof forms were carried on the trusses and were the first to receive concrete.

Using the roof slab as a runway the wall forms were then filled. In order to prevent cracks developing in the walls, from temperature changes, the pilasters formed about the main columns were concreted first up to the level of the top of the windows, after which the panels surrounding the windows were placed. The wall between the top of the windows and the roof was then placed with expansion joints at the same points as those provided in the steelwork, i.e., 62-foot centres.

To prevent leakage at all horizontal and vertical construction joints in the dams and power house substructure the adjoining sections were keyed together, and, on the gravity dams, the vertical joints were given a 3/16-inch coat of emulsified asphalt, applied with a trowel and left to set, before the adjoining concrete was placed. No asphalt was used on such surfaces in the power house, but, to prevent leakage, a steel plate 3/16-inch thick and 14 inches wide, coated with asphalt, and having end connections lapped and welded, was placed in one of the checks or keys, 7 inches into the concrete on each side.

The total quantity of concrete placed was 240,700 cubic yards and 105,000 cubic yards of this was placed in the winter. To protect this concrete from frost the sand and water were heated before reaching the mixers. The method used to heat the sand was by fitting the cars, in which it was delivered, with a system of pipes so arranged that steam could be exhausted into the body of sand for some time before the cars were unloaded.

The concrete was protected during the placing and setting by completely closing in the forms with tarpaulins carried on suitable timber supports. The temperature inside this housing was maintained well above freezing by using a number of fan heaters equipped with steam coils.

The placing of concrete continuously from foundation to finished level made it necessary to have forms of rigid construction and securely braced to withstand the pressure induced by this operation.

No radical changes were made in form design other than to increase the size of the bracing. The usual 2-inch by 4-inch studding with one-inch sheathing was used throughout for wall construction except on the gravity dams, where forms were built in panels and used repeatedly. Both of these types of form were braced horizontally by 6-inch by 6-inch walers placed 24 inches apart and over these 6-inch by 8-inch verticals were placed at 6-foot centres. The form walls were held in place by ½-inch rods threaded into clamps, fastened to the bracing on each side of the structure, and separators were placed inside the forms and removed as concrete work proceeded.

The curved portions of the draught tubes and scroll cases required forms of intricate construction and these were built in the carpenter shop. Each unit was made in two sections, split on the vertical centre line in the case of the draught tube and on radial lines in the scroll case form. These were made as light as possible for handling and additional internal bracing was necessary after they were placed and connected to the adjoining form-work.

Equipment Installation

The standard gauge tracks laid to reach all important parts of the work provided economical facilities for handling the permanent equipment to the various sites on which it was to be installed.

The aggregate weight of this equipment was 9,600 tons and the heaviest single shipments were the 220-kv. transformers which weighed 114 tons. These were unloaded by the power house cranes and moved to the permanent site on a truck designed for that purpose.

Those parts of the turbine equipment which are incorporated in the concrete were placed before the power house cranes were available. Owing to its size the speed ring came in sections which comprised: the upper stay ring, in five pieces; ten fixed vanes, and the lower stay ring which supports the movable vanes. The turbine pit liners and draught tube liners were also received in sections.

The erection commenced with the placing of anchor bolts for the fixed vanes and lower stay ring. The vanes were then placed with upper ring and, after levelling and centering the whole assembly, the anchorages were grouted and the scroll case forms with upper pit liner placed.

Before concrete work proceeded the speed ring was braced in all directions with adjustable bars placed radially out from the upper ring to anchors in the scroll case floor, and a steel frame was bolted inside the upper stay ring flanges.

These measures were adopted to prevent possible distortion of the ring or movement in the whole assembly by the lateral pressure of the concrete as it was placed, which was done, in this case, from the centre of one unit to the centre of the next. The remaining turbine parts and the electrical equipment were placed with the aid of the two 90-ton power house cranes which could be used together and their combined capacity obtained by using an equalizer beam.

The head gates were shipped completely assembled and were placed, by a 35-ton locomotive crane, from the headworks deck. Voids were left in the concrete for the gate guides and sills, and these parts were grouted in place after adjustment to the anchors, thus securing a more perfect alignment than if placed integrally with the mass concrete.

Each of the four sluice gates came in three sections and the erection involved only the riveting of two horizontal seams, with frame connections, and the welding of these seams after the gates were completely assembled and lined. The towers and bridging above the gates had to be completely assembled on the job. The procedure with regard to placing the gate guides and sills was the same as that employed on the headgates.

The installation of other permanent equipment and structural steel presented no unusual features, most of the work being done by locomotive cranes.

Earth Dam

The earth dam extends along the Ontario shore from the end of the concrete dam, for a distance of 4,300 feet. The width of the crest is 15 feet and the slopes are 2½ horizontal to 1 vertical with the up stream face brought to a finished slope of 3 to 1 with handlaid rip rap.

The material underlying the site of the dam, also that in the proposed borrow pits, was thoroughly investigated by digging test pits and was found to be clay of an impermeable nature. The area within the lines of the base of the dam was stripped of all loam and vegetable matter by tractor drawn wheel scrapers and a cut off trench was excavated along the centre line of the dam. The stripping from the base of the dam and the borrow pits was used to make the embankment of the Canadian National Railway diversion, part of which parallels the dam.

The dam is constructed as a plain embankment without any special treatment other than compacting the material as it was deposited. The clay as taken from the borrow pits was fairly moist and, after dumping, was spread in layers, 8 inches deep, by a blade grader hauled by a ten-ton tractor, and this machine travelling back and forth compacted the material.

A tractor drawn elevator grader operated in the borrow pit, excavating and loading the clay into 4- and 5-cubic yard trucks or into tractor wagons of 8 cubic yards capacity. Tractors were used to haul the wagons and all other equipment except trucks, and these passing back and forth over the embankment continued the work of compacting. Stone for rip rap was obtained from waste rock pile, and cofferdams which were being unloaded at the time rip rapping operations were underway. The rock was loaded by power operated equipment into standard gauge cars from which it was dumped down the slope of the dam, then hand placed to grades marked out by slope boards.

Conclusion

The foregoing description covers the chief features of the construction of this development which involved the placing of 95,000 cubic yards of cofferdams to unwater the numerous channels; the removal of 300,000 cubic yards of rock from the foundations of the permanent structures; the mixing of over 240,000 cubic yards of concrete and its distribution from a central plant to all parts of the work for distances which reached nearly two miles, most of which concrete was reinforced and required the incorporation of over 3,100 tons of steel; the placing of 11,000 tons of equipment and structural steel and the excavation of 186,000 cubic yards of material for the construction of an earth dam. In addition to these works there were a number of other activities in connection with the development, which space does not permit of mentioning in detail but which may be summarized briefly.

Of these, the construction of two small concrete and three small earth dams which were placed across subsidiary channels at the outlet of the Mississippi river might be mentioned. Part of the flow of the Mississippi formerly passed through these channels to the Ottawa river below Chats Falls and by the construction of these dams the whole flow was diverted to Chats Lake.

At the outlet of Chats Lake some 28,000 cubic yards of rock were removed from the channel to reduce the loss of head between the lake and power house, so that the level of the lake can be maintained at its normal elevation during flood periods by regulating the flow at the dam.

Construction methods on these two works were similar to those at Chats Falls and required independent plant and camps.

Other work was the diversion of over two miles of the Canadian National Railway; the installation of booms and piers for logging operations, and the construction of a number of houses for operating staff.

In reviewing the manner in which the work was done on this development there are certain factors which may be recognized as being responsible for the quality of the work and the successful conclusion of the construction on a project of this size. These may be enumerated as follows:

1. Power operated equipment was used wherever possible for the handling and erection of construction materials and the permanent equipment. Standard gauge tracks were laid to reach the greater part of the work and their installation proved economical, over 300,000 tons of freight having been handled over them.

2. The layout of a central concrete mixing plant with stone crushing plant was designed to operate with a minimum of labour.

3. Light railway equipment was used to deliver the concrete directly to the forms.

4. Horizontal joints in the concrete structures were eliminated by placing concrete continuously, and, with the precautions taken at all vertical joints, leakage was prevented.

5. The heating of concrete aggregate and the protection of the forms from frost during winter operations was accomplished without serious increase in cost.

6. Concrete operations were controlled by careful inspection during the mixing, placing and curing operations. This resulted in the production of concrete of uniform high quality and the elimination of delays, etc., in the progress of the work.

Hydraulic Design—Chats Falls Development

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Paper to be presented at the General Professional Meeting of The Engineering Institute of Canada, Ottawa, Ont., February 7th and 8th, 1933

SUMMARY.—The author describes in some detail the main dam, sluices, log slide, earth dyke and structures controlling the flow of the river, which has reached a maximum of 200,000 c.f.s. The power house, headgates and headworks are discussed, and a description of the turbines and hydraulic equipment follows. Eight turbines are at present installed each rated at 28,000 h.p. when using 5,300 c.f.s. under a head of 53 feet and at 125 r.p.m.

The Chats Falls power site includes the fall in the Ottawa river between Chats lake and Lake Deschenes. There are three natural divisions to this section of the river; first, a two-mile section immediately below Chats lake having a drop of some twelve feet; second, a wide level stretch of river having an area of approximately one square mile, known as Fishery Pool; and third, the Chats Falls proper in which occurred under natural conditions a drop of approximately thirty-eight feet to the level of Lake Deschenes. Since a general description of the development has been included in the first paper of this series, it will be unnecessary to go further into detail concerning the site.

The features of the development which are to be dealt with in this paper are, as implied in the title, mainly those concerning hydraulic design. Under this heading has been included a description of the arrangement and the essential features of design of the water controlling structures and the hydraulic equipment.

Main Dam

The dam is constructed on the ledge of rock which forms the main falls and rapids. It is U-shaped in plan, extending approximately one mile upstream on either mainland to reach the supporting contours. The location was in part governed by the site chosen for the power house which is placed astride the interprovincial boundary and adjacent to tailwater level. The location chosen, which gave the minimum estimated cost, crosses a series of islands and channels a short distance downstream from the rock ridges controlling the elevation of Fishery Pool, and reduces the backwater effect on the latter, and consequently on Chats lake, during periods of high flow. These ridges offered favourable sites for the necessary cofferdams.

The structure, which is approximately 16,500 feet in length, was designed for a water level of 247.0, Geodetic

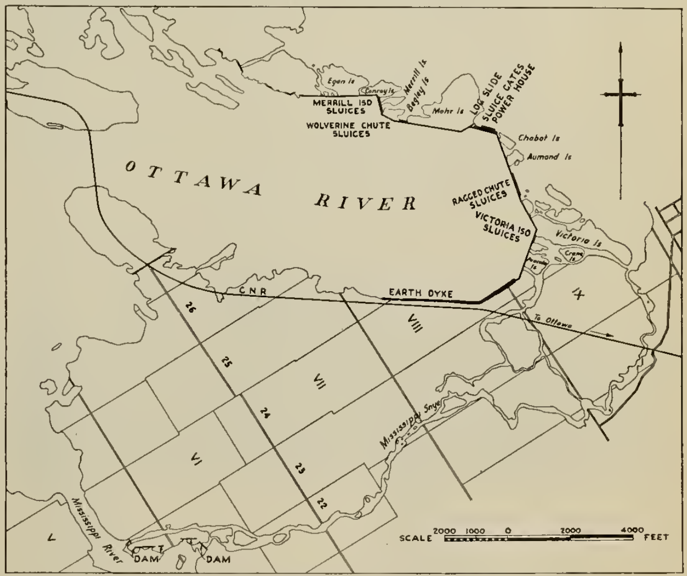


Fig. 1—General Plan of the Development.

Survey of Canada datum. It consists essentially of a number of concrete bulkhead and sluiceway sections terminating in an earth dyke on the Ontario shore. The sluiceway sections include seventy-four stop-log sluices, four gate-controlled sluices and a log slide. The main features of these various elements are briefly described hereunder.

Bulkhead Section

The bulkhead section of the dam was constructed with a vertical upstream face, a top width of 5 feet at elevation 250.0, and a vertical downstream face from the top to elevation 245.0, below which there is a batter of 8 in 12. The total length of bulkhead section is 9,400 feet. The maximum height is 45 feet, and the average height is approximately twenty-five feet.

Transverse construction joints were provided at 40-foot centres and were rendered watertight by means of keyways and a coating of a plastic asphalt compound. Each section was poured continuously to the full height of the structure. This eliminated the problem of rendering watertight the usually troublesome horizontal joints.

The section was designed with an allowance for uplift varying from two-thirds of the static head at the upstream toe to zero at the downstream toe, and an ice thrust of 5,000 pounds per lineal foot, at elevation 246.0 in addition to the horizontal water pressure.

Stop-Log Sluices

There are four series of stop-log sluices totalling seventy-four in all, each sluice having a clear opening of 18 feet. These sluices are located in the main natural channels. The sills are at elevation 225.0, and the top of the deck at elevation 251.33. Fig. 2 shows the sluices in plan and section. Forty-two of these sluices are located on the Ontario side of the river, and thirty-two on the Quebec side. The piers are 6 feet in thickness, and were streamlined on the upstream edge to provide a smooth entrance for the water. The decks are flat concrete slabs continuous over two sluices. The stop-logs are 18 inches thick at the sill, varying to 12 inches at water level, and are handled by electrically operated spud winches travelling on standard gauge tracks. In the design of the sluiceway section the same factors were considered as for the bulkhead section. Reinforcement was placed in the piers where necessary, to prevent contraction cracks.

Gate Sluices

Immediately west of the power house are located four sluices, controlled by gates of the fixed roller type, each equipped with its own hoisting mechanism. The clear opening between the piers supporting the gates is 40 feet, the sills are at elevation 223.0 and the top of the gates are at 248.0. The piers are 10 feet thick, and streamlined on the upstream ends, which are protected with heavy steel angles up to elevation 237.0. Above this point the piers slope at an angle of 45 degrees, and are heavily armoured to assist in the breaking up of ice floes which may be carried against them. Emergency stop-log checks are located a short distance upstream from the main gate checks, and structural steel gates in sections of convenient

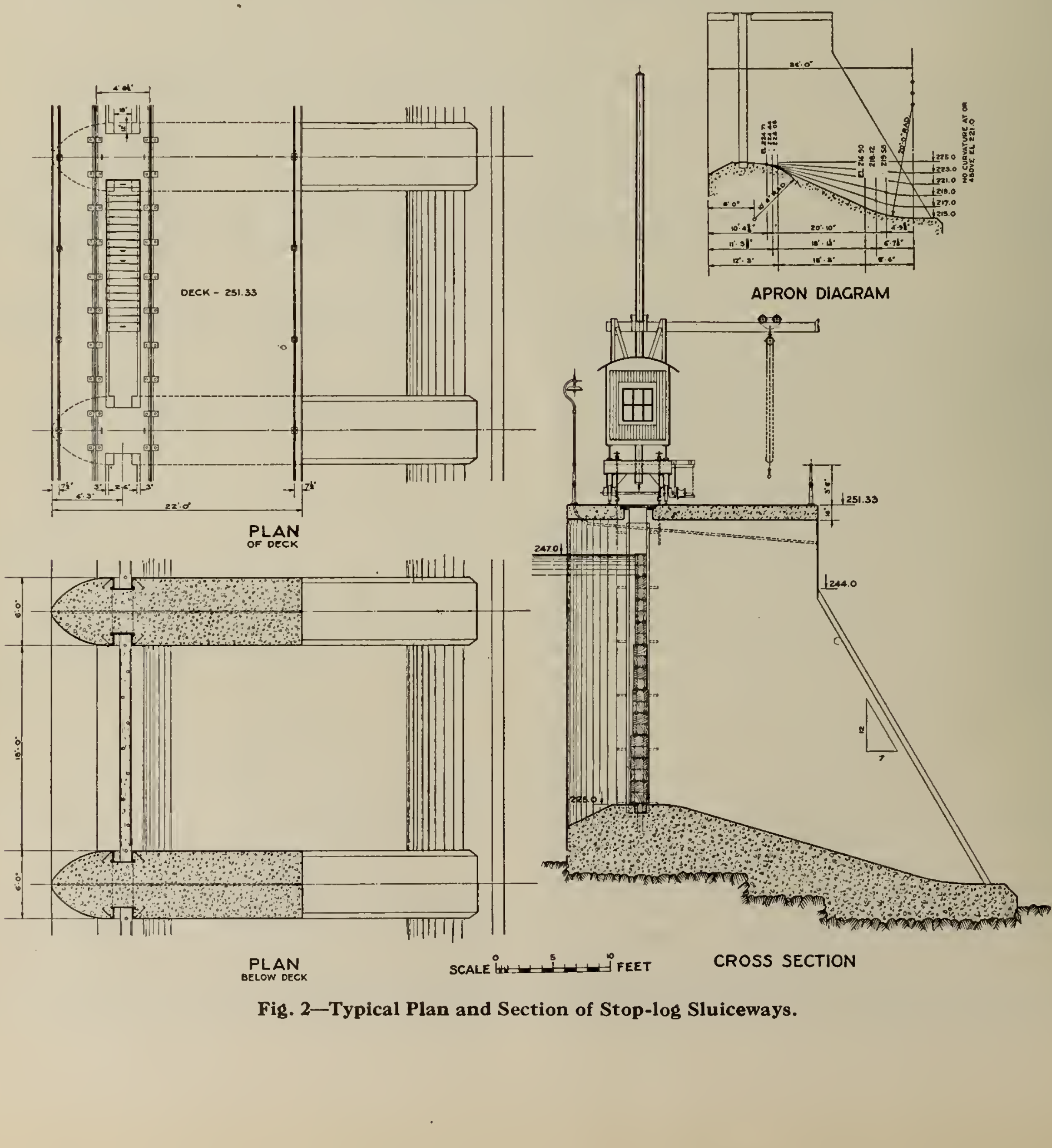


Fig. 2—Typical Plan and Section of Stop-log Sluiceways.

height, handled by means of a monorail hoist, are provided for unwatering the gates when necessary.

The deck consists of a reinforced concrete slab 10 inches thick, supported on I-beams, and is located downstream from the gate checks. In addition to serving as a convenient passageway and working platform, this deck adds lateral support to the main piers.

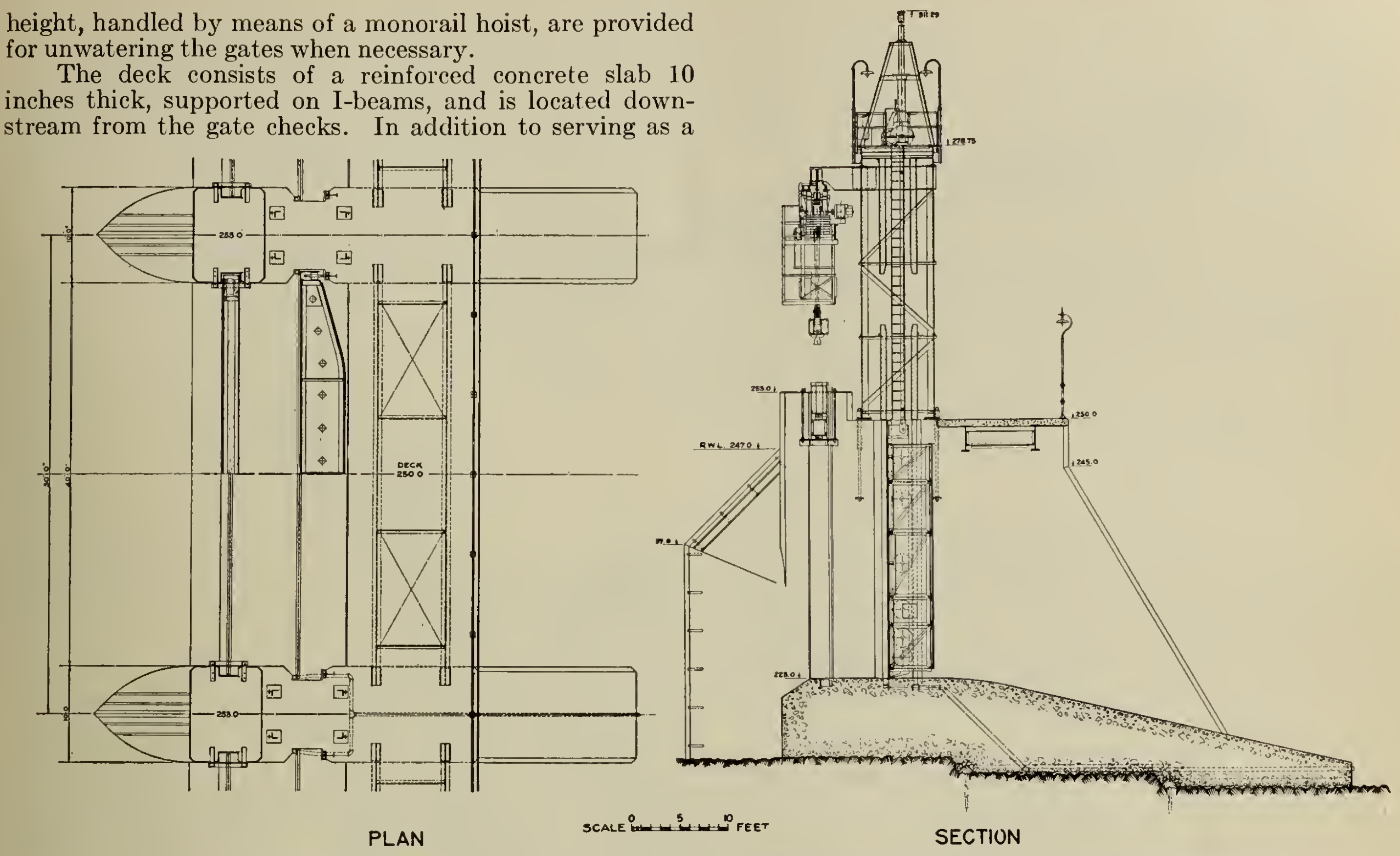


Fig. 3—Plan and Section of one 40-foot sluice gate showing Operating Mechanism and Monorail Hoist.

These sluices, which have a discharge capacity slightly greater than the full load discharge of the power house, provide a ready means of regulating daily variations in river flow and power house discharge, and permit of a minimum of stop-log operation, which is of particular advantage during the winter period.

Each gate consists of six horizontal steel plate girders connected at each end to vertical members of box section, with a ⅜-inch steel skin plate over the entire upstream face. Cast iron rollers with chilled treads are located between the webs of each of the end girders. The roller hubs are fitted with self-lubricating bronze bushings turning on fixed nickel steel pins.

To ensure operation under low temperature conditions, the gates are closed in on the downstream side and heated with electric space heaters. The checks are also protected by electric heaters in vertical chambers located in the piers adjacent to the roller paths and sealing rods, and forming a part of the embedded check steel.

The gates are rendered watertight at the ends by hard rolled bronze rods attached to the upstream face and sealing against a vertical steel plate on the gate and the planed sealing face of the embedded parts. Along the bottom of the gate a steel plate with planed edge seals tightly against the embedded steel sill.

Log Slide

A short distance west of the gate sluices is located a concrete log slide intake 30 feet wide, with the sill at elevation 236.5. This has been designed for the installation of a drop gate, but at present is closed off by the use of steel stop-logs. A timber log slide approximately two hundred feet long has been built from the intake to tailwater. A concrete wall, which extends downstream from the westerly pier of No. 4 sluice, protects the log slide from the sluice discharge. The log slide in cross-section is 5 feet in height and 14 feet wide at the bottom, with a batter of 2 in 5 on the sides.

A substantial boom extends upstream and across the river approximately 6,800 feet to guide the logs to the slide intake, and an auxiliary boom is provided which, in periods of high flow, will direct the logs to the sluices located at Sturgeon chute on the Quebec side of the river, which channel has been used for log driving in recent years.

Fig. 4—Upstream Elevation of Sluice Gates and Power House.

Earth Dyke

The earth dyke, which is the upstream extremity of the dam on the Ontario shore, is located on Chats island, and is approximately four thousand three hundred feet in length. The structure is located on a heavy layer of impervious clay, which extends down to bed rock. It is

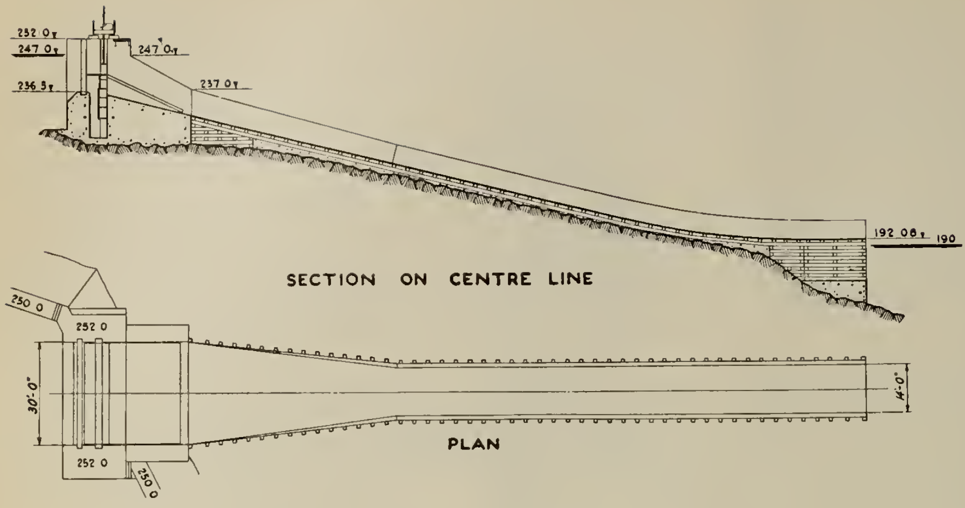


Fig. 5—Plan and Section of Log Slide and Intake.

constructed of this same clay secured from adjacent borrow pits and spread in layers. Each layer was thoroughly compacted by the heavy tractors and trucks used for transporting and spreading the material. A cut-off trench was provided along the centre line of the base, which latter was stripped of all loam and vegetable matter and ploughed before placing any fill material. The upstream face is protected by a heavy layer of hand-placed rip-rap of waste rock from the power house excavation and the unloading of cofferdams. The junction with the concrete bulkhead section of the dam is made with a specially designed U-abutment similar to the one used at the Alexander development and described in a paper presented at the Annual General Professional Meeting of The Institute in 1931.

Discharge Capacity

The maximum discharge capacity of the dam is dependent on the elevation of Fishery Pool, which level, in conjunction with the loss in the river section above, controls the elevation of Chats lake. With the sluices above described and by virtue of their location, together with the improvement in the channel at the outlet of the lake effected by the excavation of a large quantity of rock at the control section, it is possible to maintain Chats lake at or below the natural level for any high discharge. The maximum flood within the period of record occurred in 1928, when a flow in the neighbourhood of 200,000 c.f.s. was reached.

The natural discharge of Chats lake corresponding to a level of 247.0 is approximately 150,000 c.f.s. As the river flow approaches this amount the discharge through the dam must be increased until, at this stage and above, all sluices are fully opened.

Auxiliary Dams

Two small concrete dams were required to close the high water channel or snye of the Mississippi river which empties into Chats lake immediately above its outlet. One of these dams is of the bulkhead type, while the other has two 16-foot sluices controlled by stop-logs and equipped with hand-operated winches.

On the Quebec mainland several sections of bulkhead were constructed across low areas. The largest of these was to close a channel which had been excavated about 1854 for a navigation canal. A few remarks in connection with this early project may be of interest. In the above year the Legislature of Canada passed an Act authorizing the construction of a canal between Lake Deschenes and Chats lake. The canal had a projected length of 2.8 miles, with six locks 200 feet long by 45 feet wide, with 7-foot depth. A contract let in the same year for the necessary work stipulated the following schedule of prices:

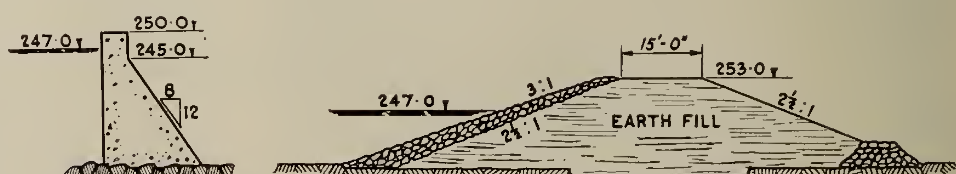
- Solid rock—5s. per cubic yard.
- Earth excavation—1s. 3d. per cubic yard.
- Clearing—£6 per acre.
- Puddling in embankments—2s. per cubic yard.
- Masonry—£1 17s. per cubic yard.

Work was carried on for about two years, when the operations were suspended after an expenditure of some $350,000 had been made, and for nearly eighty years the Chats canal has been a small water course emptying into Pontiac bay on Lake Deschenes.

Power House Headworks

The headworks or intake section of the power house is incorporated in the main dam, and has been designed for an ultimate installation of ten units. Fig. 7, showing a cross-section through the power house, indicates the relation of the headworks to the power house proper. There are three water passages per unit, each 15 feet in width and 40 feet in height to the under side of the curtain wall. Immediately downstream from the curtain wall, which is of substantial thickness to withstand ice thrust, are located the racks, which are of unit construction split horizontally into three sections and readily removable. The spacing of the rack bars is 6 inches centre to centre and these, together with the rack frames, are designed for a 10-foot head. The racks are supported in steel lined checks. Downstream from the rack checks and immediately upstream from an intermediate concrete diaphragm wall are checks for the steel stop-logs to be used for unwatering the headgates. The intermediate diaphragm forms a top seal for these emergency stop-logs, and is of material assistance in transmitting the reactions from side pressure on the main piers between units.

The headgates close an opening 15 feet wide and 23 feet high, and are of the fixed roller type, somewhat similar to the sluice gates but with the skin plate on the downstream side. Remote control apparatus enables them to be lowered from the control room. A small extension of the main power house superstructure, enclosing only the headgate hoists, permits of heating the headworks. Timber covers are provided for the deck openings, and ports have been left in the intermediate diaphragm and curtain wall



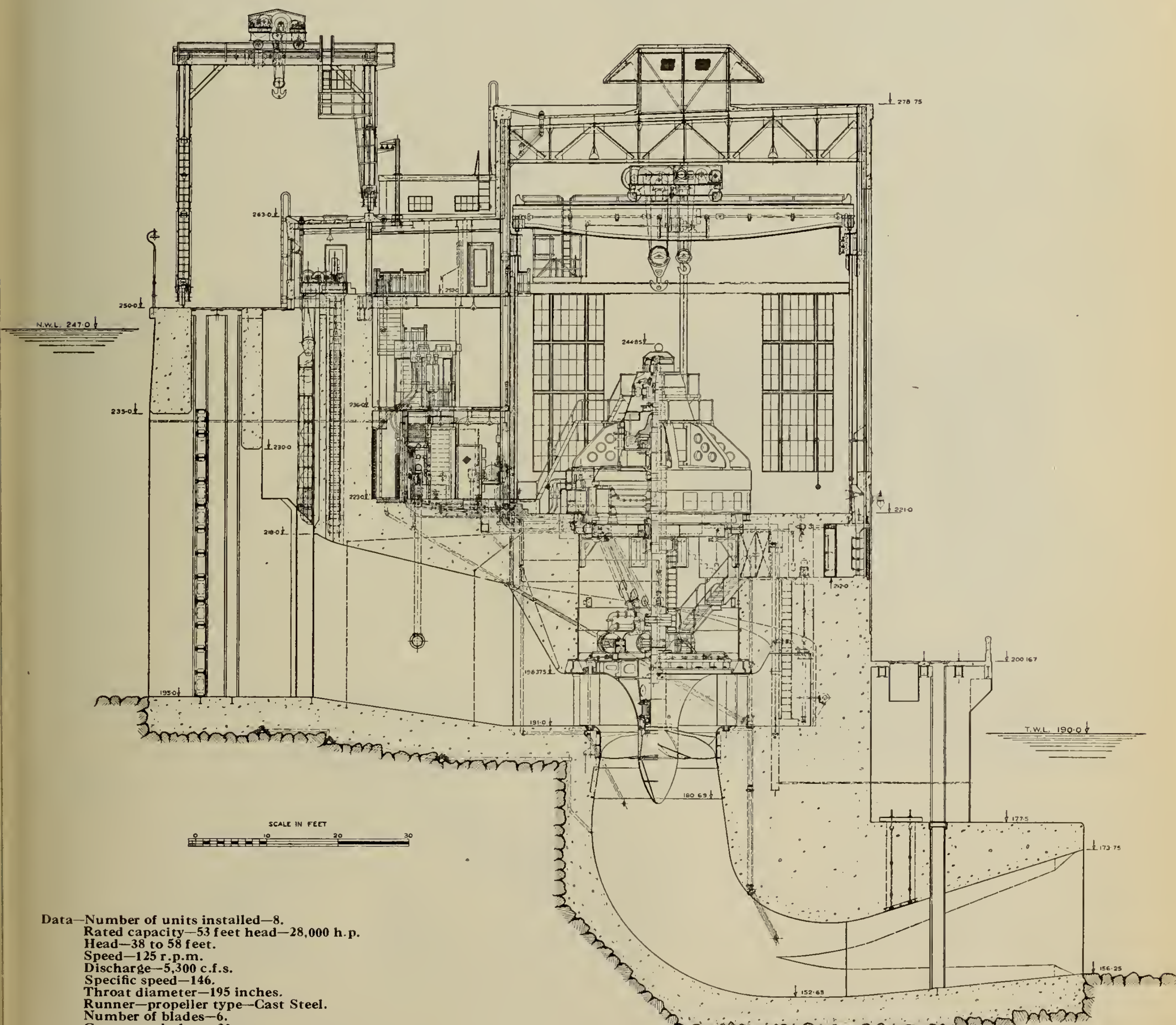
Bulkhead Walls, Typical Section. **Cross Section of Earth Dyke.**
Fig. 6

to enable the warm air from the power house to pass over the water above the racks. The headgates may be shifted upstream on two removable trolley-beams to a point clear of the superstructure wall, from which location they can be hoisted clear of the headworks deck by a 30-ton outdoor travelling gantry crane. This crane also handles the racks and steel stop-logs by means of a follower travelling in the checks, which can be attached to or released from the gates or racks from the headworks deck.

A breast wall 7 feet 6 inches in thickness separates the headworks from the power house proper. In this breast wall are located three air vents and one manhole for each unit. This manhole, with an adjustable ladder, provides access to the supply pipe and scroll case when the headgates are lowered.

There are three spare sections of racks and sufficient emergency gates for one unit. In case it becomes necessary to remove racks for cleaning, the three spare sections may be dropped into the emergency gate checks immediately downstream from the rack checks, thus protecting the opening while the regular racks are removed.

The headworks main piers have been designed as restrained beams to resist the side pressure resulting from water at maximum level. The floor of the intake was designed as an integral part of the whole structure and reinforced accordingly for vertical water loading. Underdrains were provided below the intake floor by a system of lateral and longitudinal boxes which discharge through off-takes into the tailwater.



Data—Number of units installed—8.
Rated capacity—53 feet head—28,000 h.p.
Head—38 to 58 feet.
Speed—125 r.p.m.
Discharge—5,300 c.f.s.
Specific speed—146.
Throat diameter—195 inches.
Runner—propeller type—Cast Steel.
Number of blades—6.
Gates—steel plate—20.
Governor—Morris Pelton No. 4.
Type of turbine—I. P. Morris.
Turbine manufacturer—Dominion Engineering Works.
Generator capacity—23,500 kv.-a.
Generator manufacturer—Canadian Westinghouse Co.
Stop log sluices—18 feet 0 inches wide—74.
Sluice gates —40 feet 0 inches wide—4.

Fig. 7—Cross Section through Power House on Centre line of Unit.

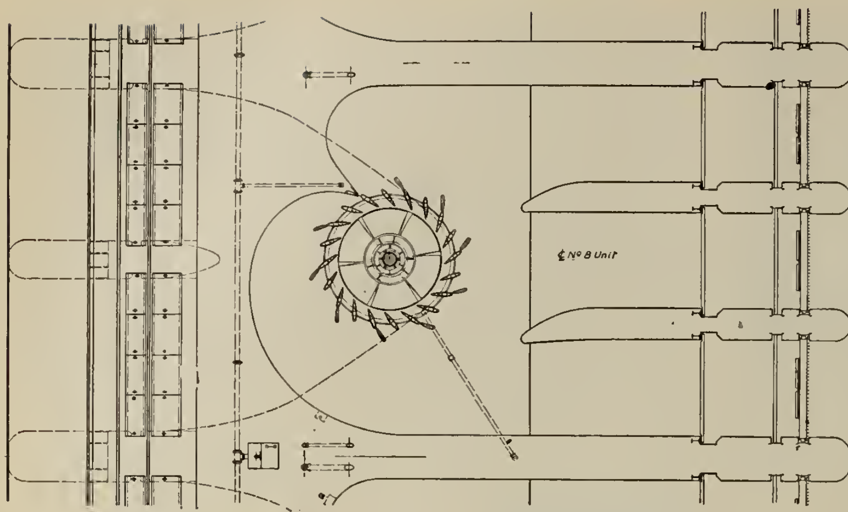


Fig. 8—Sectional Plan of Unit through Water Passages.

The roof of the headworks water passages or supply pipes was designed for hydrostatic pressure from below and for the weight of heavy equipment from above. Vertical construction joints were located in the curtain and breast walls and roof of scroll cases midway between piers, and were drained to prevent leakage into the power house.

The headworks were constructed in sections approximately twenty feet in length, each construction unit consisting of a pier, and its adjacent walls reaching to the middle of the span on each side of the pier. To eliminate troublesome and unsightly horizontal joints, each construction unit was poured from base to deck level in one continuous operation. Great care was required therefore to prevent shrinkage cracks at the intersection of horizontal and vertical surfaces, and when the concrete was within 4 feet of these junction points, the rate of placing was slowed down to 4 feet per hour.

Power House Substructure

The power house is located with the transverse centre line coincident with the boundary between the provinces of Ontario and Quebec and, as at present constructed, extends over eight units, which are spaced at 62-foot centres. The substructure is constructed entirely of reinforced concrete, in which are formed the draught tubes, scroll cases and generator air ducts.

The substructure contains no transverse expansion joints, the reinforcing in both the headworks and power house being continuous from end to end. As already pointed out, the headworks were built with construction joints at 20-foot intervals in the centre of each water passage. The scroll cases, however, were cast in blocks of 62 feet extending from centre to centre of units. Variations in length, resulting from changes in temperature, will of course be concentrated at these construction joints, and special care was taken to prevent leakage at these points. To this end the joints were sealed on the water side by means of a groove filled with a plastic compound, and were back-drained to the tailrace. In addition to this precaution, the joints were provided with baffle checks and water stops.

Draught Tubes

The draught tubes are of the elbow type and extend 30 feet downstream from the power house wall, or 60 feet from the centre line of the units. The lowest point of the tube is about 38 feet below normal tailwater level, sloping up 3.6 feet at the downstream end. The tube is 10 feet 6 inches in height at its lowest elevation, and the flare in the roof gives an exit opening 17.5 feet in height. The main piers between draught tubes are 8 feet in thickness, and an intermediate pier, 6 feet wide, forms two water passages 24 feet in width at the exit. To ensure smooth lines in the draught tube surfaces, sections were plotted in three planes before templates for the forms were detailed. The roof of the draught tube was designed for a loading of 9,000 pounds per square foot over a 54-foot span, the depth of the supporting beam being 16 feet. The reinforcing steel consisted of four rows of 1½-inch bars with ample spacing to permit of the full development of bond between the concrete and steel.

As the floor of the scroll case is approximately at normal tailwater level, the runner is submerged at all times. It was therefore necessary to provide means of unwatering the runner for inspection and repairs. To this end, gate checks were installed in the draught tube extension piers, into which steel stop-log gates may be placed, and the draught tube unwatered. Sixteen structural steel gates, each 5 feet in height, are supplied for this purpose, and are stored underneath the tailrace deck. At each unit there are two openings, 4 feet by 6 feet, in the draught tube deck adjacent to the middle piers, to give access to the draught tube. These openings are blocked off by structural steel covers flush with the ceiling of the draught tube. Structural steel covers, filled with concrete, were also placed in the gate checks to prevent the circulation of water between the draught tube and the area above. The tailrace deck is a reinforced concrete slab supported on steel beams and carrying a standard gauge track. This track furnished access across the power house site during construction, and now serves to handle tailrace gates by means of a locomotive crane through the medium of a follower.

Scroll Cases

The scroll cases are of the usual reinforced concrete type. The floor being horizontal, both design and construc-

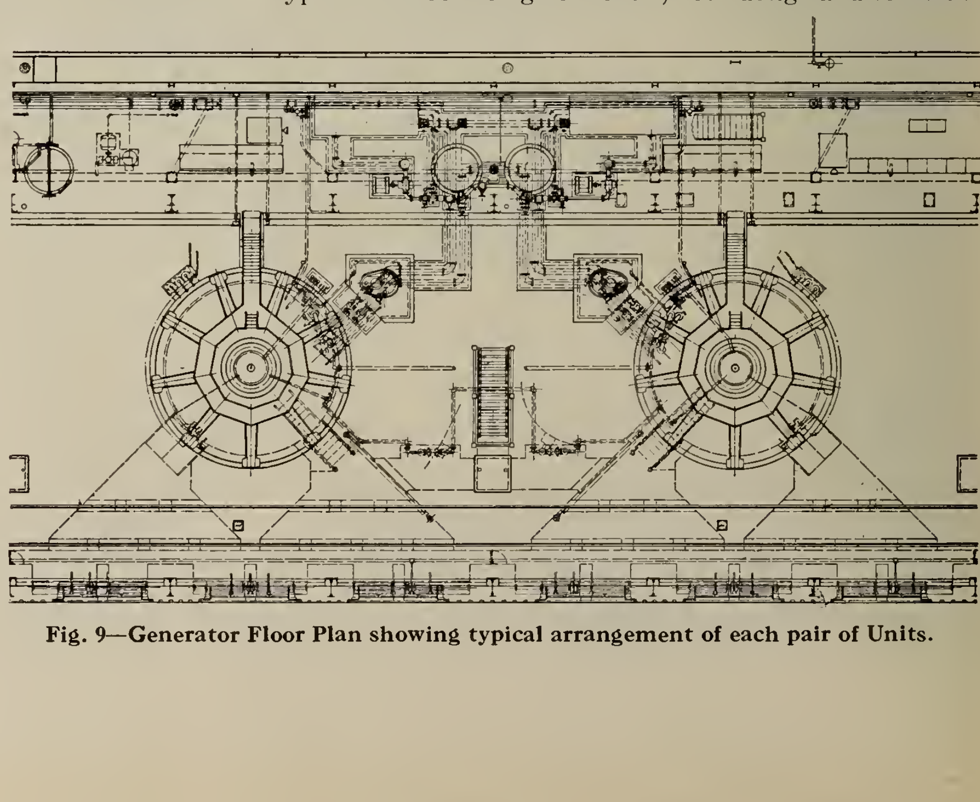


Fig. 9—Generator Floor Plan showing typical arrangement of each pair of Units.

tion were greatly simplified. The bulkhead stresses are taken care of by hooped or "U"-shaped reinforcing, the stems of which extend well back into the headworks piers. The radial segments of the scroll case are designed as reinforced concrete boxes, with the reactions on the outlet side carried through the cast steel stay vanes. The reinforcing bars, which transmit the tensile stresses to the stay vanes, are rigidly attached to the stay ring by means of a bolted connection.

Air Intakes for Generators

There are two ducts for supplying cooling air to each generator. These ducts lead from openings in the downstream power house wall to the turbine pits underneath the generators. At the point of entry to the turbine pits each air duct is 7 feet high and 6 feet wide. At the level of the floor of the ducts there is a passageway extending the full length of the power house, and equipped with steel doors midway between each unit.

To allow of access to the turbine pits,four stairways, each serving one pair of units, lead from the generator room floor to the air duct floor, from which level removable steel stairs descend into the turbine pit. Self-closing sliding steel doors are installed at the entrance from the stairway to the air duct, thus effecting a totally enclosed air cooling system for each generator. Openings in the power house floor over the air ducts allow a portion of the air in the generator room to be re-circulated through the generators if desired.

In the preparation of plans for the power house substructure, four sets of drawings were made to show, first, the concrete details; second, the reinforcing steel; third, the drains and piping; and fourth, the construction joints. This arrangement was found to be satisfactory, allowing the plans to be more readily and clearly understood by avoiding confusion of details. The results in the field appeared to warrant the additional office work involved.

Hydraulic Equipment

Turbines

The present hydraulic installation comprises eight turbine units with their attendant controlling and auxiliary apparatus. Each turbine has a rated capacity of 28,000 h.p. under a head of 53 feet and at a speed of 125 r.p.m. The discharge per unit for this rated capacity and head is 5,300 c.f.s. The operating head on the units varies from 38 feet at times of very high river flow, to 58 feet at low flows. The head at which the turbines are rated, namely 53 feet, was selected after a careful study of the water levels and the duration of various stages of the river. The capacity of the units was fixed from a consideration of the best use of the water available throughout the year, the speed of the units, and the requirement for an equal number of units on each side of the interprovincial boundary.

The turbine speed rings, which are of the built-up type, are set in the concrete scroll cases. The propeller type runners are set one foot below low tailwater level, and are consequently submerged at all times. The throat ring surrounding the runner is made of a machined 2-inch steel plate, in four sections. These sections are securely bolted together and the joints welded and ground. To the bottom of this ring is fastened the steel plate liner, forming the upper portion of the draught tube.

The stay vanes (ten in number), stay ring and pit liner were erected on the floor of the scroll case, which had been previously poured, and were concreted in place with the upper portion of the scroll case. Voids were left for the later setting of the lower distributor ring, throat ring and draught tube liner. The head cover was used for the proper centering of these members.

An annular clearance of ½ inch was left between the upper scroll case forms and the outside of the upper stay ring, to prevent the later being pushed out of alignment by any movement of the forms due to unbalanced pressure from the concrete. In addition, the stay ring was securely bolted to the scroll case floor, and a heavy structural steel frame was bolted inside the stay ring to prevent distortion.

Care was taken to secure ample anchorage for the lower ends of the stay vanes, as, under operating conditions, there may be a maximum upward pull of approximately 125,000 pounds on a single vane, due to water pressure on the roof of the scroll case.

The turbine gates, twenty in number, are of welded plate steel construction. The height of the gates is 7 feet 4 inches, and they are fitted with forged steel shafts extending through the head cover. The latter is of cast iron, and is made in three pieces to facilitate removal. The centre portion of the head cover provides the support for the main bearing, which is of the adjustable lignum vitae type. Water for the lubrication of this bearing is normally drawn from the scroll case, an emergency supply being provided by a connection to the generator bearing cooling system.

Particular attention was given to the design of the lower distributor ring, as it is believed that a generous vertical curvature at this point is of importance in the prevention of cavitation and subsequent pitting of the throat ring.

The servo-motors are located in close proximity to each other, adjacent in plan to the governor actuator, which arrangement greatly simplifies the piping and turbine pit layout.

The only auxiliary equipment located within the turbine pit is the circulating pump for the generator bearing oil. This feature, together with the servo-motor layout mentioned above, simplifies the arrangement of the stairway and operating platforms, and facilitates the inspection of the turbine operating mechanism.

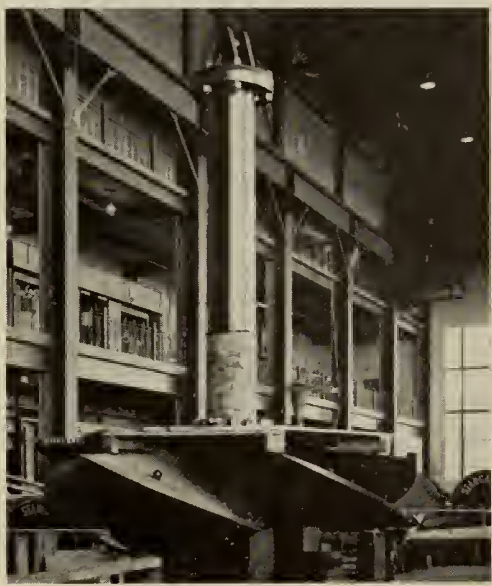


Fig. 10—Turbine Runner and Shaft Ready for Installation.

The turbine runners are of the Moody high speed propeller type, having six fixed blades. They are solid steel castings with an outside diameter of 16 feet 2½ inches. A heavy cast iron cone is attached to the lower side of the runner, to properly diffuse the flow at exit from the runner.

Governors

Each turbine is controlled by a Morris-Pelton governor. The actuators, which have a rated capacity of 80,000 foot-pounds per second, are located on the main power house floor, in alternate spaces between their respective pairs of units. This arrangement permits the use of the remaining spaces between units for the erection and dismantling of equipment.

The flyballs in the actuators are motor driven by current supplied from the generator leads through potential transformers. They are equipped with the usual load limiting and shut-down devices, the latter being arranged to operate in conjunction with the generator protective relays. Hand operated hydraulic control is arranged for regulation of the unit when the actuator is out of service.

Fig. 11—Morris-Pelton Governor Actuator.

The operating medium is a light lubricating oil, and pressure is maintained by motor driven gear pumps. Each unit has an individual pumping system with sump and accumulator tanks. The pumps are each of sufficient capacity for two units, and the piping is so arranged that each pair of governor systems may be inter-connected.

The governor pumps and motors are mounted on a common bed plate, made in two horizontal sections. The lower section is permanently fastened to its concrete base, while the upper section, with pump and motor attached, may be readily removed. A spare pump and motor, with upper section of bed plate, are provided for ready replacement in case of failure of any pumping unit.

A small capacity high pressure air compressor is also installed for supplying air to the accumulator tanks when required.

Auxiliary Hydraulic Equipment

In addition to the main turbine and generating equipment and appurtenances, there is installed or provided auxiliary equipment of various types. This includes for outside use four electrically operated stop-log winches of the spud type on the sluiceways, a 30-ton motor-operated gantry crane for headworks operation and a gasoline-driven locomotive crane for handling tailrace gates and for general yard service. Inside the power house there is installed, as already noted, a high pressure air compressor.

To ensure drainage of the turbine head covers for all conditions of tailwater and gate opening, an auxiliary drain from each head cover is taken to a drainage header extending the length of the power house and emptying into two sumps located between Units Nos. 2 and 3 and 8 and 9. In addition, certain floor drains empty into these sumps. Each drainage sump is provided with a motor-driven vertical centrifugal pump discharging into the tailrace and arranged for float-switch control.

With the turbine runner set below tailwater level, it is necessary to lower the water in the draught tubes for inspection. For this purpose, a 1,500-gallon shaft sinking pump is provided, which will operate through the openings in the tailrace deck already described.

Some consideration has been given to the use of compressed air in the scroll cases as a means of partially lowering the water in the draught tube. A rather inexpensive scheme has been developed in a preliminary way, but it is not contemplated to install this at the present time.

Appurtenant Works

Permanent Railway

A standard gauge railway connects the power house with the Canadian National Railway near Fitzroy station. This railway has a length of one-and-a-half miles, and all structures are designed for E-40 loading. Two plate girder spans carry the track over the channels at Victoria island. From Victoria island to a point near the power house, the track is located close to the downstream side of the dam. It crosses Ragged Chute sluices on steel beams supported on extensions to the sluiceway piers, and over the old river bed on either side of the sluices on timber trestles with concrete foundations carried above water level. It is intended that these and other trestles will be filled when required.

A 72-foot plate girder structure spans from the transformer turntable to the power house entrance, and carries additional rails at wide gauge to accommodate the transformer transfer truck, which can thereby be brought under the power house cranes. This span is so designed that it will permit of the installation of an additional unit without serious interference with the operation of the plant. Inside the power house the standard gauge track is carried the full length of the structure on the downstream side of the main units.

A switchback immediately east of the power house provides connection to the tailrace deck, which also carries a standard gauge track for its full length.

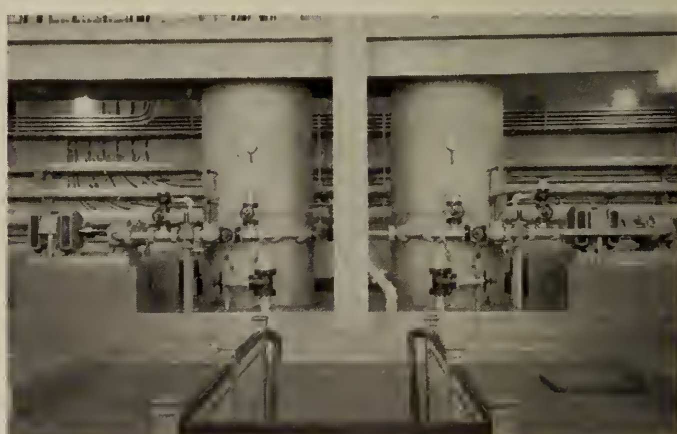


Fig. 12—Governor Pumps, Motors and Accumulator Tanks for Two Units.

Automatic Recording Gauges

In order that the operators may at all times have immediate and accurate information as to the water levels, automatic indicating and recording gauges have been installed on Chats lake, at the forebay and on Lake Deschenes.

The Chats lake gauge was installed in a rock-filled crib near the lighthouse, and a transmission line 4 miles long was required between this point and the power house. The forebay gauge is located inside the headworks superstructure, where a 12-inch pipe well had been installed to receive the float. The Lake Deschenes gauge was installed in a rock-filled crib located off Alexandria island, from which point a 2,500-foot submarine cable was laid to Mohr island, and from there a transmission line was constructed to the power house. The two remote gauges are protected by well insulated housings, and oil heaters are provided for use in winter. The levels at the above points are indicated in the control room at the power house, while a continuous record is secured at the gauge itself.

Portage

To aid passage of small boats and merchandise, a substantial timber structure has been constructed over the dam at the site of the old Indian portage on Conroy island, and the portage itself graded and improved. This route past Chats falls was used by the Indians in early times, and by the lumbermen and others in later years, and it is believed that Champlain travelled over it on his voyage of discovery to Georgian Bay.

Lighting and Railings on Dam

There are protective railings on the headworks and dam from the power house to the farthest sluices. On the bulkhead sections the railing is located on the upstream side only, while the decks of all the sluiceways are protected on all sides. The railing is constructed with cast iron posts and two through rails. The posts are located at 8-foot centres, and lights have been installed at 72-foot centres on the bulkhead sections, 48-foot centres on the sluiceways and at 21-foot centres on the headworks. The lighting standard is made as an extension to the railing post, and the wires are supported by messenger cables carried on the back of the dam and run through conduits to the centre of the posts. Power cables for the winches are similarly arranged, with outlet boxes located at posts on the upstream railing at the sluices. Telephones with siren calls are located at each sluiceway for convenience.

Railway Re-Location

To accommodate the proposed headwater level, it was necessary to either raise or re-locate a section of the Canadian National Railway main line along the Ottawa river west of Chats falls. It was found that a re-location inland to higher ground offered the most satisfactory solution. Under agreement with the railway company, a new track some two miles in length was constructed to standard main line specification. Minor protection works were also carried out at other locations, including the water-proofing of the railway bridge piers at Lavergne point.

General

Construction of the plant was started in October, 1929. The first units were placed in commercial operation in the fall of 1931 and the final installation was completed a year later, following which tests on the equipment were made. To enable the measurement of turbine discharge by the Gibson method, and for flow record purposes, manometer connections were installed at suitable locations in the supply pipes and scroll cases. The scroll case connections may be calibrated from the turbine test data to give a continuous record of turbine discharge.

The writer, as assistant hydraulic engineer of the Hydro-Electric Power Commission of Ontario, was responsible for the engineering and design of the works covered in this paper, and was assisted throughout by S. W. B. Black, A.M.E.I.C., as designing engineer. Acknowledgment is made also of Mr. Black's assistance in the preparation of this paper.

Report of Council for the Year 1932

In reporting on the events of the past year Council feels some satisfaction in pointing out that the difficult conditions through which we are passing have affected The Institute and its members less severely than had been anticipated. It is true that our revenue and the number on our membership list have both diminished, but satisfactory maintenance, and in some cases even an increase, of The Institute's activities and services to its members have so far been made possible by economy in expenditure. Our problems, particularly that of the unemployment of our members, have, on the whole, been less pressing than was feared, although they have required careful consideration and concerted effort.

The unprecedented reduction in industrial and construction activity in Canada has had a serious effect on the employment of engineers, and the prospects for the early employment of the younger men now entering the various branches of the profession are regrettably few. These conditions call for immediate action, if such is possible, and Council has therefore welcomed the formation of a National Committee on Construction Recovery, on which The Institute is represented by two of its members, and which has been established by the Canadian Construction Association with the active co-operation of the Royal Architectural Institute of Canada, The Engineering Institute of Canada, the Canadian Manufacturers Association, and a number of other organizations concerned in construction work. Activities of this kind, and the increased attention now being given by engineers to sociological questions, are an encouraging sign of the times.

The recommendations of the Committee on Development have been presented to Council in the form of an interim report; have been published in The Engineering Journal, and have aroused widespread interest among our members. They have been the subject of much debate and comment, which still continues, and in view of their primary importance as determining the lines of growth of The Institute during the coming years, Council has felt that further opportunities are needed for their consideration by the membership, and has, therefore, not thought it desirable to propose any of them as amendments to the by-laws this year. They will be brought up for discussion at the Annual Meeting, after which further time will be available for their modification and development.

For reasons of economy it was decided not to hold a Plenary Meeting of Council during 1932. In Council's opinion it is most desirable that such a meeting should be held during 1933 in order that such proposals of the Committee on Development as may be finally put forward for adoption may be fully discussed by Council before they are submitted to the membership at a general meeting and voted upon as amendments to the by-laws. It is doubtful, however, if funds will be available for such a Plenary Meeting this year.

The amendment to Section 37 of the By-laws dealing with arrears of fees, which was proposed by Council in 1931, was approved on ballot by a large majority of the membership, and became effective in May 1932. However, in view of existing conditions, Council has been reluctant to apply its provisions in the case of members now in arrears, and has extended the time for payment in the case of all such members who have signified their temporary inability to make the payments due.

Some of the most important proposals of the Committee on Development were intended to facilitate the ultimate co-operation of The Institute with the associations of professional engineers. Although taking no part in its discussions, Council is greatly interested in the work of the Committee of Four which was appointed last year by the associations to study their problems of co-ordination, and which it is understood is making some progress in its difficult task.

Council has noted with approval the degree of success which has attended the operation of The Institute's Employment Service Bureau during the past year. The number of placements effected during 1932, while not large, shows a considerable increase over the figure for 1931, and it is hoped that this encouraging condition will be maintained during the coming year.

The arrangement between The Institute and the Institution of Electrical Engineers regarding the establishment of local Radio Sections has become effective, and Council notes with pleasure the establishment of the first Radio Section by the Montreal Branch.

At the request of the Canadian Construction Association a committee of Council has been engaged in examining the Standard Forms of Contract which have been approved by the Royal Architectural Institute of Canada and the Canadian Construction Association, and has advised that it is not desirable for The Institute as a body to adopt such contract forms. It is felt that the approval of such documents would be more effectively carried out by the Canadian Engineering Standards Association, whose function it is to prepare and issue such specifications and contract forms as may be required by the profession. The associations concerned are being advised accordingly.

The first of the two bronze tablets, which will constitute The Institute's permanent War Memorial, was unveiled at Headquarters on September 6th, 1932. It records the names of one hundred and nineteen members of The Institute who were killed in action or died of wounds. It will be followed by a second much larger tablet containing the names of nearly one thousand members who served with the allied air, land or naval forces. The checking of the final list of these is now in progress.

The visit to Canada of the President and some eighty members and ladies of the Institution of Mechanical Engineers at the end of August afforded an opportunity to our members to take a prominent part in the entertainment of these welcome guests during their Canadian journeys, arrangements for which were completed with the assistance of local committees of Institute and Institution members. The efforts of The Institute branches in all the centres visited contributed greatly to the success of the Institution's tour, particularly in Montreal, Ottawa, Toronto, Hamilton and the Niagara Peninsula.

The Forty-Sixth Annual General and General Professional Meeting was held in Toronto on February 3rd, 4th and 5th, 1932, and under the able organization of the Toronto Branch was both enthusiastic and successful. The outstanding feature of this meeting was the discussion on, February 5th, of matters pertaining to Railway-Highway Transportation, which occupied the whole day, and attracted so large an audience that the meeting had to be held in the Ball Room of the Royal York hotel.

Roll of The Institute

During the year 1932, two hundred and three candidates were elected to various grades of The Institute. These were classified as follows:—Eleven Members, thirty-eight Associate Members, twenty-three Juniors, one hundred and twenty-eight Students, and three Affiliates. The elections during the year 1931 totalled two hundred and twenty-seven.

Transfers from one grade to another were as follows:—Associate Members to Members, twelve; Junior to Member, one; Junior to Associate Member, twenty-six, Student to Associate Member, twelve; Student to Junior, fifteen; Affiliate to Associate Member, one; a total of sixty-seven.

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 1932, for non-payment of dues and by resignation, sixty-seven Members, two hundred and thirty-four Associate Members, forty-eight Juniors, eighty-two Students, and thirteen Affiliates, a total of four hundred and forty-four.

Forty-four reinstatements were effected and twenty-eight Life Memberships were granted. One hundred and six were placed on the Suspended List.

Deceased Members

During the year 1932 the deaths of forty-four of The Institute's members have been reported as follows:—

Honorary Member

Girouard, Colonel Sir Percy C., K.C.M.G., D.S.O.

Members

Alison, Thos. Henry
Anglin, James Penrose
Beatty, James Albert
Brown, Frederick Baylis
Chambers, Charles
Cote, Louis E.
Forneret, Victor Frederick Wm.
Hall, Richard
Keefer, Charles Henry
Knowles, Morris
Lordly, Henry Robertson
Macredie, John Robert C.
McClelland, Harold Robinson
McHenry, Edwin Harrison
MacKenzie, Wm. Brouard
Richan, George Forrester
Tagge, Arthur Charles
Turnbull, Thomas
Tye, Wm. Francis
Weller, John Laing
Whyte, John Smith
Yorath, Christopher James

Associate Members

Barnjum, Harold Frederic Guild
Beaudoin, Horace P.
Cain, Everett Thomas
China, Ernest
Congleton, The Right Hon. Lord (John Brooke Molesworth Parnell)
Deverall, Edwin Victor
Eager, Albert Henry
Fraser, Alexandre
Gordon, Kenneth
Innes, Robert Darrow
McAdam, James
Medbury, Chas. Franklin
Preston, Frank M.
Robertson, H. H.
Rogers, George Wyon
Rutherford, Frank Nicol
Williams, Hugh Chester

Students

Adam, Ian M.
Fowler, Sidney Henry David
Olsen, Arnold Mayne
Todd, Rolph Murray

Total Membership

The membership of The Institute as at January 1st, 1933, totals four thousand, three hundred and sixty-nine. The corresponding number for 1931, was, four thousand, seven hundred and fifteen. These figures do not include those members who have been placed on the Suspended List.

1931		1932	
Honorary Members	10	Honorary Members	9
Members	1,080	Members	1,012
Associate Members	2,284	Associate Members	2,059
Juniors	445	Juniors	401
Students	840	Students	842
Affiliates	56	Affiliates	46
	4,715		4,369

Respectfully submitted on behalf of the Council,

C. Camsell, M.E.I.C., *President*,
R. J. Durley, M.E.I.C., *Secretary*.

STATEMENT OF ASSETS AND LIABILITIES AS AT 31st DECEMBER, 1932

Assets

Property			$ 89,041.64
Furniture:			
Balance as at 1st January, 1932	$ 5,387.92		
Additions during the year...	41.40		
		$ 5,429.32	
Less: Depreciation 10%		542.93	
			4,886.39
Library		1,986.45	
Less: Depreciation 10%		198.64	
			1,787.81
Stationery—On hand			571.71
Stamps—On hand			150.00
Gold Medal			45.00
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 Trust & Guarantee Corp. Certificate		500.00	
Canada Permanent Mortgage, 2 shares par value $100 each		215.00	
40 shares Montreal Light, Heat & Power Cons. N.P.V.		324.50	
			9,058.51
Accounts Receivable:			
Sundry and advertising in *Journal*, Catalogue and *News*	$13,568.92		
Less: Reserve for bad debts 10%	1,357.00		
		12,211.92	
Advances to Branches		400.00	
			12,611.92
J. F. Plow—Advance Travelling Expenses			150.00
Arrears of Fees—Estimated			2,500.00
Cash:			
Canadian Bank of Commerce, Savings Account		197.08	
Petty Cash		100.00	
			297.08
Unexpired Insurance			240.00
Special Funds:			
Investments		10,964.93	
Cash in Savings Bank		717.16	
Due by Current Funds		514.98	
			12,197.07
Postmaster—Deposit			100.00
			$133,637.13

Liabilities

Accounts Payable:		
Sundry	$ 6,980.67	
Canadian Bank of Commerce—Overdraft	7,870.39	
Amounts due to Branches	294.87	
Library Deposits	15.00	
Amount due to Past Presidents' Fund	514.98	
		$ 15,675.91
Special Funds:		
As per schedule attached		12,197.07
Surplus:		
Balance as at 1st January, 1932	105,688.58	
Add: Excess of Revenue over Expenditure for the year ended 31st December, 1932...	75.57	
		105,764.15
		$133,637.13

Montreal, 18th January, 1933.

(Verified) Riddell, Stead, Graham & Hutchinson, C.A.
Auditors.

STATEMENT OF REVENUE AND EXPENDITURE FOR THE YEAR ENDING 31st DECEMBER, 1932

Revenue

Membership Fees:		
Arrears	$ 2,927.72	
Current	26,582.14	
Advance	328.83	
Entrance	1,366.50	
		$ 31,205.19
Interest:		
On overdue fees	25.07	
" Dominion of Canada Bonds	235.50	
" Province of Saskatchewan Bonds	25.00	
" Montreal Tramways Bonds	300.00	
" Title Trust & Guarantee Certificate	30.00	
" Savings Bank Account	5.77	
Accrued on Bonds sold	28.33	
U.S. Premium on Coupons	16.26	
		665.93
Bank Exchange		21.78
Dividends:		
Canada Permanent Mortgage Stock	24.00	
Montreal Light, Heat & Power Cons.	60.00	
		84.00
Publications:		
Journal subscriptions	7,569.80	
Journal advertising	18,930.84	
Journal sales	66.13	
E-I-C News advertising	1,445.70	
Catalogue advertising	10,752.61	
Transaction sales	57.41	
Year Book advertising	578.25	
		39,400.74
Refund of Expenses of Hall		655.00
Certificates		143.75
Badges		26.00
Profit on Sale of Bonds		26.40
Life Membership Fees Invested		300.00
		$ 72,528.79

Expenditure

Building Expenses:			
Taxes—Property and Water		$ 1,828.74	
Fuel		434.82	
Insurance		117.37	
Light and Gas		307.59	
Caretaker's wages and service		1,111.40	
Repairs and expenses		663.84	
			$ 4,463.76
Office Expenses:			
Salaries—Secretary and staff		12,835.39	
Postage and telegrams		1,551.87	
Office supplies and stationery		1,083.25	
Audit		250.00	
Telephone		350.60	
Messenger and express		95.34	
Miscellaneous		250.50	
			16,416.95
Publications:			
**Journal*		20,385.30	
†*E-I-C News*		2,931.91	
‡Catalogue—paid on account		6,572.47	
" —reserve against estimated cost		4,700.00	
Year Book		126.00	
Transactions		733.53	
Sundry printing		758.20	
			36,207.11
General Expenses:			
Annual and Professional Meetings		2,154.94	
Plenary Meeting of Council		20.70	
Travelling—Vice-President		15.00	
" —Secretary		439.94	
Branch stationery		167.72	
Students' Prizes		82.71	
§Library expense and magazines		3,234.62	
Depreciation on furniture and books		741.57	
Reserve for bad debts		1,323.44	
Examinations:			
Cost	$135.51		
Less: Collected	100.00		
		35.51	
Papers Committee		50.32	
Committee on Development		161.37	
Committee on Unemployment		82.37	
			8,510.21
Rebates to Branches			6,535.89
Gzowski Medal			15.00
E.I.C. Prizes			304.00
Excess of Revenue Over Expenditure for the Year Ended 31st December, 1932			75.57
			$ 72,528.79

*Includes $5,364.38 for salaries chargeable to this item.
†Includes $303.00 for salaries chargeable to this item.
‡Includes $4,377.22 for salaries chargeable to this item.
§Includes $1,026.00 for salaries chargeable to this item.

Special Funds

Leonard Medal		
Balance as at 1st January, 1932	$ 597.46	
Add: Bond interest	30.00	
Bank interest	2.98	
	630.44	
Less: Cost of Medal	15.00	
		$ 615.44
Represented by:—		
Title Trust & Guarantee Corp.	500.00	
Balance in bank	115.44	
	$ 615.44	
Plummer Medal		
Balance as at 1st January, 1932	562.58	
Add: Bond interest	27.50	
Bank interest	2.01	
	592.09	
Less: Cost of Medal	15.00	
		577.09
Represented by:—		
Dominion of Canada Bond 4½%, 1959	500.00	
Balance in bank	77.09	
	$ 577.09	
Fund in Aid of Members' Families		
Balance as at 1st January, 1932	2,133.56	
Add: Bond interest	100.00	
Bank interest	9.14	
	2,242.70	
Less: Advanced to families	200.00	
		2,042.70
Represented by:—		
$1,000 Province of Ontario, 4½%, 1964 Bond	1,022.17	
$1,000 Dominion of Canada, 4½%, 1959 Bond	972.97	
Balance in bank	47.56	
	$ 2,042.70	
Forward		$ 3,235.23

Special Funds—*Continued*

Brought Forward		$ 3,235.23
Past Presidents' and Prize Fund		
Balance as at 1st January, 1932	$ 4,995.78	
Add: Bond interest	237.50	
Bank interest	16.48	
	5,249.76	
Less: Cost of Prizes	103.00	
		5,146.76
Represented by:—		
$3,000 Montreal Tramways 5%, 1955 Bonds	2,490.00	
$1,500 Title Trust & Guarantee Corp. 6%, 1933 Certificate	1,500.00	
Balance in bank	391.78	
Due by War Memorial Fund	250.00	
Due by Current Funds	514.98	
	$ 5,146.76	
War Memorial Fund		
Balance as at 1st January, 1932	5,162.15	
Add: Bond interest	210.00	
Bank interest	18.20	
	5,390.35	
Less: Cost of Memorial Tablet	1,575.27	
		3,815.08
Represented by:—		
$2,000 Dominion of Canada 4½%, 1959 Bonds	2,000.00	
$2,000 C.P.R. Collateral Trust 5%, 1934 Bonds	1,979.79	
Balance in bank	85.29	
	4,065.08	
Less: Loan due to Past Presidents' Fund	250.00	
	$ 3,815.08	
		$ 12,197.07

Finance Committee

The President and Council,—

The lot of the Finance committee has not been an entirely happy one during the past year. Balancing the budget of The Institute has been a task fraught with many worrying problems which the committee has tackled to the best of its ability.

During the early part of the year, in addition to smaller revenues from other sources, a serious falling off in *Journal* advertising sales was apparent and the Council found it imperative to reduce the remuneration of all the headquarters staff in the middle of the year by ten per cent, making the second reduction within six months.

Considerable study was given to the advisability of embarking upon the publication of the Engineering Catalogue, especially in view of the uncertainty of business conditions. However, the decision of the Council to proceed with this publication has been fully justified, as the publication has paid for itself, will render a useful service to members, and has provided employment among engineers and others. In view of the comparatively large amount of money involved in this publication considerable uncertainty prevailed as to the final outcome until late in the year, but The Institute's staff are to be congratulated on their accomplishment in the face of great difficulties.

Many expenditures customary in former years had to be eliminated or reduced, as for example, by the elimination of the plenary meeting of Council, reduction in issues of the *E-I-C News*, reduction in the General Secretary's travelling and so forth.

The auditors have made the customary investigation of the books and accounts of The Institute and their financial statement is appended hereto.

Arrears

The problem of the member in arrears has been ever present. The change in Section 37 of the By-laws and the unemployment situation combined to create many individual problems of a difficult nature. A large number of members were dropped from the roll late in the year because they were at least two years in arrears and because, notwithstanding many communications, no reasons were produced for special consideration. In the case of some hundreds in arrears for the year 1932, special attention has been given to every individual who through lack of employment or other good cause is in financial difficulties—but it is to be regretted that there are many members who fail to communicate with Headquarters and who let themselves get into arrears through nothing but procrastination.

During the year 365 members were dropped from the roll, through non-payment of dues. Every one of these members was *at least two years* in arrears, and many of them even three years. Furthermore, there were 106 members placed on the suspended list through inability to meet the dues. Accessions to the membership were considerably reduced in number.

The whole situation aggravates the difficulty experienced in finding the actual cash necessary to carry on the business of The Institute. Notwithstanding the fact that the revenue of the year exceeded the expenditures, the liquid assets of The Institute are not sufficient to tide over the low revenue period at the end of the year. It should be the duty of the future committees to build up larger reserves, although this will be difficult of accomplishment until general business conditions improve.

Revenue

The revenue of The Institute for the year 1932 has been $3,000 less than in 1931, notwithstanding $10,700 new revenue from the Engineering Catalogue. There was a loss of $2,200 (or 6.6%) in the revenue from fees, and of nearly $10,000 (or 34%) in *Journal* advertising, this, of course, being a situation common to all publications. Other items of revenue are small and have not changed materially.

Expenditures

The total expenditures for the year were $4,800 less than during the year 1931, the savings being distributed over practically all items. The cost of publishing the *Journal* was reduced by $6,500. The elimination of a plenary meeting of the Council saved $1,800.

Surplus

In view of the large increase in the item "Accounts receivable" which is mostly made up of advertising accounts, it was felt advisable to provide a reserve of 10% of this item, namely $1,300, for the possibility of bad debts. The usual ten per cent depreciation on furniture and library has been provided for, with the final result that there is a surplus of $75.57 on the year's operation—the first time in five years that a surplus has been shown.

The outlook for the year 1933 is clothed in uncertainty and the new Finance committee will be faced with falling, or at least fallen revenues, and the membership will, in all probability, have to be content with some curtailment of the services heretofore rendered by The Institute.

Respectfully submitted,
J. L. Busfield, M.E.I.C., *Chairman.*

Nominating Committee, 1933

Appointments to the Nominating Committee for the year 1933 have been made by the various Branches, and the chairman has been appointed by Council, as shown on the following list, which is now presented for announcement at the Annual Meeting in accordance with the By-laws:—

Chairman: C. H. Wright, M.E.I.C.

Branch	*Representative*
Halifax Branch	A. F. Dyer, A.M.E.I.C.
Cape Breton Branch	W. C. Risley, M.E.I.C.
Saint John Branch	F. M. Barnes, A.M.E.I.C.
Moncton Branch	F. O. Condon, M.E.I.C.
Saguenay Branch	G. F. Layne, A.M.E.I.C.
Quebec Branch	Philippe Methe, A.M.E.I.C.
St. Maurice Valley Branch	J. H. Fregeau, A.M.E.I.C.
Montreal Branch	F. S. B. Heward, A.M.E.I.C.
Ottawa Branch	K. M. Cameron, M.E.I.C.
Peterborough Branch	A. L. Killaly, A.M.E.I.C.
Kingston Branch	A. Jackson, A.M.E.I.C.
Toronto Branch	J. J. Spence, A.M.E.I.C.
Hamilton Branch	J. Stodart, M.E.I.C.
London Branch	W. R. Smith, A.M.E.I.C.
Niagara Peninsula Branch	C. G. Moon, A.M.E.I.C.
Border Cities Branch	W. J. Fletcher, A.M.E.I.C.
Sault Ste. Marie Branch	J. H. Jenkinson, A.M.E.I.C.
Lakehead Branch	H. G. O'Leary, A.M.E.I.C.
Winnipeg Branch	N. M. Hall, M.E.I.C.
Saskatchewan Branch	H. R. Mackenzie, A.M.E.I.C.
Lethbridge Branch	G. S. Brown, A.M.E.I.C.
Edmonton Branch	F. K. Beach, A.M.E.I.C.
Calgary Branch	B. L. Thorne, M.E.I.C.
Vancouver Branch	Frank Lee, M.E.I.C.
Victoria Branch	J. P. Forde, M.E.I.C.

Past Presidents' Prize Committee

The President and Council,—

As chairman of the *Past Presidents' Prize Committee*, I beg to report that the committee has unanimously decided to award the prize for the best essay on the subject of "The Effect of the Development of the Electronic Valve upon Electrical Engineering and Industry," to B. H. Steeves, A.M.E.I.C.

In view of the excellence of the second choice of the committee, the paper by Professor E. Geoffrey Cullwick, Jr.E.I.C., it is recommended that this paper be awarded "honourable mention."

Respectfully submitted,
E. P. Fetherstonhaugh, M.E.I.C., *Chairman.*

Gzowski Medal Committee

The President and Council,—

Your committee, having carefully studied all of the papers eligible for consideration for the award of the Gzowski Medal for the prize year 1931-32, is unanimously of the opinion that no one of them is of a sufficiently high order of merit to have earned for its author the award of this medal.

The committee therefore recommends that no award of the Gzowski Medal be made for this medal year.

Respectfully submitted,
P. L. Pratley, m.e.i.c., *Chairman.*

Plummer Medal Committee

The President and Council,—

Each member of the committee has carefully read all the papers considered eligible. Further, every effort has been made to give publicity to the Plummer Medal Award with the view of being sure that all papers bearing on the question were received.

As a result the committee is unanimous in its report that, in the opinion of the committee none of the papers were of sufficient merit, particularly from the viewpoint of new and original work, to warrant the giving of the Plummer Medal this year.

Respectfully submitted,
Harold J. Roast, m.e.i.c., *Chairman.*

Leonard Medal Committee

The President and Council,—

Your committee has carefully considered the papers eligible for the award of the Leonard Medal for the year ending June 30th, 1932, and beg to unanimously make the following recommendation:

1. *The Gold Medal to Messrs. W. B. Boggs and J. N. Anderson for their paper on "The Anode Department of Noranda"—C.I.M.M. Bulletin, April, 1932.
2. A Silver Medal to Mr. R. D. Parker for his paper on "Ventilation of the Frood Mine"—C.I.M.M. Bulletin, April, 1932.

On account of the excellence of both of these papers it was difficult for your committee to make a final decision. It was therefore thought, that if possible, some recognition should be taken of the second paper and the recommendation of the award of a silver medal is therefore made with the hope that it will meet with your approval.

Respectfully submitted,
L. H. Cole, m.e.i.c., *Chairman.*

*Note: Mr. R. J. Westwood was also a joint author of this paper but is not eligible for the medal, which can only be awarded to members of the E.I.C. or the C.I.M.M.

Students' and Juniors' Prizes

The reports of the examiners appointed in the various zones to judge papers submitted for the prizes for Students and Juniors of The Institute, were submitted to Council at its meeting on January 20th, 1933, and the following award was made:

H. N. Ruttan Prize (Western Provinces)—No award.

John Galbraith Prize (Province of Ontario)—No award.

Phelps Johnson Prize (Province of Quebec, English)—No award; no papers received.

Ernest Marceau Prize (Province of Quebec, French)—No award; no papers received.

Martin Murphy Prize (Maritime Provinces)—To J. H. Mowbray Jones, Jr.E.I.C., for his paper on "The History and Development of Fourdrinier Paper Making Machines."

Membership Committee

The President and Council,—

In the report made by the Membership Committee a year ago, it was pointed out that the progress which had been made by the Branches in securing new members had sufficiently warranted a continuance of the same policy and it was then recommended that this principle should be followed for 1932.

It has of course been a difficult year with regard to membership and it has been too much to expect that whatever efforts mights be made by any methods of securing new members, the membership could be maintained at the former level in the face of the very large number of resignations. The Branches, however, have, in the face of this, again been most active in their efforts to obtain new members, and in most cases have maintained a very creditable showing. Their efforts and their results have again demonstrated the desirability of pursuing this policy, and the Council and members generally owe the officers and members of the Branches no small debt for these continued efforts.

It is the opinion of your committee, and it is recommended, that this policy be again followed for the forthcoming year, believing at the present time that this is the most direct and logical manner by which to maintain the membership level against the losses which are occurring.

It is also the opinion, and it is recommended, that your Membership Committee be now discharged, with a view to leaving the way open for such new arrangements as may emerge from the present discussion of the policies of development arising from the studies and report of your Committee on Development, and from such further discussion as may arise at the Annual Meeting.

Respectfully submitted,
C. H. Mitchell, m.e.i.c., *Chairman.*

Papers Committee

The President and Council,—

Your committee begs to report that the personnel of the committee of the previous year was continued, with the exception that R. B. Young, m.e.i.c., who is no longer a member of Council, became vice-chairman, and his place as chairman was taken by J. J. Traill, m.e.i.c. Each Branch Executive appointed one of its members to act as a liaison officer between the Papers Committee and the Executive, and Zone representatives formed contact with these members for the purpose of carrying out the committee's work. The very comprehensive report of the previous year was put in the hands of all Branch Executives and those dealing with programmes, to serve as a guide in planning programmes for the current year. Subsequently, members of the Papers Committee made contact with the various Branch Executives in their respective Zones, and acted as a clearing house for information between neighbouring Executives with respect to programmes and papers. In a number of instances, arrangements have been made whereby papers or addresses given before one Branch have been repeated at other Branches in the same Zone.

An endeavour was made also to discover material that would be available for technical sessions at the Annual General Meeting.

Respectfully submitted,
J. J. Traill, m.e.i.c., *Chairman.*

Publication Committee

The President and Council,—

Your committee reports that, as a volume of Transactions will not be published this year, and as no other matter has been referred to the committee, no meetings of the committee have been held.

Respectfully submitted,
L. W. Wynne-Roberts, a.m.e.i.c., *Chairman.*

Library and House Committee

The President and Council,—

During the past year, in addition to the usual minor repairs required to keep the Headquarters premises in good order, it has been necessary to make certain improvements required by the city authorities in connections for the lighting and in arrangements of the exit facilities from the lecture hall. Alterations to the front staircase have also been made to suit the bronze War Memorial tablet which was placed in position this year. The expenditure in connection with the above items amounted to approximately $400.

The activity of the library and information service has been well maintained and the number of requests for technical information, bibliographies, etc., shows that the service rendered has been increasingly appreciated by the members. The statistics for 1932 are as follows:

Requests for information	457
Requests for text-books, periodicals, reprints, etc	497
Technical books borrowed	137
Technical books presented by publishers	38
Bibliographies compiled	50
Accessions to library	741
Requests for photoprints	46
Total pages of photoprints ordered for members	233

It is a matter of great regret to your committee to learn that the reduced revenue of The Institute makes it imperative to reduce expenditure in this as well as in other departments. For the coming year, therefore, it will no longer be possible to provide the full-time services of a librarian for searches and for looking up technical data desired by members. Provision is, however, being made for the continuance of the library work, although necessarily on a less complete basis.

Respectfully submitted,

D. C. Tennant, M.E.I.C., *Chairman.*

Legislation Committee

The President and Council,—

No questions regarding legislation were referred directly to your committee during the past year. During this year, however, a bill was brought before the Dominion House affecting appointments to the Civil Service, taking these appointments out of the hands of the Commission and placing them in the hands of members representing the various constituencies. This Bill was defeated largely as a result of the combined representation of engineers throughout Canada, and a committee was appointed to enquire into the workings of the Civil Service Act. As a further result Mr. Foran, Secretary of the Commission, requested the Council of the Association of Professional Engineers of British Columbia to submit recommendations regarding the necessary qualifications for engineers in the Civil Service. Recommendations were drawn up by the Association and sent to Council for their approval and to be forwarded to Mr. Foran and members of the Civil Service Commission. These recommendations were approved by Council and duly forwarded to Mr. Foran and members of the Civil Service Commission.

Respectfully submitted,

Fred. Newell, M.E.I.C., *Chairman.*

Report of the E.I.C. Members of the Main Committee of the Canadian Engineering Standards Association

The President and Council,—

The Institute nominees on the Main Committee of the Canadian Engineering Standards Association are now as follows:—

J. Morrow Oxley, M.E.I.C., retires March, 1933.
P. L. Pratley, M.E.I.C., retires March, 1934.
C. J. Mackenzie, M.E.I.C., retires March, 1935.

One new committee has been formed during the year, dealing with Safety Code for Elevators, and the membership of the Association has still increased and now stands at 642. The effects of the depression, however, have been indicated by a decrease in sustaining memberships, fourteen resignations having been received during the year and only one new member being recorded. The total sustaining membership at present is sixty-five, and the total amount received from membership fees was $5,795, a decrease of $1,105 from 1931. The headquarters of the Association have been moved to 79 Sussex Street, Ottawa, resulting in the saving of rent, and this, together with a ten per cent cut in staff salaries, has enabled the Association to carry on for the year.

The Secretary had the privilege of addressing the Engineering Society of the Northern Electric Company at Montreal; the Royal Architectural Institute of Canada at their annual meeting in February last, also the Architects Club at Ottawa. The Secretary also has attended meetings of the Dominion Fire Prevention Association, Interprovincial Road Congress, Canadian Manufacturers' Association, Engineering Institute of Canada, and the Canadian Institute of Mining and Metallurgy.

The outstanding event of the year has been the holding of the Imperial Conference at Ottawa. At this Conference a special Sub-committee on Industrial Standardization was appointed, on which the Association was represented by the Secretary. The membership of this committee consisted of representatives from Great Britain and the various Dominions, and in connection with the meetings, four industrial conferences were held dealing with steel, lumber, industrial chemicals and agricultural machinery. The committee made definite recommendations which have appeared in the public press and were also outlined in the C.E.S.A. Bulletin for September 30th, 1932.

No Year Book was published for 1931 on account of the necessity for economy, but the Bulletin has regularly appeared and is serving a very useful purpose. It is hoped to resume publication of the Year Book next year.

Work in Progress

A—Civil Engineering and Construction

Wood Piles and Pile Driving. A first report has been received from the Forest Products Laboratories in connection with available sizes for piling timber, and after this has been studied it is proposed to prepare a report for the consideration of the committee.

Building Materials. As a first step in the preparation of standards for building materials, the committee which was originally organized to consider standard brick sizes is being reorganized as a Panel under the Committee on Building Materials. Practically all the nominations for membership on this panel have been received and it is proposed to have a preliminary conference shortly.

In this connection, close co-operation has been maintained with the special committee preparing a building code for the city of Montreal, and copies of specifications covering building material have been supplied to this committee and have proved exceedingly useful.

Standard Contract Forms. The standard contract form which has been jointly adopted by the Canadian Construction Association and the Royal Architectural Institute of Canada has been submitted to the Sectional Committee on Civil Engineering and Construction for comment, it having been suggested that this contract form might be endorsed by the C.E.S.A. Comments have now been received and have been summarized and sent out for further consideration, but it is believed that it will be advisable to wait for a report from a special committee of The Engineering Institute of Canada, under the chairmanship of A. H. Harkness, M.E.I.C., this committee having been appointed to give special consideration to this question.

B—Mechanical Engineering

Screw Products. An Established List covering Cap Screws, Set Screws, Studs and Nuts, has been issued as B 33-1932. This gives full information on design and tolerances and it is believed will serve a very useful purpose in the trade.

A revised edition of the Established List of Machine Screws and Nuts has also been issued, the revision consisting of the addition of information on Machine Screw Nuts.

The Established List of Machine, Carriage and Plough Bolts and Nuts will be issued shortly, and also a standard for Binder Head Screws used in the electrical trade. Consideration is also being given to standards for Wood Screws and Small Rivets.

Bar Size Tolerances for Bolts. As a result of the first meeting of the Panel on this project, a report has been submitted by one of the members and has been sent out to the Panel for comment.

Blade Punching for Road Grading Machinery. This standard has been published as B 37-1932 and has been very favourably reviewed, the "Contract Record" printing the specification in full in one of its recent issues. It is gratifying to report that this standard has been adopted unanimously by the highway departments in all the provinces and by the three leading manufacturers of road grading machinery. This standard will allow free interchangeability of cutting blades and mould boards on road graders.

Colours for Piping Systems. A committee is at work on a standard covering the identification of piping systems in industrial plants, and it is hoped also to include provisions for the identification of water systems on steamboats and railway equipment.

Safety Code for Passenger and Freight Elevators. The Association has been requested to consider the preparation of a safety code for elevators and a committee is at present being organized. A preliminary conference will be held shortly. All provincial governments and leading municipalities will be asked to co-operate with insurance and manufacturing interests and technical bodies in the endeavour to prepare a uniform code for use throughout Canada.

C—Electrical Work

Canadian Electrical Code. The year has been marked by the adoption of the Canadian Electrical Code in the provinces of Prince Edward Island and Manitoba. The Code has now been adopted by the nine provinces of Canada and it is believed that uniformity in electrical regulations will practically now prevail throughout the Dominion. Several of the provinces have made arrangements for provincial inspection departments and it is hoped that in the near future all provinces will make similar arrangements. It was originally proposed to issue a third edition of the Code during 1933, but it is possible that this will have to be postponed.

In connection with Part II of the Code, covering approval specifications, two pamphlets have been issued, the first covering Definitions and General Requirements Applicable to All Specifications" and the second dealing with "Power-Operated Radio Devices", Specifications for Electric Signs and for Electrical Equipment for Oil-burning Apparatus will shortly be printed, but are held up pending a decision on one or two minor points. First drafts of specifications for Electric Fixtures, Electric Floor Scrubbing and Polishing Machines, Electrical Capacitors (Condensers), Portable Electric Displays and Incandescent Lamps Signs, Electric Clocks, and Fractional Horsepower Motors have now been prepared and are before the Panel and interested manufacturers for comment. A meeting of the Panel on Specifications was recently held to discuss the first four specifications. An entire revision of the specification for Enclosed Switches is being prepared and will shortly be sent out for comment. A special binder has also been issued to facilitate the filing of approval specifications. It is interesting to report in this connection that practically all approval of electrical apparatus under Code rules is now being done in Canada by the Hydro-Electric Power Commission Laboratory, their approval being accepted by the different provincial inspection departments.

Active work on Part III of the Code has been confined to the work of Sub-panel No. 3, Inductive Coordination, and a draft covering principles and practices in connection with radio interference has been prepared and is before the Panel for comment. A certain amount of progress has been made in connection with the work of the other sub-panels, but definite reports are not yet available.

Watthour Meters. A revised draft specification covering A.C. Watthour Meters and Demand Meters has been sent out to the committee for comment and a draft of the regulations of the National Research Council has also been sent out to the committee. Further action on the specification will be held up until all the comments on these different documents have been received and discussed.

Magnet Wire. It has been suggested that the Association consider a specification covering magnet wire, and enquiries have been sent to different interests to ascertain if there is a need for this specification. Present indications are that such a specification would be useful.

Oil Circuit-Breakers. A special conference was held on oil circuit-breakers, at which an active discussion was held on tests for rupturing capacity. As a result of the conference it was decided that a committee should be formed to prepare a general specification for oil circuit-breakers and this suggestion has been sent out to the different interests for their comment before taking definite action.

Capacitors (Electrical Condensers). The specification for Capacitors, which is being prepared under Part II of the Code, is confined to the smaller types of capacitors and it is believed that it would be advisable to prepare a general specification for capacitors of a larger type, particularly those dealing with the control of power factor, and it is probable that a committee will be organized to consider this question.

Industrial Contacts and Publicity

The Imperial Economic Conference has already been referred to, but in connection with the visit of Mr. le Maistre, Director of the British Standards Institution, a special conference on lumber standardization was held at which Mr. le Maistre was given an opportunity of meeting the officials of the Canadian Lumbermen's Association. It is expected that some active work will be undertaken in developing lumber trade between Canada and Great Britain.

Co-operation from the technical press and newspapers has been very helpful and several special articles have been written by the Secretary for publication in various technical papers. In spite of the prevailing depression, the sale of publications has kept well up to the mark and this indicates continued interest on the part of the industries.

Co-operation with the British Standards Institution, the Standards Association of Australia, the South African Branch of the B.S.I., and the newly formed standards organization in New Zealand, continues to be given and it is gratifying to report that much material from C.E.S.A. specifications has been adopted for use in Australia and New Zealand. Regular exchange of publications has been continued between the C.E.S.A. and the other national standardizing bodies.

Respectfully submitted,
P. L. Pratley, M.E.I.C.
J. M. Oxley, M.E.I.C.
C. J. Mackenzie, M.E.I.C.

Honour Roll and War Trophies Committee

The President and Council,—

During the summer of 1932 the War Memorial tablet was erected in the entrance hall of Headquarters of The Engineering Institute, Montreal, and on Tuesday, 6th September, 1932, this Memorial was formally unveiled by Dr. Charles Camsell, M.E.I.C., President of The Institute, in the presence of a representative gathering.

The dedication of the Memorial was carried out by Colonel The Venerable Archdeacon J. M. Almond, C.M.G., C.B.E.

The checking and confirmation of the names for the Honour Roll (in bronze) numbering approximately one thousand, have entailed a very considerable amount of clerical labour on the part of the staff of the General Secretary, but the committee now expect to be in position to place the contract for this tablet very shortly.

Respectfully submitted,
Charles J. Armstrong, M.E.I.C., *Chairman.*

Board of Examiners and Education

The President and Council,—

The results of the examinations held during 1932 for admission to The Institute are as follows:

	Examined	Passed
Examined under Schedule B (Junior)	6	6
Examined under Schedule C (Associate Member):		
Electrical Engineering	3	3
Structural Engineering	2	2
	11	11

Your Board is gratified to note the improvement in the proportion of candidates who have been successful in The Institute's examinations.

Respectfully submitted,
William Gore, M.E.I.C., *Chairman.*

Committee on Biographies

The President and Council,—

As reported to the last Annual Meeting, the Committee on Biographies has outlined a method of procedure designed to produce consistent and effective results in the future. This policy was submitted to the last Plenary Meeting of Council in September 1931 and there approved, but qualified with reference to the matter of financial expense. It had been the hope of the committee that it would be possible in submitting this report to record some definite progress in the work, but unfortunately the financial situation of The Institute has been such as to make it impossible to authorize necessary small expenditures in this connection, and on this account the work of the committee is still held in abeyance awaiting the time when it may be found possible to provide for the small, but necessary, expenses.

Respectfully submitted,
F. H. Peters, M.E.I.C., *Chairman.*

Committee on Engineering Education

The President and Council,—

Your Committee on Engineering Education outlined certain recommendations of the Committee which had been laid before the Annual Meeting in 1930 and adopted with one exception, Clause No. 4, which was referred back to the committee for further consideration. In view of the action of the Annual Meeting it was decided that the next meeting of the committee resolve itself into a round table conference to reconsider Clause No. 4 and discuss methods of making the committee's recommendations more effective.

These recommendations were considered by the committee at a meeting held in Toronto on February 4th, 1932, at which the following members of the committee were present, viz.—Brigadier-General C. H. Mitchell, M.E.I.C., in the chair; W. J. Johnston, A.M.E.I.C., Secretary of committee; Dean Ernest Brown, M.E.I.C.; Dr. O. O. Lefebvre, M.E.I.C.; Dean Augustin Frigon, M.E.I.C.; Dean E. P. Fetherstonhaugh, M.E.I.C.; Prof. E. O. Turner, A.M.E.I.C. (acting as proxy for Dr. J. Stephens, M.E.I.C.); and in addition, the following,—Professor C. M. McKergow, M.E.I.C.; Lt.-Col. R. E. Smythe, A.M.E.I.C., of Technical Service Council, Toronto; and the following from the University of Toronto:—Professor W. J. Smither, M.E.I.C.; Professor J. Watson Bain; Professor J. Roy Cockburn, M.E.I.C.; Professor A. T. Laing; W. S. Wilson, A.M.E.I.C., Secretary, Faculty of Applied Science; and also Major L. F. Grant, M.E.I.C., Royal Military College; who were invited to take part in the discussion and give the committee the benefit of their views.

A letter was read from Fraser S. Keith, M.E.I.C., chairman of the committee, at which he expressed his regret at being unable to be present and reviewed the activities of The Institute Committee on Engineering Education, as follows:—

"When The Institute's Committee on Engineering Education was first organized, one of the stipulations was that in the first instance it should be composed of men entirely outside of the universities. The reason for this was that those who sponsored the formation of the committee (amongst them a number of university professors) felt that a different viewpoint might be brought to bear on the subject if a number of past presidents and others might be induced to act and give the committee the benefit of their counsel. It was along this line that the committee worked, but the chairman of the committee previous to my acceptance of the office found it difficult or impossible to reach definite conclusions.

"Two years ago your committee made certain definite recommendations which came before the annual meeting in Ottawa. They were adopted with the exception of one which was referred back to the committee.

"Last year the committee was reorganized as at present constituted, and the specific recommendations of the former committee have been under discussion by you. The agenda you are asked to discuss is based on the former committee's recommendations, in the hope that you who now constitute the committee will arrive at conclusions in the light of the practical application of such suggestions.

"While some of you may think that in Canadian universities with engineering faculties each university has its own problems, which must be solved by its own men, there is, notwithstanding, a field of usefulness for a committee of The Engineering Institute of Canada, and if you will use this committee of The Institute as a clearing house and as a means of discussing the problems you have in mind, the result should be advantageous, not only to The Institute but to engineering education in the Dominion."

Discussion took place on each of the six original items, viz.—

1. The formation of a more intimate bond between The Institute and engineering universities throughout Canada, in order that The Institute may be in a position to advise on engineering education through its older and most successful members.

2. That steps be taken whereby The Institute becomes the definite agency—the active connecting medium, between the engineering universities and industry.

3. That a study be made by a committee on technical education in its relation to industry and to the engineering profession.

4. That immediate steps be taken by conference with university heads with a view to adopting a six-year course for engineers, or a much higher matriculation standard.

5. That the universities be urged to give consideration to giving additional time on the curriculum to public speaking and literature.

6. That immediate steps be taken leading to the formation of student branches of The Institute or student affiliations in every engineering university in the Dominion.

At this conference the following resolution was passed,—"that this conference desires that the universities impress upon their students the necessity of proper use of their native tongue, a knowledge of literature, and facility in public speaking as a supplement to their engineering education. It is suggested that this view be forwarded by The Institute to be expressed to the student bodies of the various universities."

At a meeting of Council held on March 18th, 1932, the Secretary was instructed to bring this resolution to the attention of student bodies throughout Canada through the Deans of the various engineering faculties. The sympathetic reception which was given this important suggestion of the committee is shown from replies received as follows:—

Dean R. S. L. Wilson, M.E.I.C., Faculty of Applied Science, University of Alberta, Edmonton, Alberta. ". . . . I thoroughly agree that the Council has done a useful thing in taking this action and I shall make a point of forwarding the resolution to our engineering students' organizations at the beginning of the fall term."

Dean A. L. Clark, Hon.M.E.I.C., Faculty of Applied Science, Queens University, Kingston, Ontario. ". . . . There will be no further meetings this spring but I will try to see that the report is considered by the (Engineering) Society next autumn."

Dr. C. C. Jones, President, University of New Brunswick, Fredericton, N.B. ". . . . I shall be very glad indeed to bring this to the attention of our Engineering undergraduates."

Brigadier W. H. P. Elkins, Affil.E.I.C., Commandant, Royal Military College, Kingston, Ontario. ". . . . Cadets are given opportunities to take part in public speaking within the College, and the importance of this matter is drawn to their attention throughout the course."

Dean E. Brown, M.E.I.C., Faculty of Engineering McGill University, Montreal, P.Q. ". . . . We are making a definite effort to interest the classes in each of the four years in what may be described generally as 'non-technical' subjects. We are endeavouring to lay before students the importance of reading in their leisure time as a means of self-improvement and as providing an opportunity of acquainting themselves with many phases of our present industrial and social organization. I shall make use of the Resolution passed at the recent conference and of the endorsation of the Council of The Institute in bringing to the notice of students next session the importance of the courses which we have arranged."

Dean C. J. Mackenzie, M.E.I.C., Faculty of Engineering, University of Saskatchewan, Saskatoon, Sask. ". . . . As we have been doing this very thing for the past fifteen or twenty years, which I presume most of the engineering schools have also been doing, we naturally agree entirely with the viewpoint back of the resolution. It might be interesting for the committee to know that last year an Engineering student won the oratorical contest, which was open to students of all faculties in the University."

Dr. F. H. Sexton, President, Nova Scotia Technical College, Halifax, N.S. ". . . . I believe that thorough training in writing and speaking the English language is just as essential as any advanced technical subject, or perhaps even more so, for the proper preparation of a young man to enter the engineering profession. I am glad that your Institute conference on Engineering Education emphasized these facts."

Dean R. W. Brock, M.E.I.C., Faculty of Applied Science, University of British Columbia, Vancouver, B.C. "Acknowledging the resolution of the Council regarding English, etc., I have called it to the attention of the heads of departments and also to the Student's Branch of The Institute. We have been working along these lines for some years."

At this conference the following resolutions were also passed:—

"It is the sense of this meeting that there is a real opportunity for The Institute Committee on Engineering Education to consider the question of helping certain of the younger men in the engineering profession to obtain the rudiments of those subjects necessary for passing The Institute entrance examinations.

"That a group of men not connected in teaching in a university be formed in several large centres for mutual exchange of opinion."

Your committee expresses its appreciation of the action of Council in having again last year accepted the committee's recommendation that the Past-President's Prize be awarded for a paper on Engineering Education, which prize was won by A. W. McQueen, A.M.E.I.C. and an award of honourable mention given to E. G. Cullwick, Jr.E.I.C., both of which papers were published in The Engineering Journal.

A meeting of this committee is being held during the Annual Meeting of The Institute in Ottawa for a further discussion of some of the original six items or recommendations, and also of certain other items which have since been suggested to your committee.

Respectfully submitted,
FRASER S. KEITH, M.E.I.C., *Chairman.*

Committee on Development

The President and Council:—

An interim report of the Committee on Development was published in the October 1932 issue of The Engineering Journal, following which a questionnaire was sent to all corporate members of The Institute, and discussions were arranged at a number of branches.

As a result of the expressions of opinion received, the recommendations were modified in the following manner:—

(*a*) Elimination of the proposed grade of Fellow.

(*b*) Changing the first of the professional requirements for membership to read:—
"Membership in an association or corporation "of professional engineers whose qualifications for "admission are recognized by Council."

(*c*) That the admission fee for member be changed from \$25.00 to \$20.00, and that the increase in annual fee be only put into effect to the extent of one-half for the first year.

A draft of new by-laws covering the proposals was prepared for discussion by the committee and by the Council of The Institute. It was felt however, that there was not sufficient time prior to the annual meeting for a full and comprehensive discussion of the proposals, and it was therefore decided that the recommendations should not go forward this year in the form of an amendment to by-laws, but simply that a progress report should be made and discussions continued.

It should be pointed out that the Committee on Development has only made an interim report covering the organization of The Institute, the committee has not as yet put into written form its recommendations and ideas regarding the actual development of The Institute, especially in view of the fact that many of the future lines of activity would be dependent on the structure of The Institute.

The result of the publication of the interim report indicates a wide divergence in the opinion of the membership as to how The Institute should be developed. There is unanimity of opinion with regard to the fact that something needs to be done, but some groups think that The Institute should move to the left, others that it should move to the right.

Respectfully submitted,

J. L. Busfield, M.E.I.C., *Chairman.*

Unemployment Committee

The President and Council:—

At a meeting held on April 15th, 1932, Council appointed a committee consisting of Messrs. D. C. Tennant, M.E.I.C., chairman, A. Duperron, M.E.I.C., and R. J. Durley, M.E.I.C., which was instructed to report on the action desirable in connection with the unemployment situation as it affected members of The Institute, particularly in view of conditions likely to obtain during the winter 1932-33. The committee obtained and studied information as to the steps which had already been taken by some of The Institute's Branches and by committees of engineers in New York, Boston and Cleveland. It was found that the efforts of our Branches had not been extensive and there were no data as to the extent to which members were unemployed, except in the files of the Employment Service Bureau at Headquarters, which at the time contained some two hundred names.

This committee reported on May 20th to Council who approved its recommendations and at once established a standing committee on Unemployment with the same membership as above and with power to add to their number, their work to be largely advisory and directed towards the co-ordination of Branch efforts. If considered necessary the committee was to be responsible for the issue of a general appeal for funds and the administration of these funds, The Institute staff at Headquarters co-operating in any way possible.

In line with these recommendations all Branch Secretaries were advised by letter on May 25th, that Council believed a general survey of the situation as regards The Institute membership should be made without delay and they were asked to co-operate by:—

(1) Appointing immediately a Branch Committee on Unemployment, composed of members who would give the necessary time to the work of collecting and classifying information regarding the local unemployment situation.
(2) Receiving from members of the Branch the completed Questionnaires which were sent out in duplicate to all members of The Institute by Headquarters.
(3) The classification of the information thus received to make it available for use should any further steps prove necessary.

Branch committees were also asked, after consideration of the above information, to advise Council as to what measures and general organization they recommended and whether it was possible and desirable to co-operate with other local organizations doing similar work. It was also suggested that branch committees canvass local possibilities as to "made work"; suggest to headquarters Employment Service Bureau the names of possible employers; and encourage all members who had not already done so to register with our Employment Service Bureau, thus rendering a valuable service to all concerned.

The response to your Committee's appeal for co-operation from the Branches was most gratifying, and notification was received of the appointment of Unemployment Committees in sixteen of the Branches, the Branch Executive Committees attending to the work in the remaining nine Branches.

The membership of the sixteen Branch Committees is as follows:

Branch Unemployment Committees

Halifax Branch:—A. F. Dyer, A.M.E.I.C., Chairman; H. S. Johnston, M.E.I.C., F. R. Faulkner, M.E.I.C.
Saint John Branch:—J. A. W. Waring, A.M.E.I.C., Chairman; A. F. Baird, M.E.I.C., D. G. Ross, A.M.E.I.C., G. Stead, M.E.I.C., G. N. Hatfield, A.M.E.I.C.
Quebec Branch:—A. Larivière, M.E.I.C., Chairman; P. Marcotte, A.M.E.I.C., R. Wood, S.E.I.C.
Montreal Branch:—O. O. Lefebvre, M.E.I.C., Chairman; J. A. McCrory, M.E.I.C., E. A. Ryan, M.E.I.C.
Ottawa Branch:—G. J. Desbarats, M.E.I.C., O. S. Finnie, M.E.I.C., W. S. Kidd, A.M.E.I.C., H. R. Cram, G. A. Browne, A.M.E.I.C.
Peterborough Branch:—W. M. Cruthers, A.M.E.I.C., Chairman; R. C. Flitton, A.M.E.I.C., W. F. Auld, Jr.E.I.C.
Toronto Branch:—R. E. Smythe, A.M.E.I.C., Chairman.
Hamilton Branch:—E. G. MacKay, A.M.E.I.C., Chairman.
London Branch:—D. M. Bright, A.M.E.I.C., Chairman; V. A. McKillop, A.M.E.I.C., W. R. Smith, A.M.E.I.C., F. C. Ball, A.M.E.I.C.
Niagara Peninsula Branch:—E. P. Murphy, A.M.E.I.C., Chairman; E. G. Cameron, A.M.E.I.C., W. D. Bracken, P. A. Dewey, A.M.E.I.C.
Border Cities Branch:—C. G. R. Armstrong, A.M.E.I.C., Chairman; A. J. M. Bowman, A.M.E.I.C., H. J. A. Chambers, A.M.E.I.C., H. J. Coulter, Jr.E.I.C., R. J. Desmarais, T. H. Jenkins, A.M.E.I.C., J. Clarke Keith, A.M.E.I.C.
Sault Ste. Marie Branch:—K. G. Ross, M.E.I.C., Chairman; H. F. Bennett, A.M.E.I.C., J. H. Jenkinson, A.M.E.I.C.
Winnipeg Branch:—J. N. Finlayson, M.E.I.C., Chairman; W. P. Brereton, M.E.I.C., J. W. Porter, M.E.I.C., E. V. Caton, M.E.I.C., C. T. Barnes, A.M.E.I.C.
Saskatchewan Branch:—H. R. MacKenzie, A.M.E.I.C., Convenor Southern Section; D. A. R. McCannell, M.E.I.C., P. C. Perry, A.M.E.I.C., A. R. Greig, M.E.I.C., Convenor Northern Section; A. M. MacGillivray, A.M.E.I.C., H. McI. Weir, E. S. C. Carpenter, A.M.E.I.C., Secretary entire Committee.
Lethbridge Branch:—J. T. Watson, A.M.E.I.C., Chairman; G. N. Houston, M.E.I.C., N. H. Bradley, A.M.E.I.C.
Calgary Branch:—F. M. Steel, M.E.I.C., Chairman; A. W. P. Lowrie, M. H. Marshall, M.E.I.C., M. P. Bridgland, M.E.I.C., H. W. Tooker, A.M.E.I.C.

As a result of the information obtained through circularizing the membership in this manner and through the excellent assistance of many of the Branch Unemployment Committees, your standing committee was able to base a report on the data and present it at a special meeting of Council held on September 1st for the purpose of passing on the Committee's recommendations.

From the information received it appeared that, at July 1st, 1932, 9.8 per cent of the members in 21 branches were definitely unemployed,—and that about 45 per cent of the membership had filled in and returned the Questionnaires.

It was found that conditions varied greatly. Generally speaking unemployment was more prevalent in the larger Branch centres, and these Branches were anxious to proceed with relief work immediately or in co-operation with some kindred agency. In a number of the smaller centres no relief work was necessary, and the Branches were not in favour of appeals for funds being made.

In view of the above your Committee's recommendations on September 1st, were as follows:

(1) That Branch Unemployment Committees carefully investigate present conditions and recheck their findings periodically—say once a month, so that relief measures may be adopted promptly, as soon as any need is evident. We would like to be sure that not one case of need in any Branch is neglected.

(2) That the appeal for funds, when necessary, should be made by each Branch from its own employed members for its own needy ones, and not by Headquarters, and that the distribution of relief be also handled by the Branch.

(3) In order to guide the various Branch Committees in their estimates of needy cases, it is suggested that direct relief should not be given without very careful inquiry to make sure that the unemployed member has exhausted all personal resources.

(4) Each Branch Committee should take special steps as by personal canvass or special meeting of the Branch, to make sure that the urgency of the need is well realized by those members to whom an appeal is made for funds.

(5) That each Branch Committee follow the suggestion in Report A of this Committee to Council, dated May 17th, 1932, and letter B of the General Secretary to Branch Secretaries, dated May 25th, 1932, regarding the collecting of information on needy cases, appealing for funds, handling of finances, direct relief and "made work" it being understood that the work will be done by each Branch separately and not by Headquarters and that the outline given in report A is in the form of suggestion as it is realized that conditions in Branches will differ.

(6) That Headquarters send to each Branch Secretary the names of those in the district who have been placed on the Suspended List owing to their financial stringency, that Questionnaires "C" be sent at once to them from Headquarters, and that they be treated as to unemployment in the same way as members in good standing.

(7) That Branch Committees be encouraged to co-operate with other relief agencies where they deem this advisable in collecting information or in appealing for funds and distributing them, always, however, bearing in mind that The Institute is anxious that, so far as possible, its own members should contribute to the relief fund and that no one of its own needy members should be overlooked.

(8) That Branches and Branch Committees keep Headquarters at all times fully advised as to just what relief work is being undertaken by them, so that Council and this Unemployment Committee may keep in close touch with the work of each Branch, with a view to helping in whatever way is possible.

This report was accepted by Council on September 1st and distributed to the Unemployment Committees of the Branches along with monthly report sheets which the Committees were asked to fill out and return to Headquarters each month, so that any change in conditions would be at once apparent. Unfortunately, these monthly reports have not been returned regularly by all the Branches, but such information as has been received up to December 31st, has been summarized as follows:

Halifax:—Unemployment situation not so serious as appeared at one time. Circularized members of Branch who might be of assistance in securing work for unemployed engineers. Committee has secured employment for a few unemployed.

Cape Breton:—Fully approves of Council's proposal. Hope that no direct relief will be needed as very few would be in a position to subscribe.

Saint John:—Sent letter to the Wardens and Councillors of nine counties and to the Mayor and Councillors of seven towns, regarding the question of employing engineers. Have a list of twenty engineers unemployed. Work of a temporary nature was secured for four graduates and one student. No requests for relief.

Moncton:—Returned Questionnaires without any comments.

Saguenay:—Formation of Unemployment Committee unnecessary. Lost several members through unemployment, but only in one case has a member remained in the district. Members in every large concern in the district and, should any engineering help be required for the E.I.C., Employment Service Bureau will be notified.

Quebec:—Appointed an Unemployment Committee. Ten unemployed, one placement. No case for relief.

St. Maurice Valley:—Three unemployed. No collections made.

Montreal:—Appointed Unemployment Committee. Executive strongly in favour of Council's action. There are eight really necessitous cases and an appeal made to the Branch members has yielded about $1,221.00. This sum is being used as required, in most cases to supplement the small amount of relief available from public sources, and will be distributed after due investigation under the care of the Registration Bureau for Office Workers, and on the recommendation of the Branch Unemployment Committee. Financial aid has also been given to the Technical Service Bureau for the securing of work for engineers most of whom are E.I.C. members. This organization has been operating for about ten months and has given part time employment to over twenty-five men who have received about $1,750.00 from some thirty concerns and individuals for whom they have done work. Sixteen men have obtained temporary positions outside the bureau through their efforts.

Ottawa:—Appointed Unemployment Committee. Twenty-seven unemployed. No cases requiring relief.

Peterborough:—Summary received of the results of the canvass made on the unemployment situation. This move on the part of The Institute will do much to strengthen The Institute's position with the engineering profession.

Kingston:—Report received on Questionnaires returned. Only one case in urgent need.

Toronto:—Appointed strong Unemployment Committee, which has done excellent work. Returned report on Questionnaires received from members, which showed twenty-five estimated in need of relief. Campaign for relief funds organized. All members of Branch asked to contribute. Ten Dollars asked for. Received a few $50.00 subscriptions and some $25.00 ones, probably 90 per cent of $1,000.00 subscribed has come in $10.00 subscriptions. To date, less than $200.00 has been loaned out. Opinion of Executive that fund should be a Loan Fund as members would be more willing to make use of the fund if it was in the nature of a loan. The control of the fund has been vested in a board of five trustees. Recommendations for loans are made by the Unemployment Committee.

Hamilton:—Unemployment Committee appointed. Report on Questionnaires received, which showed that there was no case needing urgent relief. No relief measures in the way of collection of funds adopted.

London:—Unemployment Committee appointed. Six unemployed, one placement. Suggests relief should be in hands of provincial governments.

Niagara Peninsula:—Appointed Unemployment Committee. Branch representatives canvassed firms in district with a view to securing employment for engineers, but without success. Not desirable to make collections for relief fund. Six unemployed. No applications for relief.

Border Cities:—Appointed Unemployment Committee. Organized an Unemployment Relief Fund. Branch membership asked for $3.00 each and collected $160.00. Only one case of need.

Sault Ste. Marie:—Unemployment Committee appointed. Branch membership scattered over large area. One member in each town appointed to report on his locality. Eight unemployed, one requiring relief. Will leave matter of raising relief funds in abeyance.

Lakehead:—Three unemployed, no requests for relief.

Winnipeg:—Formed a Joint Committee on Unemployment of the Winnipeg Branch of the E.I.C. and the Assoc. of Professional Engineers of Manitoba. No steps to appeal for relief funds have been made. A scheme is under way whereby the fund of the A.P.E.M. may be used for the relief of members of the two organizations who are in destitute circumstances. The relief to take the form of a loan not exceeding $25.00. Twenty-six unemployed. Three permanent and a few temporary placements obtained. No applications for assistance.

Saskatchewan:—Unemployment Committee appointed, and divided into two sections, southern and northern. Report compiled from Questionnaires received. Monthly reports covering November, December and January have been received at Headquarters showing that the situation is almost unchanged.

Lethbridge:—Unemployment Committee appointed. Local unemployment conditions have been taken care of. Only two members in temporary employment, and one unemployed.

Edmonton:—Report compiled from Questionnaires received, showing three cases which will be investigated.

Calgary:—Appointed Unemployment Committee. No members in need of relief. Committee endeavoring to locate position for unemployed. Doubtful as to wisdom of collecting funds.

Vancouver:—Vancouver Engineers' Club has formed a committee. Believe it would be unwise to establish a second committee. No enquiries for relief received by Branch. Unemployment has caused much need which is being well looked after by the above Committee.

Victoria:—Report on unemployment compiled from Questionnaires. About three cases to be investigated. As matters stand it is doubtful if it will be necessary to raise funds for relief.

A chart has been prepared showing information from various Branches as far as received. From this chart it is noted:

(*a*) The number of members as given totals 4,176 and includes students but does not include several hundred outside Canada.

(*b*) Some Branches have reported very recently while others have not done so for several months. The chart shows data received at Headquarters to date and is probably about correct to the end of 1932.

(*c*) Practically all Branches report some cases of unemployment.

(*d*) The numbers of unemployed do not include student members. There is quite a large number of such and the committee has no wish to suggest that they should be neglected but it was felt the information regarding the other grades would be of more urgent interest.

(e) Four Branches report funds collected for relief totalling $2,810.00.

(f) There appear to be about forty cases of actual need. This is about one per cent of the membership residents in Canada.

In order that the various Branch Committees might have up-to-date information and possibly obtain new ideas, reports as to the work done by various engineering committees in New York, Boston, Cleveland, Vancouver Engineers Relief Committee, and the Toronto Branch, E.I.C. Unemployment Committee, have been distributed periodically.

Council on September 1st also directed that each Branch be advised that the members of their Branch whose names were on the Suspended List were to receive every assistance possible to the same extent as if they were members in good standing.

In order that the Committee would be conversant with the unemployment relief work as administered in the various provinces throughout Canada, a study has been made of pertinent information regarding this, particularly with respect to the part taken therein by

(a) Cities and Towns,
(b) The Provincial Governments,
(c) The Dominion Government.

Your Committee feels that the situation regarding unemployment is somewhat more severe than when the previous report was made to Council up to July 1st, 1932. This should, we think, be emphasized at the annual meeting and, as far as possible, in all the Branches. It is impossible to forecast whether cases of distress will become more numerous and pronounced but we feel that The Institute's members should be kept fully informed, as it may be that even greater efforts and generosity may yet be necessary.

Respectfully submitted,

D. C. Tennant, M.E.I.C.,
Convenor of Unemployment Committee.

Employment Service Bureau

During the past year practically all large organizations employing engineers have been obliged to continue the reduction of their staff and it has been increasingly difficult to find vacancies or opportunities for employment for our members. About two-thirds of the placements known to have been effected by the Bureau were more or less temporary, but it is encouraging to note that the total number, 58, is larger than in 1931, although fewer vacancies were advertised in the E.I.C. News. The number of members registered with the Bureau and known to be unemployed is 255. The reports of Branch Unemployment Committees indicate that our total number of unemployed is larger than this, but little can be done to assist those members who will not register or notify us of their requirements. The difficulty of assisting our unemployed members is greatly increased by their apparent reluctance to register and, in too many cases, by their neglect to keep us informed of their numerous changes of address, or to let us know when they obtain positions themselves. A number of chances of employment requiring prompt action have been lost to members through these causes.

The following figures show the extent of the Bureau's work for 1932:—

	1932	*1931*
Number of registrations during year—Members	166	139
Number of registrations during year—Non-Members	18	37
Number of Members advertising for positions	132	130
Replies received from employers	34	76
Vacant positions registered	117	122
Vacancies advertised	18	47
Replies received to advertised vacancies	162	240
Men notified of vacancies	143	97
Men's records forwarded to prospective employers	219	397
Placements — temporary and permanent — definitely known	58	33

The Institute has been able to furnish a limited amount of work to unemployed members in connection with the preparation of the copy for the E.I.C. Engineering Catalogue, and in preparing circulars and ballots for the mail.

The discontinuance of the E.I.C. News, which it is hoped will only be temporary, will be compensated for as far as possible by the issue of mimeographed bulletins to prospective employers giving particulars of members available for employment. The Bureau throughout the year has endeavoured to keep in touch with the Employment Committees of the various Branches, and would appreciate their further co-operation.

Respectfully submitted,

R. J. Durley, M.E.I.C., *Secretary.*

Branch Reports

Border Cities Branch

The President and Council:—

The work of the Border Cities Branch has been carried on during 1932 by the following committees:—

Papers and Entertainment	H. J. Coulter, Jr.E.I.C., Chairman.
	B. Candlish, A.M.E.I.C.
	T. H. Jenkins, A.M.E.I.C.
	H. W. Patterson, A.M.E.I.C.
Reception	R. C. Leslie, A.M.E.I.C., Chairman.
	R. J. Desmarais.
	Geo. Medlar, A.M.E.I.C.
Membership	T. H. Jenkins, A.M.E.I.C., Chairman.
	B. A. Berger, S.E.I.C.
	W. J. Campbell, A.M.E.I.C.
Publicity	R. J. Desmarais.
Advertising	A. J. M. Bowman, A.M.E.I.C.
Representative on the Directorate of the Border Chamber of Commerce	C. G. R. Armstrong, A.M.E.I.C.
Nominating	Orville Rolfson, A.M.E.I.C.
Branch News Editor and Assistant Secretary	B. A. Berger, S.E.I.C.

The following meetings were held:—

Jan. 15.—Mr. Geo. F. Macdonald of Bartlet Macdonald & Gow, Ltd., spoke on **Early Surveys in Essex County.**

Feb. 12.—Mr. W. J. D. Reed-Lewis of the Super Cement Co. of Detroit, spoke on **Cements.**

Mar. 18.—Boyd Candlish, A.M.E.I.C., of the Palmer Bee Co., Detroit, spoke on **Herringbone Gears.**

April 15.—C. S. Kane, A.M.E.I.C., of the Dominion Bridge Co. Ltd., spoke on the **Kane System of Composite Construction.**

May 6.—P. L. Pratley, M.E.I.C., of Monsarrat & Pratley, consulting engineers, spoke on **The Montreal Harbour Bridge.**

June 24.—This was a special meeting. R. J. Durley, M.E.I.C., General Secretary of The Engineering Institute of Canada, spoke on **Unemployment.**

Oct. 14.—F. H. Kester, M.E.I.C., of The Canadian Bridge Co., spoke on **Islands of the South Pacific.**

Nov. 18.—O. M. Perry, M.E.I.C., of Windsor Hydro-Electric System, spoke on **Some of Aspects Hydro in Ontario.**

Dec. 16.—Annual Meeting.

Attendance at Meetings

January meeting	18	June meeting	20
February "	24	October "	33
March "	27	November "	21
April "	36	December "	13
May "	36		
Average	25.4		

Averages for other years:—

1927	*1928*	*1929*	*1930*	*1931*
20	38	34	28	25

In closing the report, appreciation and thanks were expressed to Mr. B. A. Berger for his able assistance.

Financial Statement

(For year ending December 31st, 1932)

Receipts

Balance on hand—January 1st, 1932	$180.17	
Receipts—Rebates from Headquarters, including November	156.75	
Rebates from Headquarters for December	3.30	
Branch News including November	13.39	
Advertising	11.34	
Paid dinners	106.00	
Miscellaneous	10.00	
Unemployment Committee Fund	154.62	
		$635.57

Expenditures

Printing	$ 41.69	
Stamps and Telegrams	20.41	
Typing	15.00	
Speakers' Expenses	50.30	
Meals	119.50	
Cigars	21.90	
Miscellaneous	84.20	
Unemployment Committee Fund—Personal Relief	$100.00	
Miscellaneous	1.30	
Balance in Bank	177.97	
Rebates due from Headquarters	3.30	
		$635.57

Respectfully submitted,

C. G. R. Armstrong, A.M.E.I.C., *Chairman.*
Harold J. A. Chambers, A.M.E.I.C., *Secretary-Treasurer.*

Calgary Branch

The President and Council:—

On behalf of the Executive committee we beg to submit the following report of the activities of the Calgary Branch for the calendar year of 1932:—

Membership

	Dec. 31, 1931 Resident	Non-Resident	Total
Members	23	7	30
Associate Members	55	20	75
Juniors	4	1	5
Students	4	1	5
Branch Affiliates	12	..	12
	98	29	127

	Dec. 31, 1932 Resident	Non-Resident	Total
Members	19	7	26
Associate Members	47	11	58
Juniors	4	1	5
Students	8	2	10
Branch Affiliates	12	2	14
	92	21	113

It is with deepest regret that we report the death of two prominent members during the past year, C. J. Yorath, M.E.I.C., who died on April 2nd, and C. Chambers, M.E.I.C., who died on June 11th.

The Executive committee met fourteen times during the year to deal with the various questions which arose. An Unemployment committee of five members of the executive was formed, and meeting twice since June dealt with all questions pertaining to the unemployment situation.

The committee in charge of the Annual Ball met four times, their efforts resulting in a successful ball held at the Palliser hotel on Friday, December 2nd. Due, however, to unforseen circumstances the number of guests including members was only one hundred and twenty two. This was considerably under the number of guests and members present in 1931, but the Annual Ball still continues to be a popular and important event in the social life of Calgary.

Eight general meetings were held with a fair attendance and some interesting papers and discussions.

Jan. 7.—**The Expedition of Warr and Varasour through Canada to Oregon in 1845** by Mr. H. S. Patterson, K.C., barrister and solicitor, of Calgary. Attendance, 40.

Jan. 21.—**The Science of Agriculture in Alberta** by Mr. E. W. Jones, Superintendent of Agriculture and Animal Industry, Department of Natural Resources, Canadian Pacific Railway. Attendance, 22.

Feb. 11.—**Mineral Resources of Alberta** by Dr. J. A. Allen, Professor of Geology, University of Alberta. Attendance, 52.

Feb. 25.—**Interconnected Power Stations in Alberta** by G. H. Thompson, A.M.E.I.C., chief engineer of the Calgary Power Company. Attendance, 60.

Mar. 12.—Annual Meeting and election of officers. Attendance, 18.

Mar. 31.—**Transportation Problems of The Mackenzie River and Great Bear Lake Areas** by C. C. Ross, M.E.I.C. Attendance, 85.

April 2.—Annual Dinner. Attendance, 55.

Aug. 27.—Annual Golf Tournament. Attendance, 16.

Oct. 20.—**The Glenmore Dam** by N. G. McDonald, A.M.E.I.C., resident engineer for the consulting engineers of the Glenmore dam. Attendance, 65.

Nov. 17.—Informal discussion on the Interim Report of the Committee on Development. Attendance, 30.

Dec. 2.—Annual Ball. Attendance, 122.

Dec. 15.—**The Effects of Weather Trend on Business Activity** by J. A. Spreckley, A.M.E.I.C. Attendance, 30.

Financial Statement

(For the year ending December 31st, 1932)

Receipts

Cash in bank		$ 73.43	
Value of bonds at par, (Balance of interest for 1932 not included)		1,086.66	
Dues collectable from Affiliates		38.00	
Cash account		5.60	
Rebates due, telegram Jan. 3		13.50	
			$1,217.19

Liabilities

Accounts outstanding:—			
S. Burnand	$ 1.85		
Calgary Board of Trade	5.00		
		$ 6.85	
Net value of assets, December 31st, 1932		1,210.34	
			$1,217.19

Revenue

Bank balance Jan. 1st, 1932	$201.43		
Rebates due	8.10		
		$ 209.53	
Interest on bonds and savings	53.22		
Less rent of safety deposit box	3.00		
		50.22	
Rebates from Headquarters		217.80	
Amount due on rebates to Dec. 31st, 1932		13.50	
Branch news		31.39	
Branch Affiliates	68.00		
Less amounts applicants deposits	47.00		
		21.00	
			$ 543.44

Expenditure

Expense of meetings	$121.10		
Less amount collectable from Joint Meeting	2.50		
		$ 118.60	
Stenographic		21.95	
Stamps, printing, etc		88.91	
Miscellaneous		27.50	
Annual Ball		128.82	
Cash in bank Dec. 31st, 1932		73.43	
Cash account (Secretary)		5.60	
Cash account	75.00		
Less refund from Annual Dinner	3.02		
		71.98	
Amount due on rebates		13.50	
Less accounts outstanding		6.85	
			$ 543.44

B. L. Thorne, M.E.I.C.
W. B. Trotter, A.M.E.I.C. } Auditors.

Respectfully submitted,

F. M. Steel, M.E.I.C., *Chairman.*
H. W. Tooker, A.M.E.I.C., *Secretary-Treasurer.*

Cape Breton Branch

The President and Council:—

Below is the annual report of the Cape Breton Branch for the year ending December 31st, 1932.

During the past year the Branch held five meetings as under:—

Jan. 12.—**Trans-Canada Highway** by L. H. Wheaton, A.M.E.I.C.

Feb. 16.—**Track-lifting Machines and Underground Shovels** and **Domestic Heating**,—two films followed by general discussion.

Mar. 8.—**Sanitary Engineering as Applicable to the Eradication of Yellow Fever** by Mr. O. G. Marsh.

Nov. 18.—**High Temperature Furnace Cements and Protective Coatings** by Mr. D. J. Matheson.

Dec. 15.—Annual dinner meeting followed by paper on **The Significance of Washability Curves in Coal Washing Problems** by Mr. J. L. Bowlby.

The average attendance at the above meetings was 34, and always a lively discussion followed the reading of the paper.

Financial Statement

Receipts

Balance brought forward	$171.71	
Rebates from H.Q.	77.70	
Tickets, Dinner Meeting	28.00	
		$277.41

Expenditures

Postage and telegrams	$ 5.02	
Printing	3.84	
Meetings	40.90	
Balance carried forward	227.65	
		$277.41

Respectfully submitted,
Yorke C. Barrington, A.M.E.I.C., *Chairman.*
Sydney C. Mifflen, M.E.I.C., *Secretary-Treasurer.*

Edmonton Branch

The President and Council:—

The Executive committee of the Edmonton Branch submits the following report for the year 1932.

Meetings

Lectures and papers given before the Branch during the year were as follows:—

Jan. 8.—**The Corrosion of Iron** by Dr. J. W. Shipley, Department of Chemistry, University of Alberta.

Feb. 4.—**Electric Generation and Distribution** by G. H. Thompson, A.M.E.I.C., chief engineer of The Calgary Power Co.

Mar. 8.—**Pot-pourri on History of Banking** by Campbell Fraser, manager of The Dominion Bank, Edmonton.

April 21.—**Weather Lore and Alberta Weather** by Professor L. H. Nichols, Assistant Professor of Physics, University of Alberta.

Nov. 16.—**The Duff Report on Railways**, a general discussion which was opened by Dean R. S. L. Wilson, M.E.I.C., Dean of Applied Science, University of Alberta.

Dec. 6.—A visit to the city of Edmonton power plant and a paper on the new boiler installation by Alexander Ritchie, A.M.E.I.C.

The Executive committee met five times to deal with the various questions which arose.

Membership

The Branch membership is now as follows:—

	Resident	*Non-Resident*
Members	13	2
Associate Members	26	7
Junior Members	4	..
Student Members	27	..
	70	9

Financial Statement

Receipts

Balance on hand Jan. 1st, 1932	$256.12	
May 20th—Rebates from Headquarters	93.30	
Oct. 27th—Rebates from Headquarters	8.70	
Dec. 23rd—Rebates from Headquarters	5.40	
Dec. 31st—Rebates from Headquarters	12.60	
		$376.12

Expenditures

Expenses of meetings	$ 27.05	
Printing meeting cards	20.81	
Postage	7.00	
Honorarium to Secretary-Treasurer	50.00	
Balance on hand, Dec. 31st, 1932	271.26	
		$376.12

Respectfully submitted,
H. J. MacLeod, M.E.I.C., *Chairman.*
W. E. Cornish, Jr.E.I.C., *Secretary-Treasurer.*

Halifax Branch

The President and Council:—

On behalf of the chairman and Executive committee the following report on the activities of the Halifax Branch for the past year 1932 is submitted.

Including the Annual Meeting there have been seven regular meetings of the Branch and eight meetings of the Executive committee.

The regular meetings were as follows:—

January.—The Annual Banquet, held in conjunction with the Nova Scotia Association of Professional Engineers.

February.—The meeting was addressed by J. J. MacDonald, M.E.I.C., chief engineer of the Halifax Harbor Commissioners, on **The Rebuilding of the Terminal Facilities at Saint John.** Attendance, 42.

March.—The meeting was addressed by Major R. L. Dunsmore, A.M.E.I.C., general manager of the Imperial Oil Company's plant at Imperoyal, on **South American Oil Fields.** Attendance, 23.

April.—The April meeting was held at the Lord Nelson hotel and was addressed by J. H. Mowbray Jones, A.M.E.I.C., chief engineer of the Mersey Paper Company, who spoke on **The Development of Paper Making Machinery.** Attendance, 43.

October.—The annual Student's meeting was held in the Assembly Hall of the Nova Scotia Technical College and was addressed by K. L. Dawson, M.E.I.C., on **After College—What?** This paper brought forth a great deal of discussion from the 130 members, students and guests present.

November.—The November meeting at the Nova Scotian hotel was addressed by C. H. Wright, M.E.I.C., on **The Saint Lawrence Waterways.** Thirty-five members were joined by members of the Society of International Affairs and many students, making a total of 115.

December.—The Annual Meeting at the Nova Scotian hotel on Thursday, December 15th, was devoted to discussion of the Interim Report of the Committee on Development. Following a full discussion of various phases of the report it was decided to protest any action that would bring this report before the next annual meeting.

The attendance record at meetings during the year was much greater than usual and shows an improved interest in the affairs of The Institute.

Financial Statement

Receipts

Cash on hand, Jan. 1, 1932	$300.35	
Rebates	279.45	
Branch News	17.66	
Bank interest	10.23	
Miscellaneous	40.00	
		$647.69

Expenditures

Meetings	$137.21	
Secretary's office	102.88	
Mailing list	7.00	
Miscellaneous	8.83	
Cash on hand	391.77	
		$647.69

Respectfully submitted,
Harold S. Johnston, M.E.I.C., *Chairman.*
R. R. Murray, A.M.E.I.C., *Secretary-Treasurer.*

Hamilton Branch

The President and Council:—

The Executive committee of the Hamilton Branch submits the following report for the year 1932.

Membership

Dec. 31st, 1931

	Resident	*Non-Resident*	*Total*
Members	25	5	30
Associate Members	49	9	58
Juniors	14	3	17
Students	32	1	33
Affiliates E.I.C.	3	0	3
Branch Affiliates	18	0	18
	141	18	159

Dec. 31st, 1932

	Resident	*Non-Resident*	*Total*
Members	27	6	33
Associate Members	47	10	57
Juniors	13	2	15
Students	35	0	35
Affiliates E.I.C.	2	0	2
Branch Affiliates	16	0	16
	140	18	158

MEETINGS

The following meetings were held during the year:—

Feb. 16.—**Air Transportation** by Capt. A. F. Ingram, AFFIL.E.I.C. Attendance, 55.

Mar. 15.—**Water Borne Transportation** by F. I. Ker, M.E.I.C. Attendance, 50.

April 8.—**Locomotive No. 8000** by W. A. Newman. This was a dinner meeting held in Galt. It was a joint meeting with the Engineering Society of Babcock-Wilcox and Goldie-McCulloch Ltd. Attendance, 140.

April 22.—**Mercury Arc Rectifiers** by A. L. Atherton. This was the annual joint meeting with the Toronto Section A.I.E.E. Attendance, 210.

May 10.—Annual Branch dinner and meeting. **The Hudson Bay Railway** by Dr. H. A. Innes. Attendance, 32 at dinner, 60 at the meeting.

June 24.—**Chemistry in Industry** by W. E. Paterson. This meeting was held in Brantford at G. F. Sterne and Sons' Laboratory.

Oct. 19.—**The Hamilton Filtration Plant** by W. L. McFaul, M.E.I.C. This meeting was preceded by a visit to the new Hamilton filtration plant and the Depew Street sewage disposal plant and incinerator.
E. C. Hay, S.E.I.C., presented a student paper on **Diesel Electric Drive** prior to Mr. McFaul's address. Attendance, 19 at dinner, 35 at the meeting.

Nov. 8.—**Highways of Ontario** by H. A. Lumsden, M.E.I.C. This was our annual joint meeting with the Engineering Society of Babcock-Wilcox and Goldie-McCulloch and was held in Galt.

Nov. 25.—**Development of The Institute** by J. L. Busfield, M.E.I.C. Attendance, 35.

The Branch has undertaken a new departure this year in the sponsoring of papers prepared by committees of the Branch. Response to the request for volunteers has been very gratifying and a number of papers are being prepared under various chairmen-authors. A paper on **The Value of Photography to Engineering** which is being prepared by a committee under the chairmanship of A. R. Hannaford, A.M.E.I.C., is now nearly completed and will be presented to the Branch early in the new year.

During the year the Branch by-laws have been revised and brought up to date.

FINANCIAL STATEMENT

Receipts

Balance, Jan. 1st, 1932		$303.84
Branch Affiliates	$ 36.00	
Rebates on Fees	248.55	
Branch News	43.50	
Interest	63.65	
		$391.70
Journal subscriptions		2.00
		697.54

Expenses

Printing and Postage	$192.58	
Lecture Expenses	72.60	
Stenographer	50.00	
Sundry	9.40	
Expenses of Councillor	90.00	
Flowers	10.00	
Year Book	50.56	
		$475.14
Journal subscriptions		4.00
Lantern purchased		150.00
Cash on Hand and due from Headquarters	53.80	
Bank Balance, Jan. 1st, 1933	14.60	
		$ 68.40
		$697.54

Assets

Bonds, at cost	$915.00	
Lantern	150.00	
Bank Balance, Cash, Etc	68.40	
		$1,133.40

Respectfully submitted,
E. P. MUNTZ, M.E.I.C., *Chairman.*
J. R. DUNBAR, A.M.E.I.C., *Secretary-Treasurer.*

Kingston Branch

During the year 1931-1932, the Kingston Branch adopted the plan of relying chiefly on its own members for papers. For each such meeting a dinner was held at the Badminton Club following which the paper was read. Three such meetings were held besides one meeting at which the paper was presented by a visiting engineer.

1931

Dec. 15.—**The Fixation of Atmospheric Nitrogen for Use in Fertilizers, and the Utilization of Water Power in Connection Therewith** by Dr. L. F. Goodwin, M.E.I.C.

1932

Jan. 29.—Messrs. A. H. Harkness, M.E.I.C., and H. Hellmuth addressed the members of the Branch on behalf of the Association of Professional Engineers of Ontario. Following their address, a paper on **Engineering at the End of the XVIIth Century** was presented by Professor D. S. Ellis, A.M.E.I.C.

Mar. 1.—A paper on **Locomotive Design** was read by W. Casey, M.E.I.C., vice president and general manager of the Canadian Locomotive Company.

Mar. 18.—Dr. J. L. Morris, M.E.I.C., visited Kingston on March 18th, and gave a most interesting address on **The Ontario Land Drainage Act**, in Carruthers Hall, Queens University.

During the early spring and summer the Branch Executive took up with the International Bridge Committee of the Kingston Chamber of Commerce the desirability of having a Canadian engineer report on the proposed International Bridge near Kingston, or at least so far as the Canadian section was concerned. In this they were successful and the firm of Monsarrat and Pratley, of Montreal, was employed.

The directions and instructions received from the General Secretary on the subject of unemployment among engineers have been carried out so far as possible.

The membership of the Branch as compared with last year is as follows:

	Hon. Mem.	*Members*	*Assoc. Mem.*	*Affil.*	*Jr.*	*Stu.*
1930-31	1	12	13	1	4	33
1931-32	1	12	17	1	6	7

FINANCIAL STATEMENT
1931-1932

Receipts

Balance, 1930-31	$104.99	
Dec. 15—Rebates	9.90	
Jan. 21—Rebates	.60	
" 31—Bank interest	1.65	
June 10—Branch News	12.63	
" —Rebates	59.40	
" 30—Bank interest	.51	
		$189.68

Expenditures

Dec. 15—Dinner expenses	$ 2.15	
" 17—Cards	1.03	
" 23—Contribution to Red Cross Society	5.00	
" 23—Stationery	.90	
" 23—Cards, telegram, etc	2.99	
Jan. 25—Dinner expenses	6.35	
Feb. 2—Secretary's honorarium	50.00	
" 9—Stamps	2.19	
Mar. 1—Dinner expenses	6.90	
" 10—Dues, Kingston Chamber of Commerce	15.00	
" 16—Dinner, expenses	2.00	
" 29—Maps (*re* proposed International Bridge)	1.02	
April 27—Long distance telephone, Montreal	2.15	
June 17—Cards	3.22	
Oct. 18—Cash in hand and bank	88.78	
		$189.68

Respectfully submitted,
L. F. GOODWIN, M.E.I.C., *Chairman.*
L. F. GRANT, M.E.I.C., *Secretary-Treasurer.*

Lakehead Branch

The President and Council,—

On behalf of the Executive Committee, we beg to submit the following Annual Report of the Lakehead Branch of The Engineering Institute of Canada.

MEMBERSHIP

On January 1st, 1932, there were 43 Corporate Members and 11 Non-Corporate Members, and on December 31st, 1932, there were 41 Corporate and 12 Non-Corporate Members.

MEETINGS

There was only one meeting held during the year, held on December 13th, 1932, at The Garrison Officers' Mess, Port Arthur. The meeting was held to discuss the Interim Report on Development.

H. G. O'Leary, A.M.E.I.C., was appointed the Lakehead Branch representative on the Nominating Committee.

Financial Statement
(1932)

Revenue

Balance in bank, December 31st, 1931	$370.60	
Less 1931 rebate deposited January 2nd, 1932	6.00	
Correct balance in bank, December 31st, 1931	$364.60	
Rebates of fees	70.65	
Bank interest	11.92	
Rebates due from Headquarters as at December 31st, 1932	3.90	
		$451.07

Expenditure

Balance in bank, December 31st, 1932	$447.17	
Accounts receivable—rebates due from Headquarters	3.90	
		$451.07

Respectfully submitted,

C. B. Symes, A.M.E.I.C., *Chairman.*
Geo. P. Brophy, 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 during the past year.

Since January 1st, 1932, ten regular meetings and two special meetings have been held when the average attendance was 37; also seven executive meetings when the attendance was almost 100 per cent.

The customary procedure has been continued in connection with our regular meetings, i.e. dinner meetings with short musical programmes and community singing before the address of the evening.

Once again the Branch has been fortunate in having had some excellent speakers on very interesting subjects, due entirely to a very energetic Programmes Committee. Interest in our meetings has been retained to a very great extent through the efforts of our Entertainment Committee.

The list of speakers and subjects chosen follows:—

Jan. 9.—J. R. Mackenzie; Western Superintendent Dominion Glass Co. Ltd., Redcliff. Subject: **Glass Making.**

Jan. 18.—R. S. Phillips; Representative of the Portland Cement Assoc. Subject: **Proportioning Concrete for Durability,** illustrated with lantern slides.

Jan. 23.—R. S. Trowsdale, A.M.E.I.C., Canadian General Electric Co. Subject: **Automatic Equipment,** illustrated by motion pictures.

Feb. 6.—Dr. E. H. Boomer, Research Council of Alberta. Subject: **The Uses of Natural Gas in the Chemical Industry.**

Feb. 20.—L. R. Brereton, A.M.E.I.C., Metallurgist of the Manitoba Rolling Mills. Calgary. Subject: **Steel Manufacture,** illustrated by motion pictures.

Mar. 5.—Annual Meeting. Speaker: W. Russ, Alberta Government Telephones. Subject: **The Storage Battery,** illustrated by motion pictures.

Aug. 30.—Special Meeting for N. Marshall, M.E.I.C., who was retired.

Oct. 15.—R. J. Ritchie Paterson, Chartered Accountant. Subject: **Accountancy and How to Read a Balance Sheet.**

Oct. 29.—E. Ward Jones; Supt. Animal and Agricultural Industry for C.P.R. D.N.R., Calgary. Subject: **Some Observations of Agriculture in Europe,** illustrated by lantern slides.

Nov. 12.—J. E. Theobald, City Electrician. **Transmission Lines and Distribution.**

Nov. 26.—G. H. Thompson, B.Sc., A.M.E.I.C., chief engineer for the Calgary Power Co., Calgary. Subject: **Electrical Generation and Distribution,** illustrated with lantern slides.

Dec. 10.—Ladies Night. Musical Entertainment and motion pictures.

The Annual Meeting of the Branch was held on March 5th when the officers were chosen for the season 1932-1933.

At December 31st, 1932, the membership of the branch is as follows:—

	Resident	*Non-Resident*	*Total*
Members	5	0	5
Associate Members	16	1	17
Junior Members	0	2	2
Student Members	2	3	5
Affiliates	31	0	31
			60

Financial Statement
(At December 31st, 1932)

Revenue

Bank balance as at December 31st, 1931	$53.87		
Rebates due from Headquarters for 1931	$ 2.70		
		$ 56.57	
Rebates received from Headquarters		59.10	
Branch News revenue from Headquarters		33.63	
Branch affiliate fees and Journal subscriptions		102.85	
Special donations for N. Marshall's gift		32.00	
Bank interest		0.99	
Collector of Customs.—Refund on films		68.00	
			$353.14

Expenditure

Printing and stationery	39.94	
Meeting expenses: speakers, music, films, etc	74.09	
On a/c Holmes Motion Picture Projector	60.25	
Headquarters: Branch Affiliates Journal subscriptions	22.00	
Gratuities: hotel staff, orchestra	56.75	
Postage, exchange on cheque, etc	5.15	
Collector of Customs.—Deposit on films	68.00	
		$326.18

Assets

Bank balance as at Dec. 31st, 1932, less o/s cheques	$ 26.96	
Holmes Projector value at Dec. 1931, $324.22 less 10% Depreciation	291.80	
Percentage of Members fees in arrears	17.44	
		$336.20

Liabilities

Headquarters Journal subscriptions	$ 2.00
E. A. Lawrence personal account stamps, etc	3.49

We have examined the books, vouchers, papers 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.

P. M. Sauder, M.E.I.C.
C. S. Donaldson, A.M.E.I.C. } Auditors.

Respectfully submitted,

Wm. Meldrum, A.M.E.I.C., *Chairman.*
E. A. Lawrence, S.E.I.C., *Secretary-Treasurer.*

London Branch

The President and Council:—

On behalf of the Executive committee of the London Branch we beg to submit the following summary of the Branch activities for the year ending December 31st, 1932.

Ten Executive meetings were held and eight general meetings.

The year opened with the Annual Meeting on Thursday, January 21st, 1932, preceded by an informal dinner at the Hotel London for the speaker of the evening, Lieut.-Colonel F. Fraser Hunter, D.S.O., F.R.G.S.

The Annual Meeting was afterwards held at 8 p.m. in the London Life Auditorium. Colonel Hunter's address: **India and the Post-War Orient,** illustrated by slides was appreciated by an audience of some 200 members and visitors. The business meeting with election of officers concluded the meeting.

The regular February meeting was held as a smoker, in the recreation room, city hall, and a feature was a presentation of an engraved cigarette case to F. C. Ball, A.M.E.I.C., who had held the post of Secretary-Treasurer of the Branch for six years.

The presentation was followed by an address by E. V. Buchanan, M.E.I.C., on **The Profession of an Engineer.** This was a carefully prepared paper of outstanding merit. At the conclusion of the address, Dr. Stevenson showed a number of movie reels of a South American tour. Attendance, 30.

The March meeting was held in the city hall recreation room and was addressed by Mr. Sterne, consulting chemical engineer, Brantford, on **Chemistry in Engineering.** His address was most entertaining and was followed by an animated discussion and refreshments. Attendance, 40.

The April meeting was held in the County Council Chambers and was addressed by Mr. F. H. Coates, lecturer in bio-chemistry at the University of Western Ontario. His subject was **Engineering Triumphs of the Ancient Egyptians** coloured slides made by Mr. Coates were perfect specimens of the art of photography. Attendance, 38.

The May meeting was held in the County Council Chambers and was addressed by S. W. Archibald, O.L.S., A.M.E.I.C., on **Development Work in the Sub-Arctic.** This was an illustrated address on work for the Flin Flon mine and was much appreciated. Attendance, 20.

The June meeting took the form of an inspection trip on Saturday afternoon, June 18th, of the St. Thomas filtration plant, reforestry work in connection with the water works park and also the activated sludge plant. All details were ably explained by W. C. Miller, M.E.I.C., who, personally conducted the party to the different plants. Attendance 20.

The regular October meeting was cancelled owing to the members being invited to the conference on Scientific Research held in the

Auditorium of the Medical School on Friday, October 28th. E. V. Buchanan, M.E.I.C., was one of the five speakers of the Conference.

The November meeting was held in the County Court Room and Mr. Harper, criminal intelligence officer of the London Police Force, ably explained the finger printing system and its possible adoption as a means of registration for birth certificates, passports, etc. Attendance, 18.

The December meeting was held in the Board Room of the Public Utilities Bldg., and W. C. Miller, M.E.I.C., gave a splendid paper on **Purification of Public Water Supply.** Though it was of necessity highly technical in nature, Mr. Miller was able to make it interesting to engineers of all branches who were present and a lively discussion followed. Attendance, 20.

The average attendance for the eight meetings was 48, which was equal to that of 1931.

Financial Statement

(Year ending December 31st, 1932)

Receipts

Jan.	1—Cash on hand	$ 5.00	
"	1—Bank Balance	139.28	
"	16—Rebates on Fees, due in 1931, received in 1932	2.70	
Mar.	12—Mr. Brady, Affiliate Fees 1932	3.00	
"	31—Rebates from Headquarters	93.43	
May	31— " " "	22.03	
Dec.	22— " " "	10.65	
	Rebates due from Headquarters for Dec..	5.40	
			$281.49

Expenditures

Jan.	27—Hunter Printing Co. (Jan. 16th)	$ 2.75	
"	27—Howard Printing Co	4.94	
"	27—F. Fraser Hunter, Fee and expenses	45.73	
"	27—Hotel London (Col. Hunter, dinner expenses)	2.85	
Feb.	5—Secretary's expenses	1.20	
Jan.	11—Telephone to Col. Hunter, Toronto	.90	
Mar.	11—Hunter Printing Co	2.75	
"	20—Postage stamps, February and March	2.30	
April	20— " "	2.40	
May	6—Elevator service, March 24th	1.00	
"	13—Hunter Printing Co., March printing	2.75	
"	13— " " " April "	2.65	
"	13— " " " May "	2.65	
	Telegram to Secretary, Windsor Branch.	.25	
Aug.	15—Hunter Printing Co., June printing	2.28	
	Postage stamps	2.40	
Feb.	15—Johnston Bros., cigarette case	10.00	
	Secretary's Expenses to Toronto	17.50	
Jan 3 1933	—Hunter Printing Co., Nov. and Dec. printing	4.30	
Dec.	31—Postage stamps	3.00	
	Rebates due from Headquarters	5.40	
	Cash on hand	2.10	
	Bank balance	159.39	
			$281.49

We hereby certify that the foregoing is a true statement.

G. E. Martin, A.M.E.I.C. }
J. H. Munro, A.M.E.I.C. } Auditors.

Respectfully submitted,

D. M. Bright, A.M.E.I.C., *Chairman.*
W. R. Smith, A.M.E.I.C., *Secretary-Treasurer.*

Moncton Branch

The President and Council:—

On behalf of the Executive committee we beg to submit the thirteenth annual report of Moncton Branch.

The Executive committee held four meetings. Four regular meetings of the Branch were held and, in addition, a series of nine lectures on concrete were delivered by Messrs. Portugais and Boyd of the Canada Cement Co. Ltd.

Membership

Our membership at present consists of eighty-six members as follows:

	Resident	*Non-Resident*
Members	9	2
Associate Members	20	5
Juniors	1	2
Students	41	4
Affiliates	2	0
	73	13

The annual meeting of the branch was held on May 30, 1932 at which the officers were elected for the year 1932-33.

Financial Statement

(Year ending December 31, 1932)

Receipts

Balance in bank, January 1, 1932	$244.04	
Cash on hand, January 1, 1932	3.39	
Rebates on dues	59.40	
Affiliate dues	10.00	
Branch News	10.13	
Bank interest	7.09	
Rebates due from Headquarters	14.10	
		$348.15

Expenditures

Expenses of meetings	$ 5.50	
Printing and advertising	14.23	
Postage	5.74	
Telegrams and telephones	3.38	
Miscellaneous	49.12	
Balance in bank	256.08	
Rebates due from Headquarters	14.10	
		$348.15

Assets

Balloptican lantern	$ 30.00	
Attache case	5.00	
Cash in bank	256.08	
Rebates due from Headquarters	14.10	
		$305.18

Liabilities

None.

Audited and found correct,

C. S. G. Rogers, A.M.E.I.C. }
A. S. Gunn, A.M.E.I.C. } Auditors.

Respectfully submitted,

T. H. Dickson, A.M.E.I.C., *Chairman.*
V. C. Blackett, A.M.E.I.C., *Secretary-Treasurer.*

Montreal Branch

The President and Council:—

The Executive Committee of the Montreal Branch begs to submit the following report of its activities during the year 1932:—

The committee held eleven meetings, at which there was an average attendance of ten.

Papers and Meetings Committee

The Papers and Meetings Committee was composed of the following members:—

Chairman .... J. L. Clarke, M.E.I.C.
Vice-Chairman .... F. E. V. Dowd, A.M.E.I.C.
Ex-Officio .... C. K. McLeod, A.M.E.I.C.
Aeronautical Section, Chairman ..... Capt. A. F. Ingram, Affil.E.I.C.
Civil Section, Chairman .... J. B. D'Aeth, M.E.I.C.
Vice-Chairman .... John S. Brisbane, A.M.E.I.C.
Electrical Section, Chairman .... H. J. Vennes, A.M.E.I.C.
Vice-Chairman ... R. N. Coke, A.M.E.I.C.
Junior Section, Chairman .... S. Farquharson, A.M.E.I.C.
Vice-Chairman ..... H. W. Lea, Jr.E.I.C.
Municipal Section, Chairman ...... P. G. Delgado, A.M.E.I.C.
Vice-Chairman .. L. J. Leroux, A.M.E.I.C.
Radio Section, Chairman .... H. J. Vennes, A.M.E.I.C.
Railway Section, Chairman .... L. W. Deslauriers, A.M.E.I.C.
Vice-Chairman .... H. L. Currie, A.M.E.I.C.

This committee arranged for the papers and meetings for the latter half of 1932 and the first half of 1933.

The papers given throughout the year 1932 are as follows:—

Jan. 7.—Annual Branch Meeting.
Jan. 14.—**Transportation in Canada** by G. McL. Pitts, M.E.I.C.
Jan. 21—**The Economics of Power Production** by J. T. Farmer, M.E.I.C.
Jan. 28.—**The Kill Van Kull Bridge** by Henry W. Troelsch, M.Am. Soc. C.E.
Feb. 4.—**The Diesel Engine in Aeroplanes** by Capt. A. F. Ingram, Affil.E.I.C.
Feb. 11.—**Isolation of Foundations** by F. Rosenzweig, Esq.
Feb. 18.—**Railway Law** by Allistair Fraser, K.C.
Feb. 25.—**Seaboard Power Plant** by K. H. Marsh, M.E.I.C.
Mar. 3.—**Technical Science of the Ancients** by Professor W. P. Wilgar, M.E.I.C.
Mar. 10.—**Reinforced Concrete Water Mains** by C. J. Desbaillets, M.E.I.C.
Mar. 17.—Organization of the Junior Section: **Some Economic Problems Confronting the Wider Application of Railway Electrification in America** by E. G. Adams, S.E.I.C.
Mar. 24.—**Recent Developments in Aerial Survey** by A. M. Narraway, M.E.I.C.
Mar. 31.—**Kane System of Composite Construction** by C. S. Kane, A.M.E.I.C.

Apr. 7.—**Modern Developments in Heating Practice** by G. Lorne Wiggs, A.M.E.I.C.
Apr. 14.—**Photo Elasticity** by C. Michael Morssen, M.E.I.C.
Apr. 21.—**Temperature Survey of Power Cable Ducts** by N. L. Morgan, A.M.E.I.C.
Apr. 28.—Abitibi Canyon, Sound Picture.
Oct. 6.—**Nova Scotia Coal Mining and Distribution** by C. Gerow, A.M.E.I.C.
Oct. 13.—**C.P.R. Multi-Pressure Locomotive No. 8000** by H. B. Bowen, Esq. (delivered by Mr. Newman).
Oct. 20.—**Manufacture of Cellophane** by L. C. McNab, Esq.
Oct. 27.—**Recent Development of Protective Relays** by E. G. Ratz, Esq.
Nov. 3.—Discussion on Report of Committee on Development.
Nov. 10.—**Some Consideration in the Design of Model Testing Basins** by K. F. Tupper, Esq.
Nov. 17.—**The Construction of the La Quiebra Tunnel, Colombia, South America** by C. E. Fraser, M.E.I.C.
Nov. 24.—**The Development of Telephone Service in Montreal** by A. J. Barnes, Esq.
Dec. 1.—**Military Engineering in Peace Times** by F. A. McTavish, S.E.I.C.
Topographie Aérienne by M. Jacques Limoges.
Dec. 8.—**Recent Progress in Bridge Engineering** by Professor C. R. Young, M.E.I.C.
Dec. 15.—**Trend of Modern Electric Power Distribution** by D. K. Blake, Esq.
Dec. 22.—**Bench Tests for the Human Machine** by Dr. Leo E. Pariseau.

This makes a total of twenty-nine meetings. The attendance varied from thirty-five to two hundred and seventy-five, and the average attendance was one hundred and twenty-six.

An innovation was the holding of an informal dinner meeting for out of town speakers, previous to the regular weekly meeting. This gave an opportunity for the speaker and members to become acquainted and was usually much appreciated by the speaker. Our members did not show a great deal of interest in this arrangement as the attendance at the seven meetings averaged twenty-five. If such meetings are to be continued, the attendance will need to increase.

We wish to thank the Papers and Meetings Committee for their efforts in providing an excellent programme. Owing to the curtailment of the construction of engineering projects it is becoming more difficult for them to find suitable subjects and speakers for our meetings.

Junior Section

Special mention should be made of the Junior Section which was formed to take the place of the Student Section. Arrangements were made to permit this section to have their own meeting nights when they could conduct their own meetings and have papers prepared and presented by their own members, with the object of giving them the opportunity of developing the art of public speaking on engineering subjects, and also to create an interest in the affairs of The Institute. It was also hoped that similar work of the Undergraduate Engineers' Societies of the universities could be co-ordinated with this section.

S. Farquharson, A.M.E.I.C., was appointed chairman and H. W. Lea, Jr.E.I.C., vice-chairman. They held five meetings and had an average attendance of thirty-two. The papers were as follows:—

Mar. 30.—**The Art of Public Speaking** by Claude Richardson, B.C.L. **Concrete, Plain and Reinforced** by R. F. Leggett, A.M.E.I.C.
Nov. 2.—**Public vs Private Ownership of Public Utilities** by J. A. R. Desloover, Esq. **Wooden Poles and their Preservative Treatment** by W. J. S. Dormer, Esq.
Nov. 16.—**Reinforced Concrete Pipe** by E. A. Sherrard, Esq. **Interesting Features of the Rapide Blanc Development** by L. A. Duchastel, S.E.I.C.
Nov. 30.—**La Pasteurisation du Lait** by L. E. Langevin, S.E.I.C. **The Refining Aspects of a Modern Motor Fuel** by C. E. Carson, Esq.
Dec. 14.—The Professional Relationship of the Engineer and Architect in the Province of Quebec (discussion).

Radio Section

We would also draw your attention to the Radio Section which was formed in November, with H. J. Vennes, A.M.E.I.C., as chairman. It is too short a time since the formation of this section to report activities but constructive plans are under way.

Membership

The membership of the Branch has decreased by one hundred and twenty-eight. This decrease is due to the removal from the lists of members whose dues were unpaid. Others have resigned and some have moved from the Branch district, owing to unemployment. A comparison of the number of members with the previous year is as follows:—

	1931	*1932*
Corporate Members	783	720
Non-Corporate Members	391	326
Total	1,174	1,046

Deaths

It is with deep regret that we record the loss through death of the following eleven members:—

James Penrose Anglin, M.E.I.C.
Frederick Bayliss Brown, M.E.I.C.
V. F. W. Forneret, M.E.I.C.
Col. Henry R. Lordly, M.E.I.C.
Horace P. Beaudoin, A.M.E.I.C.
Chas. Franklin Medbury, A.M.E.I.C.
Kenneth Gordon, A.M.E.I.C.
Ian M. Adam, S.E.I.C.
Wm. Francis Tye, M.E.I.C. (resident in Paris)
A. C. Tagge, M.E.I.C. (resident in U.S.A.)
Lord Congleton, A.M.E.I.C. (resident in England)

Reception Committee

The past practice of appointing a committee to act as a Reception Committee at the regular weekly meetings was discontinued, the work being undertaken by the Executive Committee members.

Publicity Committee

The Publicity Committee arranged for reports of the regular weekly meetings to appear in both the English and French press, and sent reports to the General Secretary to be included in The Journal.

Technical Service Bureau

Last March the technically trained men, who were registered with the Registration Bureau of Office Workers, formed themselves into a group called the Technical Service Bureau, with the idea of offering their services to the smaller industrial concerns for such purposes as surveys, drafting, tracing, filing and such like jobs, and to carry out research of constructional problems. They asked the Montreal Branch for their support and financial assistance if possible. After due consideration by the Executive Committee and a Special Committee, it was decided to grant them this help and an appeal was made to the members for funds. This resulted in subscriptions amounting to $443.87, and a statement of the expenditure is shown in the Secretary-Treasurer's Report.

The members of the Bureau have been successful in obtaining odd jobs and some of them have obtained permanent employment, but its scope is somewhat limited because of the number of small industrial concerns requiring such services.

The research part of the scheme does not appear to have been successful, but in the main the results that have been obtained by the Bureau justify its being carried on and the Bureau should continue to receive the support of the Branch.

Unemployment Committee

The Council of The Institute asked the Branch Executive Committee to co-operate with them in dealing with unemployment amongst the members and suggested that the Branch appoint a special committee to deal with this work. The committee was appointed and the Questionnaire "C" sent out by the Council was received and classified by them. Five hundred and six answers to the Questionnaire were received, indicating:—

361 employed and not expecting any change.
45 temporarily employed or expecting to become unemployed.
100 unemployed.

The grades of the unemployed and temporarily employed were:—

Members	6
Associate Members	63
Junior Members	19
Student Members	57

A further letter was sent to these one hundred and forty-five advising them that if they were urgently in need of aid the committee would be glad to hear from or receive a visit from them. Very shortly we shall have to give financial help to some of these members, and it will be necessary for the Branch to raise funds. These funds will be administered by our Unemployment Committee, with the help and co-operation of the Registration Bureau of Office Workers.

Outstanding Events

The contractor for the Wellington Street tunnel invited the members to visit this work, and the members who availed themselves of this courtesy were well repaid.

A party consisting of about eighty members of the Institution of Mechanical Engineers (Great Britain), and accompanying ladies, visited Montreal as part of the programme of their 1932 Convention. The Montreal Branch tendered them an informal reception in the Windsor hotel on Sunday evening, August 28th, when they were welcomed by the vice-chairman, and the following Monday afternoon the Montreal Branch assisted in entertaining them at a Garden Party held in the grounds of McGill University.

The St. James Literary Society invited the members to attend one of their meetings, when Dr. Chipman gave a paper on "Rudyard Kipling—An Appreciation."

Canadian Society of Safety Engineers

Your committee's attention was drawn to a proposal to incorporate a society under the above name, and, as they felt that this would be usurping the functions of The Engineering Institute, representations were made to the sponsors of this movement which led to its withdrawal.

Development Committee Report

In view of the Report of the Committee on Development appearing in The Journal for October it was decided that this was a matter of considerable importance to the members of the Montreal Branch. Accordingly arrangements were made to bring the matter before the members for their information and discussion. A meeting was held on November 3rd, when a full discussion took place, but no definite action was taken.

The following statement shows the financial standing of the Branch:—

Financial Statement
1932

Ordinary Revenue		
Branch News	$ 24.13	
Affiliate dues	84.00	
Rebates from Headquarters	1,782.90	
Interest on Savings Account	29.03	
		$1,920.06
Extraordinary Revenue		
Balance from 1931	$1,110.58	
Miscellaneous (dinners, lunches)	253.60	
		1,364.18
		$3,284.24
Ordinary Expenditures		
Post cards	$ 679.52	
Printing	72.18	
Stationery and stamps	67.96	
Secretary's honorarium	300.00	
Clerical assistance	120.00	
Telephone, telegrams, etc	64.39	
Lantern, slides and operator	78.54	
Subscriptions to *Journal*	30.00	
Speakers' travelling expenses	66.65	
Refreshments, Thursday evenings	43.60	
Dinners to speakers	196.35	
Entertainment to Institution of Mechanical Engineers of G.B.	100.00	
Miscellaneous	168.00	
		$1,987.19
Cash on hand		1,297.05
		$3,284.24

Technical Service Bureau Fund

The following is a statement of the receipts and disbursements of the special fund raised to assist the Technical Service Bureau:—

Receipts, subscriptions		$443.87
Disbursements	$217.14	
Balance on hand	226.73	
		$443.87

Respectfully submitted,
P. E. Jarman, a.m.e.i.c., *Chairman.*
C. K. McLeod, a.m.e.i.c., *Secretary-Treasurer*

Niagara Peninsula Branch

The President and Council:—

The Executive of the Niagara Peninsula Branch presents herein the report for the year 1932.

The Executive held four regular meetings and one electoral meeting with an average attendance of eight.

The meetings are listed as follows:—

Jan. 21.—Dinner meeting at Welland House, St. Catharines. Speaker: R. A. Fairbairn, a.m.e.i.c., Bell Telephone Co. Subject: **Automatic Telephones.**

Feb. 19.—Joint meeting with Toronto Branch, A.I.E.E. at General Brock Hotel, Niagara Falls. Speaker: J. B. McClure, General Electric Co., Schenectady. Subject: **Automatic Frequency Control.**

Mar. 31.—Dinner dance at Welland House, St. Catharines.

May 26.—Annual Meeting. Dinner meeting at Fox Head Inn, Niagara Falls. Speaker: A. E. Hay, Pratt & Lambert Co. Subject: **The Missing Link in Business**.

June 27.—Dinner meeting at Welland House, St. Catharines. R. J. Durley, m.e.i.c., General Secretary present to lead discussion regarding unemployment situation.

Oct. 26.—Inspection trip through plant of Canada Cement Co. at Port Colborne. Dinner at Guild Hall, with talk after by L. M. McDonald, Superintendent of Canada Cement Co., on **The Developments in Manufacture of Cement.**

Nov. 28.—Dinner meeting at Hotel Lincoln, St. Catharines. Report of Committee on Development discussed.

Membership

	1930	*1931*	*1932*
Members	20	18	17
Associate Members	69	70	64
Junior "	16	9	8
Student "	14	12	12
Branch Affiliates	17	20	20
	136	129	121

Financial Statement
(January 1st to December 31st, 1932)

Receipts		
Balance on hand—Jan. 1st, 1932	$ 87.16	
Rebates	200.46	
Branch News	12.01	
Proceeds, Meetings	350.25	
Branch Affiliate fees	98.00	
Bank interest	3.31	
		$751.19
Expenditures		
Postage	$ 17.69	
Printing	30.81	
Expenses, Meetings	332.95	
Flowers	20.30	
Telephone	1.40	
Journal subscriptions	38.00	
Secretary's honorarium	100.00	
Bank balance, Dec. 31st, 1932	210.04	
		$751.19

Respectfully submitted,
E. P. Murphy, a.m.e.i.c., *Chairman.*
P. A. Dewey, a.m.e.i.c., *Secretary-Treasurer.*

Ottawa Branch

The President and Council:—

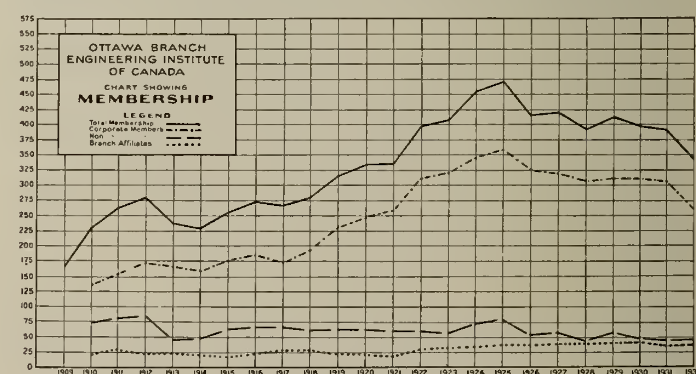
On behalf of the Managing committee of the Ottawa Branch we beg to submit the following report for the calendar year 1932.

During the year the Managing committee held eleven meetings. In addition the Branch held fifteen luncheons and two evening meetings.

A committee on Employment was appointed during the year to deal with questionnaires returned on the subject and to find ways and means, in co-operation with Headquarters, of locating whatever employment might be available.

Our entertainment of the members of the Institution of Mechanical Engineers of Great Britain on August 30th was a particularly happy opportunity to extend to their members and wives a Canadian greeting. After a drive around the city, an official welcome at the Parliament Buildings and a tour of the Houses of Parliament, a luncheon was held at the Chateau Laurier, with an address of welcome by Dr. Charles Camsell, m.e.i.c., President of The Engineering Institute. This was followed by a trip to the plants of the Gatineau Power Company and the Canadian International Paper Company.

Investigation was made as to the advisability of establishing a special section of Military Engineers. After reports had been collected and those interested had been interviewed, it was agreed that the present was not an opportune time to proceed with such a section.



Several committee meetings were held with a view to promoting interest in a Radio section and one special open meeting was held in the Carnegie Library. The final steps have not been taken as to the actual formation of such a section but the progress to date has been quite favourable.

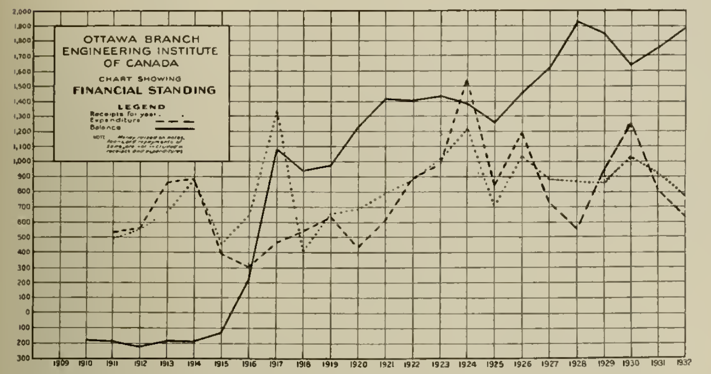
On November 23, a general meeting was held to discuss the Interim Report of the Committee on Development appointed by Council in September 1931. The principal speakers at this meeting were J. L. Busfield, m.e.i.c., Convenor of the Committee and J. B. Challies, m.e.i.c., formerly a member of the Ottawa Branch and Past Vice-President of The Institute.

It is with deep regret that we report the loss through death of two members, C. H. Keefer, M.E.I.C., and L. E. Cote, M.E.I.C.

PROCEEDINGS AND PUBLICITY

During the year fifteen luncheons and two evening meetings were held as follows:—

Jan. 7.—**The Aeronautical Laboratories of the National Research Council** by Dr. J. H. Parkin, M.E.I.C., Assistant Director, Physics and Engineering Division, National Research Council; luncheon meeting at the Chateau Laurier.



Jan. 14.—Annual Meeting—Jackson Building.

Jan. 21.—**A National Radio Plan for Canada** by C. A. Bowman, A.M.E.I.C., editor of the Ottawa Citizen; luncheon meeting at the Chateau Laurier.

Feb. 10.—Complimentary luncheon at the Chateau Laurier to Dr. Charles Camsell, M.E.I.C., President of The Engineering Institute of Canada.

Feb. 18.—**Engineering and High Pressure Chemistry** by Dr. G. S. Whitby, Director, Division of Chemistry, National Research Council; luncheon meeting at the Cheateau Laurier.

Mar. 3.—**Possibilities of Centrifugal Casting Applied to Gun Manufacture** by Lt.-Col. N. O. Carr, General Staff Officer, Artillery, Department of National Defence; luncheon meeting at the Chateau Laurier.

Mar. 17.—**Engineering Aims of the National Research Council** by Dr. H. M. Tory, President, National Research Council; luncheon meeting at the Chateau Laurier.

Mar. 31.—**Contrasted Methods of Engineering Education** by Dean A. Frigon, M.E.I.C., Director L'Ecole Polytechnique, University of Montreal; luncheon meeting at the Chateau Laurier.

April 14.—**The Ingenious Ones** by Grote Stirling, M.P., M.E.I.C., luncheon meeting at the Chateau Laurier.

April 28.—**National Standard Specifications and Empire Trade** by C. D. le Maistre, Director, British Standardization Institute; luncheon meeting at the Chateau Laurier.

May 12.—**Some Impressions of a Recent Round-the-World Tour** by Sir Newton J. Moore, President, Dominion Steel and Coal Corporation, Montreal; luncheon meeting at the Chateau Laurier.

Aug. 30.—Luncheon at the Chateau Laurier for the Institution of Mechanical Engineers of Great Britain.

Oct. 6.—**The Evolution of Lighthouses from the Ancient Fire Beacon** by D. Alan Stevenson of Edinburgh, Scotland; luncheon meeting at the Chateau Laurier.

Oct. 27.—**Inventions and their Protection** by O. M. Biggar, K.C., Affil.E.I.C., luncheon meeting at the Chateau Laurier.

Nov. 17.—**The Art of Making Money** by J. H. Campbell, Master of the Royal Mint; luncheon meeting at the Chateau Laurier.

Nov. 23.—Consideration of the Report of the Committee on Development; speaker J. L. Busfield, B.Sc., M.E.I.C., and J. B. Challies, C.E., M.E.I.C., evening meeting in the Jackson Building.

Dec. 15.—Complimentary luncheon at the Chateau Laurier to G. J. Desbarats, C.M.G., M.E.I.C., former Deputy Minister of National Defence.

The average attendance at the above meetings was 80.

MEMBERSHIP

Owing to deaths, resignations and members removed from the roll, the membership of the Branch shows a decrease of 45 for the year. The accompanying chart shows the membership of the Branch from 1909 to date.

The following table shows in detail, the comparative figures of the Branch membership for the years 1930, 1931 and 1932:—

	1930	*1931*	*1932*
Honorary Members	1	1	1
Members	107	103	83
Associate Members	202	205	174
Affiliates of Institute	4	4	4
Juniors	17	17	13
Students	22	24	28
Branch Affiliates	40	36	37
Total	393	390	345

FINANCES

The attached financial statements show the steady growth of the Branch with a credit balance of $148.34 of revenue over expenditure. The assets at the end of the year show an increase of $34.24 over the previous year.

The Branch closed the year with a balance of $889.37 in the bank, $9.90 cash on hand and $1,000 in Victory Bonds; a total balance of $1,899.27. In addition, the Branch has assets of $25.60 in rebates due from the main Institute, $3.60 in commissions due for advertising in The Journal, $0.60 due for commissions on Journal subscriptions and $21 in equipment, etc., making a total of $1,950.07. The financial standing of the Branch from 1910 to date is shown on the accompanying chart.

FINANCIAL STATEMENT

(For year ending December 31, 1932)

Receipts

Balance in bank, Jan. 1, 1932	$ 741.96	
Cash on hand, Jan. 1, 1932	8.97	
Interest on Victory Bonds	52.50	
Bank interest	20.55	
Rebates from Main Institute, Dec., 1931	15.90	
" " " " Jan. to Apr., 1932	432.90	
" " " " May to Aug., 1932	68.30	
" " " " Sept. to Nov., 1932	37.70	
" " " " Branch News, Jan. to Apr., 1932	34.37	
" " " " Branch News, June and July, 1932	11.13	
" " " " Branch News, Nov. and Dec., 1932	6.50	
" " " " Advertising 1931	28.00	
Branch Affiliate fees	78.00	
Proceeds from sale of luncheon tickets	527.25	
		$2,064.03

Expenditures

Rogers Ltd., catering, Annual Meeting, January 1932	$ 30.00	
Chateau Laurier, luncheon	897.75	
Grant to Aeronautical Section	20.00	
Subscription to Engineering Journal	6.15	
Scrims, for flowers	20.00	
Sundries, entertainment, etc	73.00	
Petty cash, postage, etc	117.86	
Balance in bank, Dec. 31, 1932	889.37	
Cash on hand, Dec. 31, 1932	9.90	
		$2,064.03

Assets

Stationery and equipment	$ 20.00	
Library— Bound Magazines, Books } nominal	1.00	
Rebates due from Main Institute on 1932 fees	25.60	
Rebates due from Main Institute for advertising in 1932	3.60	
Rebates due from Main Institute on Journal subscriptions	.60	
Victory Bonds due November 1, 1934	500.00	
" " " October 15, 1943	500.00	
Cash in bank	889.37	
Cash on hand	9.90	
		$1,950.07

Liabilities

Surplus	$1,950.07	
		$1,950.07

Audited and found correct: G. J. DESBARATS, M.E.I.C.

Respectfully submitted,

C. M. PITTS, A.M.E.I.C., *Chairman.*

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

Peterborough Branch

The President and Council:—

On behalf of the Executive committee of the Peterborough Branch, we have the honour to submit the following report covering the activities of the Branch during the year 1932.

Meetings and Papers

Jan. 14.—**What Can be Done With Electrical Prospecting** by Mr. Hans Lundberg Swedish American Prospecting Company of Toronto and New York.
Jan. 28.—**Oil Circuit Breakers** by Mr. G. R. Langley, switchboard engineer, Canadian General Electric Company.
Feb. 11.—**Maple Leaf Gardens, Toronto** by Mr. C. W. Power, Toronto manager of Ross & MacDonald, Architects.
Feb. 25.—**Electric Welding** by Mr. E. C. Chapman, Director of Engineering Research, Lukenweld Incorporated, Coatesville, Pa.
Mar. 10.—**Actuator Type Waterwheel Governors** by Mr. A. Kalin of the Woodward Governor Company, Rockfield.
Mar. 24.—**Electrical Layout of Hydro-Electric Power Stations** by Mr. T. R. Millar of The Hydro-Electric Power Commission of Ontario.
April 14.—Student and Junior Papers:
Saw-Mills by W. T. Fanjoy, Jr.E.I.C.
Spectroscopic Analysis of the Sun's Rays by W. T. Holgate, Jr.E.I.C.
April 28.—**Ferranti Surge Absorbers** by Mr. J. M. Thompson, designing engineer of the Ferranti Electric Company.
May 12.—Annual Meeting and Election of Officers.
Sept. 24.—Annual Outing—Kawartha Camp, Stoney Lake.
Oct. 13.—**The Manufacture and Distribution of Artificial Gas** by Mr. E. F. Reid, Gas Department, Peterborough Utilities Commission.
Oct. 27.—**Combustion in the Automobile Engine and the Comparative Value of Various Fuels** by Professor E. A. Allcut, M.E.I.C., of the University of Toronto.
Nov. 22.—**Annual Dinner**—Empress Hotel, Peterborough. Guest speaker, Col. Willard Chevalier, Publishing Director of the "Engineering News Record," New York City.
Dec. 7.—**Research Council of Canada** by Dr. R. W. Boyle, M.E.I.C., Director of the National Research Council—Division of Physics and Engineering.

Average attendance, including guests at Branch Meetings, 40.
Number of Executive meetings held during the year, 11.
Special Sub-Committees were appointed as follows:
(1) Unemployment Committee;
(2) Sub-Committee to consider Interim Report of Committee on Development;
(3) Various Dinner Committees.

Membership

	Jan. 1 1930	Jan. 1 1931	Jan. 1 1932	Jan. 1 1933
Members	20	18	15	13
Associate Members	31	30	34	36
Juniors	20	20	19	13
Students	30	23	19	16
Branch Affiliates	25	17	15	17
	126	108	102	95

The attendance at the regular Branch meetings and at the Annual Dinner has been particularly good during the past year. The Executive committee feel that this has been largely due to the high quality of the papers that have been presented, and wishes to thank all those who have contributed to the programme.

Financial Statement
(For year ending December 31, 1932)

Receipts

Bank balance, Jan. 1, 1932	$104.13	
Rebates on fees	125.40	
Journal News	7.26	
Affiliate fees	40.00	
Picnic surplus	6.25	
Annual dinner	100.50	
Bank interest	3.80	
		$387.34

Expenditures

Rent	$ 55.00	
Printing	67.77	
Meetings and speakers	19.15	
Affiliate Journal subscriptions	20.75	
Annual dinner	141.28	
Flowers	18.00	
Secretary's expense	6.15	
Treasurer's expense	1.00	
Insurance	9.60	
Bank balance, Dec. 31, 1932	48.64	
		$387.34

E. R. Shirley, M.E.I.C., Auditor.
V. S. Foster, A.M.E.I.C., *Treasurer.*

Respectfully submitted,
B. Ottewell, A.M.E.I.C., *Chairman.*
W. F. Auld, Jr.E.I.C., *Secretary.*

Quebec Branch

Au Président et au Conseil:
Le Conseil de la section de Québec a l'honneur de vous soumettre son rapport pour l'année 1932, comme suit:—

Rôle des Membres

	1er janvier, 1933 Résidents	Non Résidents	Total
Membres à vie	7	2	9
Membres	13	..	13
Membres associés	53	8	61
Membres juniors	10	1	11
Membres étudiants	9	6	15
Membres affiliés	1	2	3
Total:	93	19	112

Assemblée Annuelle

L'assemblée annuelle de la Section de Québec eut lieu le 9 mai 1932, sous la présidence de J. M. Hector Cimon, M.E.I.C., président pour l'année 1931-1932 et réélu comme tel pour l'année 1932-1933.

Rapport des Activités

Il y eut, au cours de l'année 1932, huit réunions du Conseil de la Section; en plus dix réunions générales comme suit:—

Le 11 janvier.—Déjeuner-causerie. M. A. G. Penny, B.A., Président de la Chambre de Commerce de Québec, nous parle de l'application de l'aménagement et du tracé des villes à des problèmes nationaux.
Le 25 janvier.—Déjeuner-causerie. M. Adrien Pouliot, B.Sc.A., Licencié en Sciences Mathématiques, Professeur à l'Ecole de Chimie de Québec: **En marge des théories d'Einstein.**
Le 8 février.—Réunion du soir. Conférences par A. M. Robertson sur l'opération du téléphone dans la cité de Québec; J. L. Bizier, A.M.E.I.C., **Draguage et Sondage à l'Anse au Foulon;** R. Wood, S.E.I.C., sur l'opération d'une distribution électrique.
Le 22 février.—La Section de Québec fête le 25e anniversaire de sa formation par un dîner au Château Frontenac; la présentation officielle de la charte de la Section eut lieu à cette occasion.
Le 7 mars.—Déjeuner-causerie. M. K. G. Fenson, I.F., du Canadian Hardwood Bureau: **Utilisation des Ressources Forestières Canadiennes.**
Le 21 mars.—Déjeuner-causerie. G. Gordon Gale, M.Sc., M.E.I.C., Vice-Président de la Gatineau Power Company: **Force Motrice** (Power).
Le 18 avril.—Déjeuner-causerie. Alex. Larivière, M.E.I.C., membre de la Commission des services publics de Québec: **La Radioélectricité, Principes fondamentaux et Applications.**
Le 9 mai.—Assemblée annuelle.
Le 23 novembre.—"Cocktail" en l'honneur de W. G. Mitchell, M.E.I.C., à l'occasion de son départ de Québec.
Le 12 décembre.—Réunion générale du soir pour discuter le rapport intérimaire du Comité de Développement.

Rapport Financier

Recettes

En caisse au 1er janvier, 1932	$115.38	
Intérêt sur dépôt	1.32	
Remises du Bureau-Chef	205.50	
Nouvelles	18.00	
Divers	5.00	
		$345.20

Déboursés

Réunions	$ 91.99	
Timbres, papeterie, etc	19.14	
Services de Sténographes	10.00	
Impressions	39.48	
Allocation au Secrétaire	100.00	
	$260.61	
En caisse au 1er janvier, 1933	84.59	
		$345.20

Respectueusement soumis,
J. M. Hector Cimon, M.E.I.C., *président.*
Jules Joyal, A.M.E.I.C., *Secrétaire-Trésorier*

Saguenay Branch

The President and Council:—
On behalf of the Executive committee of the Saguenay Branch of The Engineering Institute of Canada, we beg to submit the following report covering the activities of the Branch for the calendar year, 1932.

Membership

We regret to report an appreciable loss of membership, including one member, 3 Associate Members, one Junior and 2 Students. This loss being partially offset by the addition of one Junior and one Affiliate.
Except for one Junior who resigned, we understand that all these members left the district to accept employment elsewhere.

The following table gives a comparison of our membership as at December 31st for the past three years:—

	1930	*1931*	*1932*
Members	6	5	4
Associate Members	25	19	16
Junior Members	7	4	4
Student Members	11	7	5
Affiliates	..	..	1
Total	49	35	30

FINANCIAL STATEMENT

(As at December 31, 1932)

The Balance reported as on hand at December 31st, 1931, of $284.09 was too high by $17.40. Our books are closed at the end of the Branch year and the practice has been to make only a trial balance at the end of the calendar year. The statements for 1930 and 1931 included the final rebates from headquarters for the preceding year in each case, these having already been included in the totals of the preceding year; this together with slight errors in reporting the expenditures for each of the above calendar years resulted in the above discrepancy in spite of the fact that the books balance as at the end of each Branch year. The Branch Executive committee have therefore instructed the Treasurer to write off this apparent deficit and in future balance and close the books twice a year.

Receipts

Balance on hand December 31, 1931	$284.09		
Less Written Off	17.40		
		$266.69	
Rebates from Headquarters		72.90	
Branch News		7.50	
			$347.09

Disbursements

Printing, stationery, postage and exchange	$ 29.63	
Expense of meetings	94.71	
Miscellaneous expenses	11.77	
Secretarial expense, travelling and stenographer	18.10	
Balance on hand	$192.88	
		$347.09

BRANCH MEETINGS

During the year Branch meetings were held as follows:—June 2nd, at Riverbend. A luncheon tendered in honour of a party of members of the Federal government, who were in this district on a fishing expedition.

The party included Dr. Charles Camsell, M.E.I.C., Deputy Minister of Mines and President of The Engineering Institute of Canada, Hon. W. A. Gordon, Minister of Mines, Labour and Acting Minister of Immigration, Hon. George Black, Speaker of the House of Commons, Hon. John Sullivan, Member for St. Anne, Montreal, and Mr. J. Cullen, private secretary to Hon. W. A. Gordon.

Dr. Camsell and Hon. W. A. Gordon gave short addresses on the mineral resources of Canada, including a sketch of the development of the mining industry in the past two decades and what prospects were held for the future development of these resources. Thirty-one members were present.

Aug. 8.—Annual general meeting and luncheon was held at Chicoutimi. A paper on **Aluminum—Its Early History, Recent Development, and Future Possibilities** was given by A. W. Whitaker, Jr.A.M.E.I.C., vice-chairman of this Branch. This was followed by a visit, as guests of the Chicoutimi Harbour Commission, to the construction in progress of the Chicoutimi-St. Anne Bridge. Twenty-one members were present.

Oct. 19.—At Arvida. A paper on **Anhydrite, an Undeveloped Mineral Resource** by L. H. Cole, M.E.I.C., mines engineer, Mines Branch, Department of Mines, Ottawa. This lecture was illustrated by lantern slides and was followed by an interesting talk by Dr. A. W. G. Wilson, Ph.D., chief engineer of the Mineral Resources Division of the Department of Mines, on the work of his department and some of the problems being dealt with by the research workers of the Mineral Resources Branch. Forty members and friends were present.

The Branch Executive committee met several times, particularly recently, to keep in touch with what is being done by the Branches and Headquarters in regard to relief of unemployment and to discuss the Interim Report of the Committee on Development, and the views of the Branches on this important matter.

Respectfully submitted,

N. F. MCCAGHEY, A.M.E.I.C., *Chairman.*
G. H. KIRBY, A.M.E.I.C., *Secretary-Treasurer.*

Saint John Branch

The President and Council:—

Following is the annual report of the Saint John Branch for the year ending December 31st, 1932.

During the year the Branch Executive committee which was elected at the Branch Annual Meeting on May 10th met nine times.

STANDING COMMITTEES

Chairmen of standing committees of the Branch are as follows:

Programmes and Meetings	W. J. Johnston, A.M.E.I.C.
Entertainment	W. R. Pearce, M.E.I.C.
Employment	J. A. W. Waring, A.M.E.I.C.
Membership	The Branch Executive
Policy	The Branch Executive
Salaries	S. R. Weston, M.E.I.C.
Publicity	C. G. Clark, S.E.I.C.
Natural Resources	C. C. Kirby, M.E.I.C.
Auditors	E. J. Owens, A.M.E.I.C. Capt. W. H. Blake, A.M.E.I.C.

BRANCH MEETINGS

During the year, Branch meetings were held as follows:—

Jan. 11.—A meeting was held for the purpose of discussing the report of the Civic Taxation Committee.

Jan. 25.—Joint dinner meeting with the Association of Professional Engineers of New Brunswick. Speaker: C. H. Wright, M.E.I.C., of Halifax, N.S. Subject: **Engineering Developments in Northern Manitoba.**

Feb. 29.—Mar. 4.—A series of five meetings were addressed by J. M. Portugais and D. O. Robinson, A.M.E.I.C., of the Canada Cement Company, Limited, on the subject: **Cement and Concrete.**

May 10.—Annual meeting and dinner at the Riverside Golf and Country Club.

Sept. 2.—Visit of inspection to the new Harbour Commissioners Docks, under construction at West Saint John, N.B. The visit was arranged by the Saint John Harbour Commission and the Atlas Construction Company.

Nov. 8.—A meeting was held to discuss the interim report of The Institute Committee on Development.

Nov. 24.—Speaker: S. Hogg, A.M.E.I.C. Subject: **Secondary Stresses in Bridges.**
Speaker: J. H. McKinney, A.M.E.I.C. Subject: **Field Control of Concrete, Saint John Harbour Commissioners' Docks, West Saint John, N.B.**

MEMBERSHIP

The following is a statement of the membership as at December 31, 1932:—

	Branch Residents	*Non-Residents*	*Total*
Members	12	5	17
Associate Members	24	13	37
Juniors	3	5	8
Students	15	15	30
Affiliates	1	0	1
	55	38	93

The gain in membership over that on December 31, 1931, is one.

FINANCIAL STATEMENT

(Year ending December 31st, 1932)

Assets

Balance in bank, December 31, 1932	$338.49	
Rebates due from Headquarters for Dec. 1932	2.40	
		$340.89

Liabilities

Outstanding accounts	$ 12.84	
Surplus as at December 31, 1932	328.05	
		$340.89

Receipts

Balance in bank, December 31, 1931		$246.68	
Received from Headquarters, rebates, Dec. 1931	$ 7.20		
Received from Headquarters, rebates Jan.-Nov. 1932	178.80		
Received from Headquarters, Branch News	15.39		
Miscellaneous (Entertainment committee)	8.00		
		$209.39	
			$456.07

Expenditures

Stamps, postcards, etc	$ 11.75		
Meetings	19.80		
Printing	40.53		
Stenographic assistance	16.50		
Honorarium to Secretary	25.00		
Miscellaneous	4.00		
		$117.58	
Balance in bank, December 31, 1932		338.49	
			$456.07

Respectfully submitted,

A. A. TURNBULL, A.M.E.I.C., *Chairman.*
G. H. THURBER, A.M.E.I.C., *Secretary-Treasurer.*

St. Maurice Valley Branch

The President and Council:—

We beg to submit the annual report of the activities of the St. Maurice Valley Branch which is one of the smallest of The Institute.

Our branch was organized in 1926 and is composed of the members residing in GrandMere, Shawinigan Falls, Cap-de-la-Madeleine and Three Rivers. We count six members, twenty-five Associate Members, seven Juniors and eight Students.

Our first Chairman, Mr. Ellwood Wilson, M.E.I.C. who had been reelected since the Branch incorporation left GrandMere during 1932 to occupy a chair of Silviculture, at Cornell University, Ithica, N.Y.

J. A. Vermette, A.M.E.I.C., vice-chairman, acted as chairman during the absence of Mr. Wilson.

John H. Fregeau, A.M.E.I.C., was appointed on the Nominating Committee.

The finances of the Branch are in good standing. We finish the year with a balance in hand of $92.84.

We had only one Social Meeting in 1932. It was a dinner at the Chateau De Blois, Trois-Rivieres on the 24th of April. All the profes-fessionals of the St. Maurice district were invited.

Respectfully submitted,

B. Grandmont, A.M.E.I.C., *Chairman.*
J. A. Hamel, A.M.E.I.C., *Secretary-Treasurer.*

Saskatchewan Branch

The President and Council:—

On behalf of the Executive committee we submit the following report of the activities of the Saskatchewan Branch for the year 1932.

Membership

The membership of the Branch shows a decrease of fourteen from last year, the present membership being:—

	Resident	*Non-Resident*	*Total*
Members	5	8	13
Associate Members	36	32	68
Juniors	3	8	11
Students	2	18	20
Affiliates	1	0	1
Branch Affiliates	3	0	3
	50	66	116

The Executive committee was elected on March 18, 1932, and held eight meetings during the year:

Committees

The standing committees are:—

Papers and Library........J. J. White, A.M.E.I.C., (Convenor).
Nominating..............D. A. R. McCannell, M.E.I.C., (Convenor).
Unemployment...........H. R. MacKenzie, A.M.E.I.C., (Convenor).

Meetings

There were six regular and one special meetings of the Branch. The regular meetings in all cases were preceded by a dinner at which the average attendance was thirty-six, the same as for the preceding year. The general interest in the meetings has been good.

We regret to record the loss, by death, of two of our members: E. China, A.M.E.I.C., Weyburn, and J. R. C. Macredie, Moose Jaw. Mr. Macredie was a past chairman of the Branch.

The programme for the year included the following:

Jan. 20.—Address by R. S. Phillips on **The Durability of Concrete.** This was a specially called meeting.
Jan. 22.—Address by John Cameron on **Commercial Fertilizers.**
Feb. 26.—Address by T. C. Main, A.M.E.I.C., on **Drought and Soil Drifting in Saskatchewan.**
Mar. 18.—Address by J. M. Campbell, A.M.E.I.C., on **How an Engineer Views the Depression.**
Oct. 21.—Dinner and smoker held jointly in Moose Jaw with the American Institute of Electrical Engineers, Saskatchewan Section.
Nov. 18.—Address by G. H. Thompson, A.M.E.I.C., on **The Generation and Distribution of Power in Alberta.**
Dec. 16.—Address by S Young, A.M.E.I.C., on **The Taxation of Land.**

The annual scholarship of $50 donated by the Branch to the most deserving student in engineering in the graduating class, University of Saskatchewan, was awarded to Alvin Johnson.

The present financial standing of the Branch is as follows:—

Bank balance, December 31st, 1931	$162.49	
Rebates from H.Q.	193.50	
Branch News	10.40	
Branch dues	10.00	
Office		$ 34.75
Meetings		129.92
Scholarship		50.00
Honorarium		100.00
Miscellaneous	9.20	18.65
Bank balance, December 31st, 1932		52.27
	$385.59	$385.59

Respectfully submitted,

J. D. Peters, A.M.E.I.C., *Chairman.*
Stewart Young, A.M.E.I.C., *Secretary-Treasurer.*

Sault Ste. Marie Branch

The President and Council:—

The following is the report of the activities of the Sault Ste. Marie Branch for the year ending December 31st, 1932.

There were nine regular dinners and meetings held by this Branch during 1932. One of these included an inspection tour of the Great Lakes Power Company's plant.

The average attendance at the dinners was fifteen and at the meetings, twenty-two.

Jan. 29.—**Transportation**—Discussion of Professor Jackman's paper on that subject.
Feb. 26.—**Manufacture of Steel** by J. H. McDonald, Algoma Steel Corporation.
Mar. 18.—**Developments of Telephone Industry** by C. E. Horton, Bell Telephone Company.
April 29.—**Report on Engineering Profession Act** by John Lang, M.E.I.C., and L. R. Brown, A.M.E.I.C.
May 27.—**Inspection Great Lakes Power Plant** by A. E. Pickering, M.E.I.C., and R. A. Campbell, A.M.E.I.C.
Sept. 30.—**Canada's Stake in Transportation** by W. S. Wilson, A.M.E.I.C.
Oct. 31.—**Production and Application of Lubricating Oils** by W. A. P. Schorman, British American Oil Company, Ltd.
Nov. 25.—**Central Heating in Winnipeg** by O. H. Wing, Winnipeg Heating Co.
Dec. 30.—Report of Committee on Development.

The chairmen of the standing committees of the Branch are as follows: Papers Committee, Harry F. Bennett, A.M.E.I.C.; Nominating Committee, L. R. Brown, A.M.E.I.C.; Membership Committee, A. H. Russell, A.M.E.I.C.

Membership

	Residents 1932	*Residents* 1931	*Non-Residents* 1932	*Non-Residents* 1931
Members	9	8	11	11
Associate Members	15	18	29	29
Junior Members	4	4	6	10
Students	0	0	12	10
Affiliates of E.I.C.	1	2	1	1
Branch Affiliates	8	9	0	0
	37	41	59	61

The above comparison shows that we have a reduction in total membership of 6 for 1932 as compared to 1931. Under the conditions that exist at the present time due to unemployment the showing is good. There are several prospective members in this district who have expressed their desire to join as soon as conditions improve and they have steady employment.

It is wished to impress upon the 1933 Membership committee the importance of securing new members as the life of The Institute depends upon this.

Financial Statement

(For year ending December 31st, 1932)

Assets		
Balance in savings account	$236.36	
Balance in current account	207.15	
Accounts receivable	6.80	
Files, bound volumes, projector, etc	......	
		$450.31
Liabilities		
Surplus at end of 1931	349.24	
Added to surplus during 1932	101.07	
		$450.31
Revenue		
Rebates from Headquarters	$169.50	
Commission on Journal Advertising	22.80	
Journal subscriptions collected	12.00	
Branch News	9.01	
Fees from Branch Affiliates	21.00	
Receipts from dinners	105.00	
Interest on savings account	6.79	
Refund on express charges	.45	
Accounts receivable (H.Q. rebates $4.80; (1 Journal subscription 2.00)	6.80	
		$353.35
Disbursements		
Printing and stationery	$ 56.83	
Telegrams and express	4.85	
Postage	3.00	
Exchange on cheques	.30	
Journal subscriptions paid	14.00	
Dinners and entertainment	135.80	
Secretary's honorarium	25.00	
Stenographer	12.50	
	252.28	
Added to surplus	101.07	
		$353.35

Respectfully submitted,

Carl Stenbol, M.E.I.C., *Chairman.*
G. H. E. Dennison, A.M.E.I.C., *Secretary-Treasurer.*

Toronto Branch

The President and Council:—

The Executive committee of the Toronto Branch respectfully submits the following report for the year 1932:—

The members of the Executive committee for 1932-33 were elected at the annual meeting of the Branch held on March 31, 1932. Three members of the committee, A. U. Sanderson, A.M.E.I.C., W. E. Bonn, A.M.E.I.C., and W. E. Ross, A.M.E.I.C., were elected for a period of two years.

STANDING COMMITTEES

Papers	J. Roy Cockburn, M.E.I.C.
Finance	Archie B. Crealock, A.M.E.I.C.
Publicity	W. W. Gunn, A.M.E.I.C.
Meetings	W. E. Bonn, A.M.E.I.C.
Membership	G. H. Davis, M.E.I.C.
Student Relations	W. E. Ross, A.M.E.I.C.
Branch Editor	A. U. Sanderson, A.M.E.I.C.

The outstanding event of the past year in the Toronto Branch was the Annual General and Professional Meeting held at the Royal York hotel on February 3, 4, and 5, 1932. A Committee, under the chairmanship of L. W. Wynne-Roberts, A.M.E.I.C., with W. B. Dunbar, A.M.E.I.C., as secretary, carried this meeting to a most successful conclusion.

Contributions towards the expenses of this meeting were received from the city of Toronto and a number of other bodies, as well as from the Headquarters of The Institute, and the total cost to the Branch was eight hundred dollars.

The Executive committee of the Toronto Branch appointed an Employment Committee, consisting of Messrs. R. E. Smythe, A.M.E.I.C., C. S. L. Hertzberg, M.E.I.C., and W. S. Wilson, A.M.E.I.C., in May, to deal with the employment situation in the Branch. One of the Branch members was employed to make a survey of the entire Branch Membership and the information obtained was forwarded to Headquarters. Later, it was decided that a fund should be raised, and a Board of Trustees, consisting of Messrs. F. A. Gaby, M.E.I.C., William Storrie, M.E.I.C., William Inglis, A. H. Harkness, M.E.I.C., and C. H. Mitchell, M.E.I.C., was appointed to administer it. The fund is known as the "Toronto Branch E.I.C. Loan Fund"; about one thousand dollars have been raised among our members, without any personal canvass.

The entire cost of raising the fund, for printing, clerical assistance, etc., has been borne out of Branch funds. No part of the money contributed has been used for any purpose but to help our members. Already, the fund has been of considerable assistance in furthering the purposes for which it was raised.

On September 26, 1932, the chairman of the Toronto Branch was asked by the Board of Control of the city of Toronto to report upon the tenders received by the city for the supply and installation of four water tube boilers and appurtenances required at the John Street pumping station. In response to this request, a sub-committee, consisting of Messrs. J. Roy Cockburn, M.E.I.C., E. A. Allcut, M.E.I.C., and M. Barry Watson, A.M.E.I.C., was appointed to study the specifications and tenders and report back to the Executive of the Toronto Branch. The recommendation of the Executive of the Toronto Branch was later adopted by the City Council. A full report of this matter was submitted to the President and Council of The Institute on November 21, 1932.

The Executive committee of the Branch has held twenty meetings for the transaction of Branch business, and thirteen general meetings, as well as a large number of meetings with the Annual General and Professional Meeting Committee.

The custom of entertaining speakers at dinner previous to the meetings has been continued. All members of the Branch have also been invited to attend these dinners, and a very gratifying response has been met with; also, it has increased the attendance at meetings.

The average attendance was about one hundred.

The following meetings were held during the year 1932:

Jan. 8.—**The Apparent Failure of Democracy** by Dean A. T. DeLury, Dean of the Faculty of Arts, University of Toronto. This meeting was a joint one, held with the Toronto Section, A.I.E.E.

Jan. 14.—**The Bergen Railway** by Carl J. Printz, Knight of the Order of St. Olaf, Norwegian Vice-Consul.

Jan. 21.—**Engineering of the Ancients** by Lieut.-Col. W. P. Wilgar, M.E.I.C., D.S.O., Professor of Civil Engineering, Queen's University.

Feb. 3, 4, 5.—Annual General and Professional Meeting, The Engineering Institute of Canada.

Feb. 25.—**The Toronto Waterfront Development** by Brig.-General J. G. Langton, general manager and secretary of the Toronto Harbour Commission. This meeting was a joint one, held with the Military Engineers Association of Canada.

Mar. 17.—**The Toronto Transportation Commission** by H. W. Tate, A.M.E.I.C., assistant manager of the Toronto Transportation Commission.

Mar. 31.—Annual Meeting of the Branch.

Oct. 12.—**The Department of Works of the City of Toronto.** An address by R. C. Harris, Commissioner of Works of the City of Toronto.

Nov. 10.—**Standards** by Professor J. F. Macdonald, M.A., of the Department of English, University of Toronto. A joint meeting, held with the Ontario Section of the A.S.M.E. and the Toronto Section of the A.I.E.E.

Nov. 24.—The Report of the Committee on Development. A general meeting called for the discussion of the Report, and address by J. L. Busfield, M.E.I.C.

Dec. 1.—**Reinforced Brick Masonry** by Hugo Fillipi and Earl Miller, of the Chicago Office of the Common Brick Manufacturers' Association.

Dec. 15.—**Modern Building Equipment for Building Air Conditioning** by H. B. Matzen, M.E., vice-president in charge of the Cleveland office of the Carrier Engineering Corporation. This meeting, to which the Toronto Branch, E.I.C., was invited, was arranged by the Ontario Section of the A.S.M.E.

The membership of the Branch on December 31, 1932, is made up as follows:

	Resident	Non-Resident	Total
Members	107	4	111
Associate Members	237	15	252
Juniors	59	1	60
Students	80	18	98
Affiliates	5	..	5
Branch Affiliates	2	..	2
Total 1932	490	38	528
Total 1931	520	37	557
	−30	+1	−29

It is with regret that we record the death of the following members of the Branch during the past year: J. A. Beatty, M.E.I.C., E. V. Deverall, A.M.E.I.C., and J. McAdam, A.M.E.I.C.

FINANCIAL STATEMENT
(For calendar year 1932)

Receipts

Bank balance at January 1st, 1932	$1,611.52	
Rebates and Branch News	669.90	
Bank interest	24.85	
Affiliate fees	10.00	
Sale of bookcases	75.00	
Advertising in Year Book	32.00	
Annual General Meeting printing	10.94	
Refund to Branch from Annual Meeting Committee	156.24	
Proceeds of Military Institute dinner	5.00	
Refund from A.I.E.E. for printing	7.05	
		$2,602.50

Expenditures

Printing and advertising	$ 295.10	
Year Book printing	68.00	
Room rental	36.50	
Councillors' expenses to Montreal	91.75	
Speakers' expenses	49.90	
Entertainment of guests and graduates	58.93	
Secretary's honorarium and expenses	130.75	
Advance to Annual Meeting	750.00	
Refund to H.Q. re Annual Meeting	156.24	
Stenographic services	45.00	
Affiliate Journal fees	2.00	
Provincial Treasurer, film rental	1.50	
Flowers	7.50	
Employment Committee, clerical expenses	19.20	
Annual Meeting, Secretary's expenses	7.80	
	$1,720.17	
Bank balance at December 31, 1932	882.33	
		$2,602.50

Respectfully submitted,
J. ROY COCKBURN, M.E.I.C., *Chairman.*
W. S. WILSON, A.M.E.I.C., *Secretary-Treasurer.*

Vancouver Branch

The President and Council:—

We beg to submit the following report of the activities of the Vancouver Branch of The Institute for the year 1932.

MEETINGS

During the 1932 session eight meetings of the Branch were held, which included one joint meeting with the A.I.E.E., Vancouver Branch, and one inspection trip to the First Narrows Pressure Tunnel, as outlined below:—

Jan. 4.—Professor H. F. Angus, M.A., B.C.L., on **National and International Aspects of the Gold Standard.** Joint meeting with A.I.E.E.

Feb. 29.—H. B. Muckleston, M.E.I.C., on **The South Fork Dam at Nanaimo, B.C.**

Mar. 8.—Professor A. H. Finlay, M.A.Sc., on **Mechanical Stress Analysis.**

Mar. 14.—F. C. Knewstubb, A.M.E.I.C., on **Investigation of High Head Power Sites in British Columbia.**

April 11.—J. L. Thomson, B.Sc. (Edin.), on **Some Applications of Microscopy, Photomicrography and X-rays in Engineering Practice.**
May 30.—Major T. V. Scudamore on **Stockholm, Sweden and Its City Hall.** This meeting took the form of an informal dinner.
Oct. 10.—Inspection trip of the Branch and Members of the Engineering Bureau Board of Trade to the Pressure Tunnel under First Narrows.
Oct. 25.—Major J. R. Grant, M.E.I.C., on **The Burrard Bridge.**
Nov. 16.—Student night.
Dec. 12.—Annual Meeting.

The Executive aimed at getting a few more general rather than too technical subjects and it seems as though the idea was successful judging from the increased attendance. The average attendance for the meetings was 60.

Executive Meetings

During the year six executive meetings were held to transact the routine business of the Branch and to discuss matters of policy. The executive has given very serious thought to the matter of Federation and their keen interest in the matter of Institute Development resulted in a letter being drafted to express the lack of sympathy with the Interim Report as set out in the October issue of The Journal. Copies of the letter were forwarded to all Branches and the Councillors of The Institute and a limited number are available for members desiring same.

Walter Moberly Memorial Prize

The prize for 1932 was awarded to Harry Marshall Van Allen for his thesis **Loading of Telephone Circuits** as the best submitted by any student in the Senior year of the Faculty of Applied Science at the University of British Columbia.

Association of Professional Engineers

To enable the Vancouver Branch to keep in close touch with the Association of Professional Engineers of British Columbia, the Branch Executive appointed the President and Registrar of the Association to be honorary members of the Executive. This arrangement has lent itself to greater co-operation between the bodies and is recommended to the incoming Executive.

American Institute of Electrical Engineers

The Branch has been fortunate in having been able to carry out arrangements with the local branch of the A.I.E.E. similar to those made in 1931.

Membership

	Residents	*Non-Residents*
Members	48	13
Associate Members	46	33
Juniors	9	3
Students	37	11
Affiliates	2	0
	142	60

Student Section

The Student section has notified this Executive of the formation of the "University of British Columbia Engineering Society" to replace the Student Section of The Engineering Institute of Canada and its objects are:—

(*a*) To coordinate the activities of the various existing student engineering organizations.
(*b*) To sponsor a series of lectures of general interest to the Students of engineering.
(*c*) To assist students in departments now lacking professional organization to obtain the benefits of such organization.
(*d*) To promote intercourse between students and practising engineers, through co-operation with:
  (1) The Association of Professional Engineers of B.C.
  (2) The several Canadian and International Voluntary engineering societies.

Membership is open to all students in engineering and allied subjects.

Elections

Ninety-eight ballots were returned out of a total of 110 mailed.

Financial Statement

Receipts

Bank balance, December 1931	$125.97		
Cash in hand	6.88		
Rebates from H.Q. (Aug. 1931 to Aug. 1932)	274.00		
Branch News	10.50		
Refund to petty cash (J. C. Oliver)	9.50		
			$426.85

Disbursements

Office Expenses:			
Rent	$ 75.00		
Petty cash	26.91		
Telegraph	2.55		
Addressograph plates	1.27		
Stenographer	15.00		
Stenographer (Circular Report)	5.00		
		$125.73	
Meetings:			
Notices	$ 99.54		
Auditorium rental	48.75		
Eastman kodak	10.00		
Dinner meeting	15.00		
		$173.29	
Student section		5.00	
E. C. Hay (ex. secretary Student Section)		5.59	
Honorarium to Secretary		50.00	
Balance:			
Balance in bank, Nov. 30, 1932	$110.94		
Owing to petty cash	.03		
	$110.91		
Outstanding accounts	43.67		
Balance Dec. 31, 1932		67.24	
			$426.85

Walter Moberly Prize Fund

Receipts

Bank balance of December, 1931	$ 80.29	
City of Vancouver bond interest	25.00	
Dominion of Canada bond interest	5.00	
Bank interest	2.78	
		$113.07

Disbursements

Bank charges	1.00	
Bursar, University of B.C.	25.00	
Bank balance, December 1932	87.07	
		$113.07

Bonds Held in Trust

City of Vancouver No. 663—5%—1964	$500.00	
Dominion of Canada No. TA 065189—5%—1943.	100.00	
		$600.00

Audited and certified correct: H. B. Muckleston, M.E.I.C.

Respectfully submitted,
P. H. Buchan, A.M.E.I.C., *Chairman.*
W. O. Scott, A.M.E.I.C., *Secretary-Treasurer.*

Victoria Branch

The President and Council:—

The undersigned have the honour to present a report on the activities of the Victoria Branch of The Engineering Institute of Canada for the year 1932.

The Annual Meeting was held on December 17th, 1931 at which Branch officers for the year were elected.

MEMBERSHIP

At the close of the year 1932, the standing of members was as follows:—

	Resident	*Non-Resident*
Members	19	1
Associate Members	22	3
Juniors	2	3
Students	10	2
	53	9

The foregoing includes four members who have been suspended on account of inability to pay membership dues.

During the year three Associate members and one Student member were dropped from the list of members for non-payment of dues.

The Executive committee, assisted by the General Secretary, R. J. Durley, M.E.I.C., made efforts to increase the membership:

(*a*) By writing to previous members of the Association who had for various reasons severed their connection with The Institute.
(*b*) By writing to other engineers who had not previously been members of The Institute.

Some forty-five personal letters were sent out in this connection from Branch Headquarters. The response was not very encouraging.

Meetings

During the year nine Executive committee meetings were held, one social meeting, and thirteen ordinary meetings of the Branch, six of which were technical. On the whole the attendance was very satisfactory.

The technical meetings were as follows:

Feb. 15.—**Investigation of High Head Hydraulic Power Sites in B.C.** by F. W. Knewstubb, A.M.E.I.C., S. H. Frame, A.M.E.I.C., with whom was associated Mr. Farrow. Attendance, 75.
Mar. 18.—**Construction of Variable Radius Arch Dam—South Forks Nanaimo River** by A. G. Graham, A.M.E.I.C. Thirty-five members and friends were present.
Sept. 26.—**The Romance of Electricity** by E. Davis, M.E.I.C. Thirty-five members and friends were present.
Oct. 28.—**Design and Construction of the Burrard Street Bridge** by J. R. Grant, M.E.I.C. Thirty members and friends were present.

Nov. 7.—**An Engineering Problem** prepared by the Executive Committee. Attendance was poor.

Nov. 25.—**Construction of Burrard Street Bridge and other works** depicted by moving picture films, described by J. P. Hodgson, M.E.I.C. Fifty-two members and friends were present.

By-Laws

During the year a committee redrafted the Branch By-laws which received the approval of the Executive sitting as a committee of the whole. These were approved by Council on November 22nd, 1932, and adopted by the Branch at the Annual General Meeting, December 16th, 1932.

Unemployment

No special committee was appointed to deal with the survey requested by Headquarters, the Executive committee acting as a committee of the whole. An examination of the returns and careful consideration of the list of members shows as follows:—

Retired	7
Private Practice	6
Employed	32
Unemployed	4
Expected to become unemployed	4
No information	13
Total	66

The committee considered that those who had not reported were not likely to be in necessitous circumstances, and it therefore only appeared necessary to enquire into the circumstances with regard to the four who were unemployed. This was done and no action was found necessary by the committee.

Death of Member

The death of F. M. Preston, A.M.E.I.C., city engineer of Victoria, a former member of the Branch, is recorded with great regret. Mr. Preston had maintained consistently the highest of professional standards and left behind him a record of achievement than which no better monument for an engineer exists.

Annual Meeting, 1932

This was held on December 16th, 1932 and the Committee for 1933 elected.

Financial Statement

Receipts		
Balance in hand, December 1st, 1931	$ 71.76	
One Branch Affiliate's dues	3.00	
Rebates from Headquarters	101.40	
Branch News	16.13	
Thirty-four Branch dues—$1.00	34.00	
Refunds	4.00	
Miscellaneous receipts	4.75	
		$235.04
Disbursements		
Honorarium (K. M. Chadwick, Secretary)	50.00	
Repairs to typewriter	5.20	
Stenographer	12.45	
Mimeographing, mailing and addressing	50.70	
Stamps and stationery	11.16	
Hire of rooms and chairs for Meetings	19.00	
Phone calls	2.38	
Miscellaneous expenses	5.60	
Blue printing	6.90	
Total Expenditure	$163.39	
Balance in hand Dec. 6th, 1932	71.65	
		$235.04

Year's receipts $163.28
Year's expenditure 163.39

Audited and found correct: K. M. Chadwick, M.E.I.C., Auditor.

We wish to express our appreciation of the unfailing courtesy and assistance which we have received from the Headquarters staff.

Respectfully submitted,
H. L. Swan, M.E.I.C., *Chairman.*
I. C. Barltrop, A.M.E.I.C., *Secretary-Treasurer.*

Winnipeg Branch

The President and Council:—

The following report of the Winnipeg Branch, for the year ending December 31st, 1932, is respectfully submitted.

Membership

	Resident	*Non-Resident*	*Total*
Members	41	4	45
Associate Members	98	26	124
Juniors	9	4	13
Students	47	9	56
Affiliates	2	0	2
Branch Affiliates	7	0	7
	204	43	247

It is reported with regret that the corporate membership of the Branch has been reduced during the past year by the deaths of Thos. Turnbull, M.E.I.C., and A. H. Eager, A.M.E.I.C.

There were thirteen regular meetings of the Branch held during the year as tabulated below.

Jan. 7.—**Chemical Control of Noxious Weeds on Railways** by J. D. Ruttan, A.M.E.I.C. Attendance, 22.

Feb. 4.—**Field Tests of 32,500-Kva. Generators at Seven Sisters** by J. P. Fraser, A.M.E.I.C. Attendance, 54.

Feb. 18.—(Annual Meeting). **Explosives** by Jas. Aitken, D. S. Binnington and E. Able. Attendance, 72.

Mar. 3.—**Detection of Hidden Defects in Steel Rails** by E. N. Johnson. Attendance, 46.

Mar. 21.—**Changing a Power System from 30 to 60 Cycles** by Trevor A. Robinson. Attendance, 40.

April 7.—**The Economic Situation in Manitoba** by Hon. D. G. McKenzie. Attendance, 49.

April 21.—**Main Street and Norwood Bridges, Winnipeg and St. Boniface** by H. M. White, A.M.E.I.C. Attendance, 57.

Oct. 6.—**Ore Dressing, Past and Present** by Geo. E. Cole, A.M.E.I.C. Attendance, 49.

Oct. 20.—**Flow in Solids, Ice, Rock-Salt Rock** by J. S. DeLury. Attendance, 49.

Nov. 3.—**Manganese Steel, Its Properties and Peculiarities** by J. A. DeBondy. Attendance, 47.

Nov. 17.—**Aerial Transportation** by W. B. Burchall. Attendance, 55.

Dec. 1.—**Newer Justice** by Judge F. A. E. Hamilton. Attendance, 31.

Dec. 15.—**Tree Ring Growth** by G. B. Gill. Attendance, 29.

Four prizes were awarded to students for papers, two to students in Electrical Engineering and two to students in Civil Engineering.

With regard to unemployment, the Branch through the Executive Committee acted jointly with the Manitoba Association of Professional Engineers in the formation of a Joint Committee on Unemployment, the personnel being:—

J. N. Finlayson, M.E.I.C., Chairman
J. W. Sanger, A.M.E.I.C.
T. C. Main, A.M.E.I.C.
W. P. Brereton, M.E.I.C.
Chas. T. Barnes, A.M.E.I.C.
Herbert Hunter

This committee has been very active, holding fortnightly meetings and has had some success in obtaining work for unemployed members. Latterly the committee has devoted much of its efforts to the relief of members in straitened circumstances, and its actions in this respect have been much appreciated.

It was decided that following December 31, 1931, the collection of Branch dues would be discontinued, and in order to offset the reduction of income resulting from this decision, economies would be made so that the principal functions of the Branch could be carried out without creating a deficit.

Financial Statement

Receipts			
Balance in bank, December 31st, 1931		$479.34	
Deposit of cheques on hand, Dec. 31st, 1931		151.80	
Rebates from H.Q. for Dec. 1931		9.50	
Branch dues up to Dec. 31st 1931 received in 1932		93.00	
Rebates from H.Q. for 11 months of 1932		320.76	
Branch news		17.51	
Journal subscriptions Branch Affiliates		4.00	
Interest on Victory Bond		27.50	
Bank interest		5.28	
Advice by wire from H.Q. December rebates		6.00	
			$1,114.69
Expenditures			
Refreshments at Branch meetings	$ 25.47		
Janitor services	32.00		
Christmas gift to janitor	10.00		
Student prizes	80.00		
Printing notices of meetings, ballots, stationery and postage	232.90		
Supper-dance, 1931	200.00		
Supper-dance, 1932	100.00		
Telegrams, messenger service and taxi	5.90		
Flowers (funerals and hospital)	20.00		
Flowers (hospital)	3.00		
Contribution to farewell dinner to old member	8.00		
Honorarium to Secretary	100.00		
	$817.27		
Balance in bank, December 31st, 1932	341.92		
		$1,159.19	
Less December rebates, wire only received		6.00	
		1,153.19	
Less cheques outstanding		38.50	
			$1,114.69

Respectfully submitted,
T. C. Main, A.M.E.I.C., *Chairman.*
E. W. M. James, A.M.E.I.C., *Secretary-Treasurer.*

THE
ENGINEERING JOURNAL
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Instability in Industry

Wide publicity has recently been given to the utterances of a self-appointed group of inquirers in the United States who claim that their rather sensational announcements as to our future are based on theories worked out by the application of engineering methods to industrial and economic problems. The hurried acceptance of these predictions by some, and their off-hand rejection by others, at all events indicates that the public would be disposed to listen attentively to the views of the profession if presented with the backing and approval of recognized engineering organizations. A prominent American engineer has said that "Engineering is a profession having an intimate knowledge of industry possessed by no other group," and, in fact, both in Europe and America a great deal of investigation work is being done under the auspices of the various engineering societies, as is evident from the many articles on various phases of industrial economics which are appearing in their transactions and in the technical press. In these the nature and causes of the evident instability of industrial conditions, and the manner in which these conditions have been affected by the evolution of industry, have received a good deal of consideration.

In practically all countries the development of industry during the past fifty years has been characterized by a progressive increase in the size of the average manufacturing plant, a change due not only to the economic advantages inherent in large scale production, but also to the introduction of more efficient methods of management and business control and the widening of markets brought about by increased facilities for transportation, features which tend to benefit the large rather than the small organization. Canada has been no exception, as is shown by the fact that between 1922 and 1929 the number of industrial establishments in Canada which reported a gross annual production of over $1,000,000 increased in number from 420 to 719. There was also an increase in the proportion of the total manufacturing production of the country which came from such larger plants, a proportion which increased from 51 per cent in 1922 to 62 per cent in 1929.

The larger manufacturing plants in Canada are, of course, few in number as compared with the smaller ones. In Ontario and Quebec, for example, in 1929 there were nearly 4,000 establishments employing more than 20 but less than 500 hands, while there were only 160 plants whose average number of employees during that year exceeded 500. The smaller plants, further, furnished occupation to almost twice as many employees as the larger ones. Incidentally, it may be noted that in the seven-year period referred to, the number of persons employed in Canadian manufacturing industries increased 32 per cent in spite of the progressive displacement of men by machines on which so much stress has recently been laid.

These figures are of interest as applying to a period during which industry was recovering from the depressed conditions of 1922, a period which terminated in the activity and industrial slump of 1929. They also indicate the extent to which the country is still dependent upon the enterprise and activity of the smaller industrial plants, which, although less spectacular in their achievements and perhaps less aggressive in putting their products before the public, are fortunate in possessing certain elements of stability which become evident in times of lessened activity like the present.

Several writers, in recent studies of the economics of machine production, have pointed out that a manufacturer's operations tend to instability of profit and output when carried out under conditions involving a high fixed investment and a low variable labour cost. In such a case it may well happen that although such a plant has shown a satisfactory financial result when working at full capacity, a comparatively small reduction in sales and, therefore, in output, will cause profit to disappear. This is due to the fact that fixed charges for maintenance, taxes, depreciation, bond interest, etc., do not diminish with the volume of output and, therefore, make it impossible to reduce the total cost of production below a certain minimum. Thus, the proportional reduction in expenditure which can be made to keep pace with reduced sales may actually be less for a highly mechanized plant, in which expensive equipment has replaced men, than for a less efficiently equipped organization. In other words, it may happen that a large expensively equipped plant may cease to earn a profit if worked below fifty or sixty per cent of its capacity, while an equally well managed, but less elaborately organized competitor may still be able to make ends meet if its production drops even to twenty or thirty per cent of normal.

It has been remarked that "this condition has led to a frantic endeavour on the part of business to keep output above the critical percentage. In many industries this has meant that the total of such efforts gave an output greater than the capacity of the market to absorb it." The inevitable result has been that just at a time when total output should have been reduced, it actually increased, thus intensifying a situation which was already bad enough.

Here, in outline, is one of the many causes which have contributed to our present unstable industrial situation. One of its results has been that in times of stress like the present, the well managed plant operating on a small scale has often been able to carry on with a considerable measure of success, even although larger concerns have been losing ground, discharging their employees, or going through the process known as "re-organization." During the period of hectic activity which terminated three years ago, it is probable that many industrial firms who had survived previous depressions were led into a programme of ill-advised expansion. As a result, such plants assumed a load of fixed charges which greatly increased the difficulties under which they have to labour to-day. A potential source of trouble in future can be avoided if this lesson is learnt by financiers and businessmen. Stability in industry is one of our pressing needs and there is no question that one great disadvantage of highly developed machine production, particularly on a large scale, is the small variation possible in the output of establishments whose fixed charges are so high as to impair their power of operating at less than full capacity.

These reflections, familiar as they may be to financiers, do not seem to have received the attention they deserve from executive officers and engineers.

Meeting of Council

A meeting of Council was held at Headquarters on Friday, January 20th, 1933, at eight o'clock p.m., with Vice-President O. O. Lefebvre, M.E.I.C., in the chair, and four other members of Council present.

A further resolution was presented from the Toronto Branch in connection with a possible reduction in entrance fees, but as this would involve a change in the by-laws it was suggested that the Toronto Branch might bring the matter forward for discussion at the Annual Meeting.

The annual report of the Finance Committee was considered, together with the financial statement for the year, and it was noted that a reduction in The Institute's revenue for 1933 over 1932 seemed probable. In view of this, certain measures of economy were authorized.

Further action was taken in connection with members in arrears for 1932, with reference to an extension of credit to those who have sent in requests for consideration.

The Report of Council for 1932 was discussed and approved for presentation at the Annual Meeting, together with the reports of the various standing and other committees.

The membership of the Nominating Committee for 1933, as submitted by the various branches was noted, and C. H. Wright, M.E.I.C., was appointed chairman of the Nominating Committee for the current year.

The reports of the committees on the Past-Presidents' Prize, the Gzowski Medal, the Plummer Medal, the Leonard Medal, and the Students' and Juniors' Prizes were presented and received, together with the branch reports.

A letter was presented from Councillor L. W. Wynne-Roberts, A.M.E.I.C., suggesting that, if possible, Council meetings should be held regularly in Toronto as well as in Montreal. This proposal was favourably received, but it was felt that decision on this point should be left in the hands of the incoming Council.

J. M. Oxley, M.E.I.C., was renominated as a representative of The Institute on the Main Committee of the Canadian Engineering Standards Association.

Seven resignations were accepted, seven reinstatements were effected, four Life Memberships were granted, fifty-four members were placed on the Suspended List, and a number of special cases were considered.

A number of applications for admission and for transfer were considered, and the following elections and transfers were effected:

Elections		*Transfers*	
Associate Member	1	Assoc. Member to Member	1
Students admitted	6	Junior to Assoc. Member	3
		Student to Assoc. Member	1
		Student to Junior	2

The Council rose at twelve fifteen a.m.

ELECTIONS AND TRANSFERS

At the meeting of Council held on January 20th, 1933, the following elections and transfers were effected:

Associate Member

CHRISTIE, George William, B.Sc., (N.S. Tech. Coll.), asst. chief engr., Imperial Oil Limited, Dartmouth, N.S.

Transferred from the class of Associate Member to that of Member

PORTAS, John, B.Sc. (Eng.), (London Univ.), chief engr., J W. Cumming Mfg. Co. Ltd., New Glasgow, N.S.

Transferred from the class of Junior to that of Associate Member

CRAWFORD, Robert Eric, B.Sc., (McGill Univ.), sales and advertising, Dominion Engineering Works, and instructor, mech'l. drawing, Montreal Technical Institute, Montreal, Que.

SIMPKIN, Douglas Benjamin, B.Sc., (Univ. of Alta.), designer, Noranda Mines, Limited, Noranda, Que.

STEWART, Donald, B.Sc., (McGill Univ.), divn. equipment engr., Montreal Divn., Bell Telephone Company of Canada, Montreal, Que.

Transferred from the class of Student to that of Associate Member

RUTHERFORD, James Forest, B.Sc., (McGill Univ.), sales engr., Pollock International Corporation, Limited, Montreal, Que.

Transferred from the class of Student to that of Junior

DUCHASTEL DE MONTROUGE, Leon Alexandre, B.A.Sc., C.E., (Ecole Polytech.) designer, Power Engineering Company, Montreal, Que.

YEOMANS, Richard Henry, B.Sc., (McGill Univ.), inspection engrg. work, Northern Electric Company, Limited, Montreal, Que.

Students Admitted

BENOIT, Jacques, (Ecole Polytech.), 481 Prince Arthur St. West, Montreal, Que.

BRIDGLAND, Charles J., (Univ. of Toronto), North House, University of Toronto, Toronto, Ont.

CHALK, Henry Edwin, (McGill Univ.), 4951 Western Ave., Westmount, Que.

FLEXMAN, James Kenneth McAthy, (Queen's Univ.), (Grad. R.M.C.), Officers' Mess, R.C.H.A., Kingston, Ont.

PAINTER, Gilbert Walter, (McGill Univ.), 1025 Burnside Place, Montreal, Que.

POWELL, Clarence M., (N.S. Tech. Coll.), Nova Scotia Technical College, Halifax, N.S.

STARKEY, John Leonard, (Junior matric., McGill Univ.), 4559 Madison Ave., Montreal, Que.

TRISCHUK, William, (Univ. of Sask.), P.O. Box 1260, Saskatoon, Sask.

OBITUARIES

John Brooke Molesworth Parnell, Lord Congleton, A.M.E.I.C.

The many friends of John Brooke Molesworth Parnell, Lord Congleton, A.M.E.I.C., in this country, have learned with regret of his death in London on December 22nd, 1932.

Lord Congleton was born at Clonmel, Tipperary, Ireland, on May 16th, 1892, the second son of the fourth Baron Congleton. He was educated at the Royal Naval Colleges at Osborne and Dartmouth, and from 1909 to 1919 served in the Royal Navy as midshipman, sub-lieutenant and lieutenant, retiring with the rank of lieutenant-commander. At the close of the war Lord Congleton entered McGill University in the Faculty of Engineering, graduating in 1921 with the degree of B.Sc.

For some time following his graduation he remained in Montreal in business, and then removed to England, where he was associated with the engineering firm of G. D. Peters & Company, Limited, London. He was a director of the Canadian subsidiary of the same firm, G. D. Peters & Company of Canada, Limited.

Lord Congleton joined The Institute as a Junior on December 30th, 1919, and transferred to Associate Membership on January 17th, 1922.

Kenneth Gordon, A.M.E.I.C.

Much regret is expressed in recording the death at Montreal on December 25th, 1932, of Kenneth Gordon, A.M.E.I.C.

Mr. Gordon was born at London, England, on December 2nd, 1884, and received his education at Madras College, St. Andrews, Scotland, 1892-1899, and Armstrong College, Newcastle-on-Tyne, 1904-1906. During the years 1899 to 1904 he was an apprentice in the shops and drawing office of Messrs. Philip and Son Limited, Dartmouth, Devon, England.

In 1906-1908 Mr. Gordon was junior watch keeping engineer with the Royal Mail Steam Packet Company. Coming to Canada he was rodman and assistant on railway construction with the New Canadian Company, Gaspe, Que., from April to October, 1909, and was next connected with the Railway Signal Company of Canada, Ltd., Lachine, Que., as designing engineer and draughtsman. In 1914 he was signal inspector with the Canadian Government Railways at Moncton, N.B., and enlisted in August, 1914. Mr. Gordon served overseas with the Canadian Expeditionary Force, first with the First Field Company, Canadian Engineers, and later as second lieutenant with the Royal Field Artillery. Demobilised in 1919, and returning to this country after the war, Mr. Gordon resumed his former position with the Canadian National Railways at Moncton, and in the following year was appointed second assistant signal engineer. In May 1923, he was transferred to Montreal as assistant signal engineer.

Mr. Gordon became an Associate Member of The Institute on January 26th, 1920.

Alexander Macdonald Grant

Regret is expressed in recording the death at Ottawa on January 19th, 1933, of Alexander Macdonald Grant.

Mr. Grant was born at Egerton, N.S., on December 10th, 1882, and graduated from Queen's University in 1908 with the degree of B.Sc.

Following graduation Mr. Grant entered the Dominion Civil Service in the Topographical Surveys Branch, Department of the Interior, as examiner of survey returns, in 1911 was in charge of observing party with the Geodetic Survey, and in 1912 was placed in charge of the laying out of the triangulation and organization and direction of the parties engaged on the reconnaissance, tower building and direction measurement of the primary and secondary triangulation in Ontario. From 1916 to 1918 Mr. Grant was gauge examiner with the Inspection Department, Imperial Ministry of Munitions, and in 1919 resumed his position as geodetic engineer with the Geodetic Survey of Canada, holding this office until the time of his death.

Mr. Grant joined The Institute as an Associate Member on April 27th, 1920 and became a full Member on May 23rd, 1923.

John Robert Clarke Macredie

It is with regret that the death is recorded on December 6th, 1932, of John Robert Clarke Macredie, at Moose Jaw, Sask.

Mr. Macredie was born at Saint John, N.B., on June 13th, 1879, and graduated from the University of New Brunswick in 1901 with the degrees of B.E. and B.Sc.

In 1902, Mr. Macredie entered the service of the Canadian Pacific Railway Company, being on survey as a rodman at Chapleau, Ont. In May, 1904, he was appointed resident engineer for the Construction Department at Fielding, Ont., and later, in 1906, was engaged in double-tracking the line between Kenora and Winnipeg. In 1908 Mr. Macredie was on construction work at Lethbridge, working on the Weyburn-Lethbridge line as assistant engineer, and in 1910-1915 took part in important bridge construction work, which included the erection of bridges at Empress, Lethbridge, Outlook and Ronalane on the Suffield branch, where a bridge was constructed across the Bow river. Mr. Macredie's rank at that time was assistant engineer. In 1915 he was transferred to Glacier, B.C., where he was resident engineer during the construction of the Connaught tunnel through the Rogers Pass.

In 1917 Mr. Macredie was appointed district engineer at Moose Jaw, Sask., which position he held until the time of his death.

Mr. Macredie joined The Institute as an Associate Member on October 24th, 1907, transferring to the class of Member on December 9th, 1911. He always took an active part in the affairs of The Institute, and served a term as chairman of the Saskatchewan Branch.

Robert Manson Wilson, M.E.I.C.

By the death on January 4th, 1933, of Robert Manson Wilson, M.E.I.C., Montreal has lost a well known engineer who took a prominent part in the development of the system of electrical supply and distribution in the district.

Mr. Wilson was born at Montreal on July 29th, 1874, and graduated in science with honours from McGill University in 1899.

During the years 1898 to 1902 he was engineer in charge of installation and operation of the plant at Chambly for the Royal Electric Company, which in 1902, formed one of the component units of the original Montreal Light, Heat and Power Company. From 1902 to 1904 he was assistant to the general superintendent, and superintendent of stations of the Montreal Light, Heat and Power Company, becoming general superintendent of the company in 1904. In 1909 Mr. Wilson was appointed general superintendent and chief engineer, which position he held until ill-health necessitated his retirement from active service in the autumn of 1925. In 1928 Mr. Wilson returned to active practice as vice-president and consulting engineer of the Power Engineering Company.

One of his most notable achievements in the field of electrical engineering was at Cedar Rapids, the development of power from which commenced in 1912. Mr. Wilson was responsible for the installation of the electrical equipment in that plant and took a great interest in its construction and final completion.

Mr. Wilson joined The Institute (then the Canadian Society of Civil Engineers) as an Associate Member on November 17th, 1904, and became a Member on February 18th, 1913.

PERSONALS

A. R. Macgowan, A.M.E.I.C., is at present connected with the Hoboken Manufacturers Railroad Company, at Hoboken, N.J.

J. E. Haury, Jr.E.I.C., is now engineer of power and lighting, electrical department, City of Montreal. Mr. Haury was formerly assistant engineer in the Rapid Transit department of the Montreal Tramways Company.

Brig.-General C. H. Mitchell, C.B., C.M.G., D.S.O., LL.D., D.Eng., M.E.I.C., Dean of the Faculty of Applied Science, University of Toronto, and consulting engineer, has been elected president of the Toronto Board of Trade for the year 1933.

Jean Saint-Jacques, S.E.I.C., a graduate of McGill University of the year 1931, is now on the staff of the Quebec Power Company, at Quebec, Que. Mr. Saint-Jacques was for a time with the Shawinigan Water and Power Company, Montreal.

P. W. Greene, A.M.E.I.C., who has since 1929 been sales engineer with the United States Steel Products Company at Toronto, has been transferred to the company's New

York office. Mr. Greene, who is a graduate of the University of Toronto, and a Dominion Land Surveyor, spent five years in China with Messrs. Little, Adam and Wood, on building construction and harbour work. On returning to Canada in 1928 he was for about a year associated with Gordon L. Wallace, A.M.E.I.C., consulting engineer.

C. D. Wight, A.M.E.I.C., is now attached to the engineering department of the city of Ottawa, Ont. Mr. Wight who graduated from Queen's University in 1928 with the degree of B.Sc., was for some time partner in the firm of MacRostie and Wight, consulting engineers, Ottawa.

E. W. Oliver, M.E.I.C., has recently been appointed director of Service and Research, St. Louis Southwestern Railway, St. Louis, Mo. Mr. Oliver has been since 1928, manager, for the Canadian National Electric Railways, at Toronto. He was for a time general superintendent of the Niagara, St. Catharines and Toronto Railway, and later was connected with the Electric Lines, Canadian National Railways, Toronto.

George H. Harlow, Jr.E.I.C., has joined the staff of the Dominion Engineering Works, Limited, at Lachine, Que. Mr. Harlow, who graduated from the University of Toronto in 1922 with the degree of B.A.Sc., was for a time instructor and later, lecturer, in Thermodynamics with the Department of Mechanical Engineering at the same university. In 1931 he was mechanical engineer with the Dunlop Tire and Rubber Goods Limited, at Toronto.

RECENT ADDITIONS TO THE LIBRARY

Proceedings, Transactions, etc.

The Institution of Mechanical Engineers: Proceedings, vol. 122, January-June, 1932.

American Society for Testing Materials: Proceedings, vol. 32, 1932. Part 1: Committee Reports; Tentative Standards. Part 2: Technical Papers.

Reports, etc.

Dept. of Mines, Mines Branch, Canada:
Investigations of Mineral Resources and the Mining Industry, 1931.

Dept. of Mines, Geological Survey, Canada:
Economic Geology Series No. 11: Rare-element Minerals of Canada.
Economic Geology Series No. 12: Manganese Deposits of Canada.

Dominion Water Power and Hydrometric Bureau, Canada:
Hydro-electric Progress in Canada in 1932.

Bureau of Mines, United States:
Mineral Production of the World, 1924-1929: A Statistical Summary.

University of Minnesota:
Engineering Experiment Station Bulletin No. 8: Heat Transmission Through Building Materials.

National Electric Light Association:
Underground Systems Committee, National Engineering Section: Acceptance Inspection and Testing of Cable.
Underground Systems Committee, National Engineering Section: Cable Operation, 1931.

Technical Books, etc., Received

Principles of Industrial Management, by E. A. Allcut, M.E.I.C., 1932. *Presented by Sir Isaac Pitman & Sons (Canada) Ltd.*

The Gazette Commercial and Financial Review for the Year 1932. *Presented by The Gazette.*

C.E.S.A. Canadian Electrical Code, Part 2, Specification No. 0: Definitions and General Requirements, 1932. *Presented by Canadian Engineering Standards Association.*

Pitman's Technical Dictionary of Engineering and Industrial Science in Seven Languages, Vol. 5: Index, 1932.

Canadian Almanac and Legal and Court Directory, 1933.

Whitaker's Almanack, 1933.
Purchased.

BOOK REVIEWS

Steel and its Practical Applications

By William Barr and A. J. K. Honeyman. Blackie, London, 1932, cloth, 5 x 7½ in., 125 pp., photos, figs., tables, $2.00.

Reviewed by Professor Alfred Stansfield, D.Sc., M.E.I.C.*

The authors write from the Dalzell Steel and Iron Works at Motherwell, which is about twelve miles south east of Glasgow. The letters A.R.T.C. suggest that they studied metallurgy at a technical college, while a study of their book shows that they are well informed regarding the manufacture, properties and treatment of steel and have a fair knowledge of the scientific theory underlying this practice.

The book deals briefly with the manufacture of steel by the open-hearth process and more fully with the casting of this steel into ingots and with its hot and cold working and case-hardening. It deals also with the nature and properties of wrought iron, plain carbon steels and alloy steels, including the "non-corrosive" and heat-resisting varieties, the mechanical testing of steel and its microscopic and macroscopic examination.

The book is small, 125 pages, 5 by 7½ inches, with more than one hundred illustrations. It is clearly written, and will be helpful to steel-workers of all classes, while it contains information that would be of use to many practising engineers.

Professor of Metallurgy, McGill University, Montreal, Que.

The Early Years of Modern Civil Engineering

By R. S. Kirby and P. G. Laurson. Yale University Press, New Haven, 1932, cloth, 6¼ x 9½ in., 324 pp., front., photos, illus., $4.00.

Reviewed by R. O. Wynne-Roberts, M.E.I.C.*

This volume is an interesting story of the development of modern civil engineering between the later sevententh and the earlier nineteenth centuries, and, incidentally, some work built before and after. The information is collected from excellent sources.

There are very few books which treat of the historical incidents and the experience of engineers, except those dealing with some particular lines of study. This book is of note as furnishing a general outline of the efforts of engineers, and also of men, in the earlier days, who were educated in the school of experience, without having any theoretical knowledge of the art.

Surveys, two hundred years ago, were made by crude instruments. Among the inventors was Gunter, a practical-minded professor, and an ingenious clergyman—a pitiful preacher—whose mind was always involved in the solution of mathematical problems. His logarithmic scale and the decimally divided chain are well known.

One party of surveyors of 1760 who made a part of the survey of the state boundaries of Maryland and Pennsylvania—afterwards known as the Mason and Dixon line,—seem to have been of bibulous disposition. "One hogshead of port wine, eleven gallons of spirits, and forty-two gallons of rum were consumed in a remarkably short time." The term Mason and Dixon originated from the fact that these were the surnames of two English astronomers sent out by the British government to fix the southern boundary of Pennsylvania and the nearly north and south line between Maryland and Delaware.

Brindley, a local untutored mechanic, planned and built the Bridgewater canal, and thereby earned the title of the Father of British inland waterways. When Peter the Great ordered 30,000 men to report for the construction of great canals in Russia, the local authorities were in opposition, for the reason "that God had made the rivers to go one way and it was Presumption in Man to think to turn them another."

It is stated that John Smeaton, builder of the Eddystone lighthouse, was the first one, in 1761, to call himself a civil engineer.

Roads, well into the nineteenth century, were in a shocking state. Even when cobblestones were laid they were neglected to such an extent that large water holes were frequent.

The Yonge street road from Toronto is reputed, in 1835, to have been the first plank road built in America.

The authors refer to the first railway from Liverpool to Manchester, and consider that in the century since it was opened the only advance made has been in details of equipment and operation. "To have a curve on a railway is," writes one early English engineer, "at best, a misfortune."

"The locomotive engine runs every day for passengers at half past 4 p.m. Parties wishing it at any other hour can be accommodated by applying to the engineer" (1831, *Charleston Mercury*).

Bridges are described in about thirty pages. London Bridge had served the people for six hundred years. In 1757 the houses on the bridge had been removed and the bridge widened to 31 feet. The water-works pumps were acquired in 1824, and a new bridge was built. Westminster Bridge was erected in 1739-50. There was a wooden viaduct over the Clyde at Glasgow, with fourteen arches, 34-foot span, designed by Robert Stephenson.

The Town truss bridge over the James river at Richmond, Virginia, on the line of the Richmond and Petersburg Railroad, was 2,900 feet long, on eighteen granite piers, and cost £24,200 sterling, in 1838. This cost seems very small. Ithiel Town was a scholarly architect of New Haven, Connecticut, and his bridges were of wood lattice truss construction.

Early cast iron bridges, suspension, tubular and cantilever bridges are well described. The first tunnel in the United States was for a canal near Auburn, Pennsylvania, and was built in 1820-21. In 1855-56 it was straightened and made an open cut, so that Drinker says, "Our first American tunnel is now an airy nothing."

Water-works and sewerage works are dealt with. Paris' first artesian well, 1,800 feet deep, was bored in 1833-41, by a self-taught engineer named Mulot.

Montreal embarked on its first comprehensive water-works from above Lachine rapids in 1854. The engineer was Thomas Coltrin Keefer, (1821-1915), the first President of the Canadian Society of Civil Engineers.

In Edinburgh, in 1750, it was disagreeable, if not dangerous, to go out at night, and sometimes a guide would call out in a loud voice, in the Scotch dialect, "Haud your haunde" (stop your hand) because dirty water was thrown out of the windows.

Referring to sewage disposal, it is stated that "to combine a sound conception of the biological principles involved with a study of the engineering data of operation on a practical scale was left for American investigators." This is surely a generous tribute to American enterprise if it were true.

The remainder of the book covers river and harbour improvement, and materials of construction, concluding with a series of brief biographical outlines regarding early engineers. A selected bibliography of each topic is given.

The volume is excellently illustrated, and is a mine of information.

*Partner, Wynne-Roberts, Son & McLean, Civil Engineers, Toronto, Ont.

Principles of Industrial Management

By E. A. Allcut. Isaac Pitman, Toronto, 1932, cloth, 5½ x 8½ in., 218 pp., photos, figs., $3.00.

Reviewed by G. I. MacKenzie*

In the preface to this book the author states that it was written "for use by students as a text, and with the hope that it might be of some service to those engaged in the engineering industries who wish to obtain some general knowledge of the principles of management." The intended scope of the book, therefore, is very broad, necessitating a very brief treatment of some topics.

The ground covered is indicated by the chapter headings, which are as follows:—

I. Mainly Historical.
II. Specialization and Standardization.
III. The Principles of Management.
IV. Organization.
V. Reports.
VI. Designing and Drafting.
VII. Purchasing.
VIII. Budgets.
IX. Planning.
X. Receiving, Handling and Storing Materials.
XI. Arrangements for Manufacture and Assembly.
XII. Time and Motion Study.
XIII. Inspection.
XIV. The Payment of Labor.
XV. Costs and Cost-Keeping.
XVI. Personnel.
XVII. Waste.
XVIII. Scientific Management.

The first chapter deals with the industrial revolution which took place during the latter part of the eighteenth century, and points out the advantages to be obtained through mass production methods of manufacture. The next sixteen chapters deal with the organization, administration, and operation of the various departments required to carry on mass production, and the final chapter sums up the claims made for scientific management, together with the objections raised by organized labour. In chapter IX is shown the development of two very interesting formulae, namely:—

1. Economy of Labor Saving Equipment
2. Economical Lot Sizes to Manufacture

while chapter XVI contains some very worthwhile thoughts and suggestions on the problem of unemployment.

Throughout the book the author makes frequent reference to, and uses numerous quotations from, other works on similar or related subjects, and the reader will find a pleasing mixture of scientific principles illustrated by elementary examples.

Due to the wide diversity of management problems, many of them being peculiar to one particular industry or organization, the author has wisely omitted specific details of operating routines. The book is particularly well illustrated with photographs and charts which will be of great assistance to the student who has not had the benefit of shop experience.

Since the subject of scientific management is becoming of increasing importance, this new book is of timely interest and should prove to be quite adaptable for use as a student's text, and as a reference work for the industrial engineer and business executive.

*Northern Electric Company Ltd., Montreal, Que.

Bulletins

Asphalt Road Construction—"Surface Treatment Types" is the title of the second manual of a series covering studies of road beds, traffic capacities of road surfaces, road maintenance and tests, along with a glossary of terms used in surface treatment operations. It is published by the Asphalt Institute of New York, and contains 128 pages.

Safety Fuses—The Canadian Safety Fuse Company, Brownsburg, Que. describes in a 24-page booklet how blasting efficiency may be increased with the proper care and use of safety fuses, and illustrates the correct way to arrange the fuse in charge holes.

Crawler Tractors—Two 6-page bulletins issued by the Cleveland Tractor Company, Cleveland, have been received, and describe their Type 80 tractor and its application to road construction.

Automatic Valves—The Golden-Anderson Valve Specialty Company, Pittsburg, Pa., have distributed an 8-page bulletin on their patent automatic cushioned, high-pressure, cold and hot water float valves also reducing and receiving valves.

Motors—A copy of a 6-page bulletin has been received from the Louis-Allis Company, Milwaukee, which contains a description of their new splash-proof type motor.

Roofing—The Barrett Company, Montreal have just issued a 64-page architects' and engineers' reference manual, containing specifications and detail drawings treating with the following: Built-up roofing for flat and steep roof decks, roof flashing and drainage and waterproofing. For unusual problems, this company maintains a service department which is available for consultation.

Nickel Products—The fall edition of the 34-page periodical "Inco" distributed by the International Nickel Company of Canada, Ltd., Copper Cliff, Ont., has just been received, and contains a number of interesting short articles on the use and development of nickel, this includes kitchen, marine, chemical and other fields.

Copies of the above will be sent on request.

The Length of an Hyperbolic Arc

J. B. Macphail, A.M.E.I.C.

A search through several mathematical text books failed to reveal a formula giving the length of an hyperbolic arc, and the following notes on the derivation of an expression for the purpose are therefore given for reference.

Consider the hyperbola $\frac{y^2}{b^2} - \frac{x^2}{a^2} = 1$ and the general expression for the length s of any arc,

$$s = \int_0^x \sqrt{1 + \left(\frac{dy}{dx}\right)^2} \cdot dx$$

By differentiation and substitution, and on putting $c^2 = \frac{b^2}{a^2}$ we get

$$s = \int_0^x \sqrt{\frac{a^2 + (1 + c^2)\, x^2}{a^2 + x^2}} \cdot dx$$

This suggests that the solution will be in terms of elliptic integrals which can easily be evaluated from any of the currently available numerical tabulations of these functions. They may be found, for example, in Pierce's "Short Table of Integrals."

Substitute $x = \frac{a}{\sqrt{1 + c^2}} \cdot \tan \phi \qquad dx = \frac{a}{\sqrt{1 + c^2}} \sec^2 \phi \, d\phi$

and we get $s = \frac{a}{\sqrt{1 + c^2}} \int_0^{\phi} \frac{1}{\cos^2 \phi} \cdot \frac{d\phi}{\sqrt{1 - k^2 \sin^2 \phi}}$

where $k^2 = 1 - \frac{1}{1 + c^2} = \frac{c^2}{1 + c^2} = \frac{b^2}{a^2 + b^2}$

The integral is now in a form which can be recognized in tables of integrals, so substituting the result of integration from Hancock, quoting Legendre, we get

$$s = \frac{a}{\sqrt{1 + c^2}} \cdot \frac{1}{1 - k^2} \Big[\tan \phi \sqrt{1 - k^2 \sin^2 \phi} + (1 - k^2)\, F(k, \phi) - E(k, \phi) \Big]_0^{\phi}$$

$$= \sqrt{a^2 + b^2} \Big[\tan \phi \sqrt{1 - k^2 \sin^2 \phi} + \frac{a^2}{a^2 + b^2} F(k, \phi) - E(k, \phi) \Big]_0^{\phi}$$

where E and F are elliptic integrals, and

$$\phi = \tan^{-1} \frac{x}{a} \sqrt{1 + c^2} = \tan^{-1} x \cdot \frac{\sqrt{a^2 + b^2}}{a^2}$$

Reference to tables of elliptic integrals will require the calculation of $\theta = \sin^{-1} k$ since they are prepared with θ and ϕ as arguments. With this substitution, $F(k, \phi)$ and $E(k, \phi)$ become $F(\theta, \phi)$ and $E(\theta, \phi)$. The limits of integration have been taken from 0 to x. A lower limit different from zero could equally well have been chosen, but the later numerical work of calculating two arcs measured from $x = 0$ and taking the difference is exactly equivalent and perhaps a little clearer.

As a numerical example, consider the hyperbola previously mentioned: put $a = b = 1$ and calculate the length of the arc from $x = 0$ to $x = 2$. By substitution in the above formulae we get

$$\phi = \tan^{-1} 2\sqrt{2} = 70°.529 \qquad k = \frac{1}{\sqrt{2}} \qquad \theta = 45°$$

$$E(45°, 70°.529) = 1.106 \qquad F(45°, 70°.529) = 1.382$$

$$\sqrt{1 - k^2 \sin^2 \phi} = 0.745$$

$$s = \sqrt{2} \Big[2\sqrt{2} \times 0.745 + \frac{1}{2} \times 1.382 - 1.106 \Big]$$

$$= 2.395$$

BRANCH NEWS

Calgary Branch

H. W. Tooker, A.M.E.I.C., Secretary-Treasurer.
J. A. Spreckley, A.M.E.I.C., Branch News Editor.

Weather Trends

On the assumption that climate is essentially one of the forces of nature and a fit subject for investigation by engineers the evening of December 15th was devoted to a discussion of the causes and effects of cyclic changes in weather conditions.

Lieut.-Colonel Steel, M.E.I.C., occupied the chair and the subject was introduced by J. A. Spreckley, A.M.E.I.C. By a series of charts the speaker showed that the prices of wheat and other commodities are intimately related to the world production of wheat, which depends on the aggregate of many local adjustments of heat and moisture. Particular reference was made to the work of Dr. R. E. DeLury, the assistant chief astronomer at Ottawa, who, by many years of study, has shown that solar influence can be detected in Canadian records of temperature, precipitation and the abundance of wild animal life. He has also related tree-growth and commodity prices to the same source, and established an enviable reputation for sound predictions of future trends.

As an instance of the practical value of such investigations an original diagram was presented for twenty years of wheat yields in Canada with the corresponding cumulative sun-spot numbers.

The form of the chart was suggested by the peculiar effect of solar radiation on evaporation from a free water surface at Saskatoon, being approximately halved in alternate years. This change is reflected in crop growth and is probably due to the reverse effects of heat, or solar energy, at the equator and the poles.

According to Dr. C. E. P. Brooks, "the relation between solar constant and sunspot numbers does not appear to be simple" but both occur in rhythmic sequence and residual values can be estimated a few years in advance.

In opening the discussion, A. Griffin, M.E.I.C., remarked that the relation of natural phenomena on our earth to solar, lunar and other celestial phenomena have long been the subject of painstaking study by scientists, and that these studies are constantly being extended in scope and volume with constantly improving instruments and methods. Even if, as some believe, the very thought trends of human kind are determined or influenced by solar radiations, yet man is a perverse and imperfect creature and is constantly striving to order his own affairs first in line with and then against the influences outside himself. Those who give of their time and effort to such studies are our benefactors.

J. R. Wood, A.M.E.I.C., pointed out that salmon packs could be estimated in advance by observation of river flood conditions during the spawning seasons. The occurrence of exceptional floods from mountain sources caused much inconvenience to city officials and improved methods of prediction would be of great assistance.

Steel Manufacture

L. R. Brereton, A.M.E.I.C., metallurgist at the Rolling Mills of the Dominion Bridge Company in Calgary, was the speaker at a meeting on Thursday, January 12th, 1933. He combined a general review of the history of iron and steel with a description of Calgary's latest industry.

Opening with early references to the use of iron and natural steel, he traced the series of inventions which culminated in the Bessemer and open hearth methods of making steel to conform to modern requirement and specifications for different purposes in construction and industry. Rapid tests and analyses are necessary to avoid delay or failure in preparing the molten metal for casting into moulds and although scientific knowledge has advanced enormously, the skill and judgment of the operator remains an important factor.

With electrical and other modern methods of smelting, the use of pig iron is no longer necessary, but the selection of steel scrap requires much experience to obtain good results. Ingots of from 60 to 600 pounds are numbered for reference to analyses and can be used for rolling as required. The process of annealing steel castings was explained by means of a diagram showing critical temperatures for different carbon contents. The speaker concluded with an invitation to inspect the various operations at the plant.

A vote of thanks was accorded on the motion of T. Lees, M.E.I.C., seconded by Major F. G. Bird, A.M.E.I.C.

In congratulating the author on his able presentation of the subject, the chairman, Lt.-Colonel F. M. Steel, M.E.I.C., mentioned his own early association with the steel industry in Monmouthshire. He referred particularly to the effect of coal fuel on the composition of the resultant product.

Kingston Branch

L. F. Grant, M.E.I.C., Secretary-Treasurer.

On January 12th, the members of the Kingston Branch had the privilege of listening to an address on welding by Mr. Frank McKibben, president of the American Welding Institute. The meeting, which was held in Ontario Hall, Queen's University, was attended by about sixty members and others.

Welding

In opening, Mr. McKibben surprised many of his audience by pointing out that the practice of welding metal was at least two thousand years old, and that the same can be claimed for rivetting. He then presented a very full and concise outline of the different methods and of welding, in modern use, with their variations. This was followed by diagrams illustrating the stresses in the weld, as developed in building construction, and a brief discussion of the mechanics involved.

The speaker next discussed the question of estimating for welded construction, and gave a complete cost analysis based on figures in a recently constructed building. This was followed by a number of interesting views of structures in which welding has been employed, close-up pictures of the actual connection being shown.

The large number of questions which Mr. McKibben was called upon to answer at the conclusion of his address, testified to the interest of his audience. A very hearty vote of thanks was moved by Wm. Casey, M.E.I.C., and seconded by Professor L. M. Arkley, M.E.I.C. of Queen's University.

Lethbridge Branch

E. A. Lawrence, S.E.I.C., Secretary-Treasurer.
R. B. McKenzie, S.E.I.C., Branch News Editor.

The regular dinner meeting of the Lethbridge Branch of The Institute was held at 6.30, December 10th, in the Marquis hotel. This was ladies night and also the last meeting before Christmas and a turkey dinner and special musical entertainment were enjoyed.

The feature of the evening was to have been a talk with motion pictures by Mr. Poole, of the Poole Construction Company, on a trip to Port Churchill with the Canadian Chamber of Commerce. Mr. Poole was unfortunately unable to be present but his talk was given by P. M. Sauder, M.E.I.C.

Mr. Sauder in his preliminary remarks said that the Hudson Bay Railway was started from The Pas in 1911 but after the building of three hundred and thirty miles of roads and the expenditure of some $6,000,000 at Port Nelson construction was stopped by the War. When work was recommenced in 1927, the question of terminal was reconsidered, and Port Churchill, rather than Port Nelson, chosen on expert advice.

Port Churchill is very interesting, historically, three forts were built there by the English and each destroyed by the French in 1688, 1718 and 1734 respectively. The last was a great stone fort known as Fort Prince of Wales and the remaining guns and walls may be seen there today.

The Hudson Bay route through Churchill enjoys many advantages chief among them being the shortening of total distance and the shortening of rail haul, from the grain producing areas of the West, to the Liverpool market. These points were well illustrated with figures and a quotation made from an article in McLeans magazine to show other advantages.

Mr. Poole's pictures were then shown. These started in The Pas, showed one of the large mines, then passed on to Churchill, not without stopping on the way however for a visit to "Diamond Lil," whose teeth are set with diamonds. At Churchill the grain elevator, the port, and so on were shown. A visit to the ruins of Fort Prince of Wales and some views of the new Prince Albert National Park completed the film.

Three other films were shown by the courtesy of the Canadian Pacific Railway Company. These were "A Cruise to the East" on the Empress ships, the Nipigon River fishing, and the "St. Lawrence Seaway." These very interesting pictures completed the evening, and the meeting closed with the singing of "God Save the King."

Ottawa Branch

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

Luncheon to G. J. Desbarats, C.M.G.

As a signal honour to G. J. Desbarats, C.M.G., B.Ap.Sc., M.E.I.C., who has recently retired from the high post of Deputy Minister of the Department of National Defence, a complimentary luncheon was tendered to him by the Ottawa Branch at the Chateau Laurier on Thursday noon, December 15th. The regard in which Mr. Desbarats was held was attested by the attendance of many high government officials and by the messages of good wishes read out at the luncheon from those who could not be present.

Hon. H. A. Stewart, Minister of Public Works, in a felicitous address, indicated his pleasure at the opportunity afforded him of expressing his appreciation of the long and faithful services of the guest of honour. He spoke about his associations with him as a member of the government service and characterized Mr. Desbarats as a charming gentleman, and a delightful companion and associate, whose dominating spirit was to serve faithfully, conscientiously and consistently. He joined with The Institute in extending his congratulations and good wishes to Mr. Desbarats and to Mrs. Desbarats with the hope that they would still have many years of good health spared to them so that they would have a long and happy evening of life.

F. H. Peters, M.E.I.C., Surveyor General of Canada, speaking more particularly on behalf of The Engineering Institute in place of The Institute President, Dr. Charles Camsell, M.E.I.C., who was unfortunately ill, traced over Mr. Desbarats' connection with that organization. He had, stated Mr. Peters, at all times been an outstanding member of The Institute and in fact was a member even before the local Ottawa

Branch was formed. Mr. Peters read out from letters of good wishes received on the occasion from the following: Hon. D. M. Sutherland, Hon. C. C. Ballantyne, Hon. J. L. Ralston, Sir Robert Borden, Hon. Rodolphe Lemieux, Hon. Geo. Graham, and Hon. E. M. MacDonald.

Mr. Desbarats, in rising to reply, was accorded prolonged applause. He stated that there was nothing he valued greater than the appreciation of his brother engineers and spoke about the happy relations that always existed between himself and the ministers under whom he served.

Mr. Desbarats, in reminiscent vein, then outlined his career from the time when he graduated at the age of eighteen from the Ecole Polytechnique and Laval University down to the present. In 1879 he entered the Department of Railways and Canals as assistant engineer connected with the construction of the Carillon canal, and later with the construction of the St. Anne's canal and the Lachine canal. He was assistant to the late John Page, chief engineer of Canals and was engaged in designing the present Canadian locks at the Soo, the Welland canal and the Soulanges canal. Between 1892 and 1896 he was an inspector of railway construction in British Columbia and coming east in 1896 became associated with Larkin and Sangster, later re-entering the government service, when he was engaged on a hydrographic survey of the St. Lawrence. Following this Mr. Desbarats was placed in charge of the government shipyard at Sorel during which, as he stated, he spent seven happy years.

Later he was appointed acting and then deputy minister of the Department of Marine and Fisheries, and in 1910 became deputy minister of Naval Service on the decision of the government to establish a Canadian navy. On the amalgamation of the naval, military and air forces of the Dominion Mr. Desbarats was made acting deputy minister of Militia and Defence and in 1923 became deputy minister of National Defence.

Mr. Desbarats interspersed in the narration of his career, accounts of most interesting incidents that took place, revealing some of the difficulties with which a young engineer in his upward climb had to contend.

In concluding his address he handed down a word of advice to the young engineer of today. That was to cultivate enthusiasm for his profession and to attack it at all times with his greatest power and vim. The young engineer should qualify himself, he stated, thoroughly for his work, and treat whatever he is called upon to do as a pleasure rather than as a task. He should familiarize himself with the experiences of others through extensive reading and otherwise, and steep himself in the essential knowledge for the proper carrying on of all classes of his work.

After a lifetime spent in the pursuit of the engineering profession, some of his happiest recollections, he stated, lay in the accomplishment of what lay before him and in the pleasant intercourse that he had had with his fellow engineers and others associated with them. It was this sort of thing that makes life worth living, concluded Mr. Desbarats.

C. McL. Pitts, A.M.E.I.C., local chairman, presided. Head table guests included: Col. Bogart, Commander C. P. Edwards, A.M.E.I.C., G. H. Desbarats, Jr.E.I.C., Group Captain Lindsay Gordon, W. A. Found, G. J. Desbarats, C.M.G., M.E.I.C., F. H. Peters, M.E.I.C., Sir Charles Kingsmill, Hon. H. A. Stewart, Brig. A. C. Caldwell, Alex. Johnson, L. Cote, K.C., M.P., A. B. Lambe, A.M.E.I.C.

Peterborough Branch

W. F. Auld, Jr.E.I.C., Secretary.
W. T. Fanjoy, Jr.E.I.C., Branch News Editor.

Erecting Steel Buildings and Strengthening Steel Bridges by Welding

"There is no new thing under the sun," stated Frank P. McKibben, president of the American Welding Society, quoting from the first chapter of Ecclesiastes at the outset of his address to members of the local Branch of The Engineering Institute of Canada and their guests, on the subject of "Erecting Steel Buildings and Strengthening Steel Bridges by Welding," at Paragon Hall, Tuesday evening, January 10th.

In proof of his contention, Mr. McKibben showed as the first of a series of interesting lantern slides the pictures of a bath tub now in the Field Museum at Chicago.

The tub, it is claimed, was excavated from the ruins of a Roman palace and dates back over nineteen hundred years. Made of five pieces of bronze, it is welded together, and all the joints are still safe and sound. In addition, it has two lions' heads as ornaments riveted into the side, the rivets being the same in pattern as those in modern-day use.

The speaker, whose visit had been arranged by A. B. Gates, A.M.E.I.C., and whose Canadian itinerary included a visit to the Toronto, Kingston and Ottawa Branches, was introduced to the gathering by H. B. Hanna, A.M.E.I.C., plant engineer at the Peterborough Works of the Canadian General Electric Company. It is interesting to note that Mr. Hanna supervised construction of the new arc-welded switchboard building at the plant, which is the only completed building of its kind in the Dominion.

B. Ottewell, A.M.E.I.C., president of the Branch, presided, and at the conclusion of the very interesting and enlightening address, threw the meeting open for discussion.

During the course of his address proper, Mr. McKibben spoke of the three important kinds of welds as being (1) the chemical process, (2) gas welding and (3) electric welding.

Ninety-nine percent of all the welded bridges and buildings in the United States were welded by the arc-welding method, which was a good, fast and cheap means of fabricating such structures.

He prophesied that with a return to normal trade conditions, the demand for arc-welded structures would largely increase, and that cities which did not now allow buildings to be fabricated by welding would make provision in their building codes or by-laws for this increasingly popular type of building. Elimination of noise, such as was unavoidable in the riveted steel structure, was one of the main features of the electric welding method of building. It was a feature of prime importance where building was done in the vicinity of hospitals or office and hotel blocks.

A large number of slides were shown and included one of the Dallas Power and Light Company's welded steel structure, which ranked as the highest structure of its kind yet built.

Saskatchewan Branch

Stewart Young, A.M.E.I.C., Secretary-Treasurer.

The regular meeting of the Branch was held in the Hotel Champlain, Regina, on Friday evening, December 16th, 1932, being preceded by the usual dinner at which there were twenty-four guests and members.

Immediately following the dinner J. D. Peters, A.M.E.I.C., chairman, introduced several visitors, including J. J. Smith, Deputy Minister of Municipal Affairs, Murdo Cameron, chairman, Saskatchewan Assessment Commission, E. Dickinson and E. L. Paterson, A.M.E.I.C., after which the meeting proceeded with the business of the evening.

J. J. White, A.M.E.I.C., reported for the Papers and Library committee, stating that arrangements were being made for a meeting on Friday evening, January 20th. On discussion it was unanimously decided, on motion of A. P. Linton, A.M.E.I.C., seconded by J. N. DeStein, that Friday evening, January 20th, be Ladies' Night.

The Secretary reported for the executive committee, advising the meeting of the growing opposition in several Branches of The Institute to the proposed changes in the constitution and by-laws as the same appeared in the October issue of The Journal. He stated further that at a meeting of the executive held in Regina on November 4th, 1932, the executive had decided that:

1. Any increase in the fees of the present associate members, due to a re-classification, would have a tendency to cause many such members to drop their membership.
2. The Institute will be of increasing value to engineers at large as it co-ordinates its activities with the activities of the several associations of professional engineers.
3. On account of the expense to the individual in supporting two separate organizations, there will be a tendency to withdraw from one and inasmuch as membership in the Professional Associations is obligatory, The Institute automatically will suffer.

P. C. Perry, A.M.E.I.C., informed the meeting of the nature of the opposition.

With respect to the recent passing of past-chairman J. R. C. Macredie, the Secretary was instructed by resolution, moved by R. N. Blackburn, M.E.I.C., seconded by P. C. Perry, and passed unanimously, to convey to Mrs. Macredie the sincere sympathy of the Branch.

There being no further business, S. Young, A.M.E.I.C., presented his paper on the "Taxation of Land."

After pointing out that there were great sources of untapped revenue, the speaker produced evidence showing that in the field of municipal taxation land was being overburdened and suggested the desirability of concerted action by municipal authorities looking towards a thorough investigation of the possibilities for enlarging the basis of municipal taxation.

Those contributing to the discussion were J. N. DeStein, Murdo Cameron, L. A. Thornton, M.E.I.C., and J. J. Smith.

Economic Aspects of Professional Papers

Engineers must be dollar-conscious—their work demands it. For in the end, almost everything they do is going to measured by a financial as well as a professional yardstick. Engineers become thus doubly practical and doubly materialistic, for they must serve the dictates of both physical and economic laws.

This economic or financial aspect of engineering problems adds interest as well as hazard to the work of engineers, it should therefore be given proper consideration and authors should not feel that it is out of place in papers and addresses in which they describe their work to fellow-engineers and laymen. No plea is made here for a commercialism expressed in terms that advertise a private interest before a professional body. Professional-society papers must not be lowered to such standards. But interest, as well as value, is added to a paper in which some attention is paid to the economic considerations and advantages that may be an important factor in the subject discussed. The dollars of saving involved speak with a louder voice and to a broader audience than does a fractional increase in theoretical efficiency. The economic consequences of a new or improved design are more potent factors in securing its adoption than the novelty and ingenuity of the mathematical analysis or experimental investigation upon which the design is based. As practical men, engineers should recognize the interest that others have in these important and practical aspects of their work.—*Mechanical Engineering.*

Preliminary Notice

of Applications for Admission and for Transfer

January 19th, 1933

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 March, 1933.

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

COGDELL—HERBERT, of 105 Quinn Blvd., Longueuil, Que., Born at Liverpool, England, Nov. 21st, 1886; Educ., 1901-06, Liverpool Technical School; Engrg. courses, Royal Navy, under Admiralty instructors; 1903-06, apprenticeship; 1907-14, marine engr., Messrs. T. & J. Harrison, Liverpool; 1914-19, on active service with the Royal Navy, as Engr. Sub.-Lieut. and Engr. Lieut.; 1920-24, chief engr., Canada Paper Co., Windsor Mills, Que.; 1925-28, mech'l. and elect'l. engr., Cerveceria de Maracaibo, charge of all design, constrn. and operation; 1929 to date, engr., National Supply Co. Ltd., Montreal. Charge of design, constrn. and installn., and operation of oil burning installations for power houses.

References: F. A. Combe, E. A. Ryan, J. T. Farmer, F. S. B. Heward, H. G. Thompson.

CROUCH—MILTON EDWIN, 81 Brock St., Kingston, Ont., Born at Rochester, N.Y., Dec. 10th, 1886; Educ., Grad. S.P.S., Univ. of Toronto, 1911; O.L.S., D.L.S.; 1906-08, waterworks dept., 1908-11, city engr's. staff, City of Rochester, N.Y.; 1911-13, field chief, Lang & Ross, Sault Ste Marie, Ont.; 1913-15, charge of resurvey; City of Port Arthur, Ont.; 1915-22, private practice, mostly on govt. surveys, Nipigon, Ont.; 1919-22, town engr.; Nipigon, Ont.; 1922-25, mgr., Porcupine Pulp and Lumber Co., Hoyle, Ont.; 1925-28, town engr., Millburn, N.J.; 1925-28, town engr., Maplewood, N.J.; 1928-32, mgr., Morristown, N.J., branch office of Grassmann & Kreh, Civil Engrs.; at present in private practice as civil engr., Dominion and Ontario Land Surveyor, associated with George C. Wright, C.E., Kingston, Ont.

References: A. G. MacLachlan, L. F. Goodwin, W. L. Malcolm, D. S. Ellis, J. L. Lang, K. G. Ross, L. T. Rutledge.

KINGHORN—ANDREW A., of Toronto, Ont., Born at Toronto, Jan. 2nd, 1884; Educ., Grad. S.P.S., Univ. of Toronto. 1907. B.A.Sc., 1908; Summer work, dftsman., structl. dept., Canada Foundry, Toronto; 1905, chainman, D.L.S.; 1906, asst. to city engr., testing of materials, Toronto; 1907-09, inspr. of roadways, City of Toronto; 1908-09, demonstrator, Fac. of App. Sci., Univ. of Toronto; 1910-11, asst. engr., charge of contract work, 1912, supt. of constrn. day labour work, City of Toronto; 1917, inspecting engr., for Ontario Dept. of Highways, Toronto-Hamilton Highway; 1913-30, president and manager, Asphaltic Concrete Co. Ltd.; 1930-33, vice-president, Redfern Construction Co. Ltd.; 1931-33, president and manager, Kinghorn Construction Co. Ltd., Excelsior Life Bldg., Toronto, Ont.

References: A. J. Grant, G. G. Powell, T. H. Hogg, C. R. Young, C. R. Redfern, J. R. W. Ambrose.

TOOVEY—THOMAS WILLIAM, of Port Alice, B.C., Born at Ovington, North'd., England, Sept. 21st. 1899; Educ., Rutherford and Armstrong Colleges, 1914-20; Reg'd. chem. engr., Prov. B.C. 1930 after passing examination; 1914-17, ap'ticeship in chemical and metallurgical labs., Messrs. Sir W. G. Armstrong Whitworth & Co., Elswick Works, Newcastle-on-Tyne; 1919-21, research, metallurgical lab. and in charge of experimental iron foundry; 1923-28, in charge of practical work, equipment and men in one divn. of the research dept., Canadian International Pulp & Paper Co. Ltd., Hawkesbury, Ont.; 1928 to date, chemical engr., British Columbia Pulp & Paper Co., Port Alice, B.C.

References: W. L. Ketchen, S. Wang, C. C. Ryan, E. A. Wheatley, B. Grav.

TYSON—ALBERT EDMUND, of 27 Indian Road, Toronto, Ont., Born at Wiarton, Ont., May 6th, 1901; Educ., B.A.Sc., Univ. of Toronto, 1931; 1922-23, mgr. of sawmill, Geddes-Ryson Lumber Co.; 1923-24, contractor, logging and milling, Algoma Lumber Co.; 1925 (summer), rafting bass, Whicher Lumber Co.; 1931 to date, engr. in charge of plant erection for G. W. Rayner, M.E.I.C., Toronto, Ont.

References: G. W. Rayner, J. R. Cockburn, T. R. Loudon, C. R. Young, E. A. Allcut, A. D. LePan, C. H. Mitchell, W. S. Wilson, J. J. Spence, W. B. Dunbar, W. J. Smither.

FOR TRANSFER FROM THE CLASS OF ASSOCIATE MEMBER TO THAT OF MEMBER

ROSS—ROSS, Donald deCourcy, of 123 Adolphus St., Cornwall, Ont., Born at Montreal, June 23rd, 1896; Educ., B.Sc. (Mech.), McGill Univ., 1917; Passed exams. for rank of Engr. Sub.-Lieut., R.C.N., Halifax; 1917-18, mate engr., R.N.C.V.R., Second Engr. Officer, A.P.S. "Hochelaga" and H.M.C.S. "Rainbow"; 1918-19, Engr. Sub.-Lieut., R.C.N., Second Engr. Officer, H.M.C.S. "Niobe," and in charge of all engine room instructional work, H.M.C. Dockyard, Halifax; 1919-20, instructor in steam power plant engrg., Central Technical School, Toronto, D.S.C.R.; 1920-22, planning dept., 1922-25, asst. mech. supt., Dominion Rubber Co.; 1925 to date, with Howard Smith Paper Mills Ltd., as follows: 1925-27, combustion engr., Cornwall Divn., 1927-28, asst. to mill mgr., Cornwall Divn., 1928-29. production engr., Cornwall Divn., 1929-31, chief industrial engr., and from February 1931 to date, chief industrial engr., of main company and all subsidiary companies. (*S. 1916, Jr. 1918, A.M. 1921.*)

References: M. B. Watson, H. E. Meadd, V. W. MacIsaac, W. G. Scott, A. R. Roberts, C. M. McKergow, H. L. Johnston.

FOR TRANSFER FROM THE CLASS OF JUNIOR

CREGEEN—KENNETH THOMAS, of Montreal, Que., Born at Montreal, Dec. 31st, 1898; Educ., B.Sc., McGill Univ., 1923; 1922 (May-Oct.), elect'l. dist. dept., Montreal Light Heat & Power Cons.; 1923-24, bldg. operation and plant mtce., and from 1924 to date, in charge of bldg. operation and plant as res. engr., Sun Life Assurance Company of Canada, Head Office Bldg., Montreal, Que. (*S. 1921, Jr. 1927*)

References: E. A. Ryan, F. A. Combe, A. J. C. Paine, C. V. Christie, G. A. Wallace, C. K. McLeod.

CROSS—GEORGE ESPLIN, of 434 Clarke Ave., Westmount, Que., Born at Westmount, March 14th, 1899; Educ., McGill Univ., B.Sc., 1923; 1926-29, struct'l. steel dftsman., Dominion Bridge Company; 1923-26, with Geo. W. Reed & Co. Ltd., charge of estimating doors and windows, preparation of shop drawings, roofing, asphalt floors, and misc. steel work; 1926-31, struct'l. design dept., Dominion Bridge Company, design of transmission towers and misc. struct'l. steel work, estimates of bridges, bldg. steel, etc.; at present, lecturer in mech'l. drawing and geometry, Montreal Technical School, Montreal, Que. (*S. 1921, Jr. 1928.*)

References: D. C. Tennant, N. Cageorge, J. C. Longstaff, J. Weir, A. Peden.

LLOYD—DAVID S., of Toronto, Ont., Born at Winnipeg, Man., Oct. 5th, 1903; Educ., B.A.Sc., Univ. of Toronto, 1925; 1918-19, Marconi wireless operator; 1920 (4 mos.), ap'tice armature winder, Algoma Steel Corpn.; 1920-21 (11 mos.), electn's helper, power house constrn.; 1922 (4 mos.), clerk and timekpr., road constrn., Dept. Northern Development; 1922 (1 mos.), rodman, Ross & Lang, Ltd., Sault Ste Marie; 1923-4-5 (part time 6 mos.), dftsman., G. L. Ramsay, O.L.S.; 1923-4-5 (8½ mos.), steel inspr., R. W. Hunt Co., Sault Ste Marie, Ont.; 1924-25 (7 mos.), asst. engr., Dept. Northern Development, bridge and road constrn., Sault Ste Marie, Ont.; 1925-26, salesman, and 1926 to date, service engr., Dominion Oxygen Co. Ltd., mfrs. and distributors of compressed gases and equipment—in charge of engrg. service dept., field development of new gas welding and cutting processes, design and supervision of gas piping installns., generators, etc. (*S. 1923, Jr. 1928.*)

References: J. L. Lang, T. R. Loudon, R. E. Smythies, C. M. Pitts, C. H. L. Jones, J. W. LeB. Ross, K. G. Ross, R. A. Campbell.

MILLS—CHARLES PERKINS, of Barcelona, Spain., Born at Ottawa, Ont., March 19th, 1899; Educ., B.Sc. (E.E.), McGill Univ., 1923; 1923-24, student engr., statistics dept., Stone & Webster Inc., Boston, Mass.; 1924-25, secretary to gen. mgr., Columbus Electric & Power Co. of Columbus, Georgia, operated by Stone & Webster; 1925-26, industrial engr. with above company, investigation of elect'l. and gas rates and new properties cost analysis; 1926-29, sales mgr., South Georgia Power Company, organization and direction of New Business Dept., including merchandise sales dept., and industrial power sales; 1929-30, power sales engr., Columbus Divn., Georgia Power Company; June 1930 to date, industrial engr., Ebro Irrigation and Power Company, Barcelona, Spain. (*S. 1921, Jr. 1927.*)

References: G. H. Rochester, L. B. Rochester, E. Brown, C. G. Porter, A. N. Scott, N. E. D. Sheppard, H. G. Rose.

FOR TRANSFER FROM THE CLASS OF STUDENT

WILLIAMS—RICHARD LOUIS, of 159-24th Ave., Lachine, Que., Born at Redcar, Yorks, England, Nov. 6th, 1902; Educ., B.Sc., McGill Univ., 1931; with Dominion Bridge Company, Montreal, as follows: 1918-22, machinist ap'tice; 1922-26, and summers 1927 to 1930, dftsman.; 1931 (June-Sept.), mech. inspr.; 1931 to June 1932, time study observer. (*S. 1930*)

References: A. Peden, A. H. Munson, C. M. McKergow, R. M. Herbison, F. Newell, E. Brown, D. C. Tennant.

Grit Emission From Power-Station Chimneys

In June, 1930, the Electricity Commissioners appointed a committee, to report upon the measures which had been taken to obviate the emission of grit from power-station chimneys. A technical sub-committee paid a number of visits to plants in Great Britain, Germany and France, besides taking a good deal of evidence, both at home and abroad. The result has been the collection of a mass of useful information and comment as well as a number of pertinent recommendations, all of which are well worth study by those concerned.

Statistics show that grit-extraction plants are installed in 60 selected stations in this country, "cyclones" being used in 53 cases, a combination of cyclones and washing in four, washing alone in two, and electrostatic apparatus in one. In 51 stations no plant is installed. Seventeen, or 14 per cent of the stations used pulverised fuel, and 14, or 81 per cent of these employ extraction plant. Of the 94 stoker-fired stations only 46 or 51 per cent are thus equipped. In the Continental stations washing was more popular than cyclones, possibly due to the fact that many of them were generating power for chemical or other works and that settling tanks for use in connection with gas washing were available. German opinion favours the electrostatic system, and special attention is called to the installation at the Leipzig Nord station.

The concentration of grit in flue gases is governed by the method and rate of combustion, the design of the boilers and flues, and the nature, characteristics, size, and ash content of the fuel. It is a minimum when stokers and low gas velocities are used, and a maximum when pulverised fuel with a high ash content is employed. It could be reduced by burning a fuel of low ash content, though this might not be possible with the stokers in common use. A difficulty, which arises in dealing with it, is the absence of a reliable grading test for the dust, and especially of the particles, which are smaller than 43 microns. Grading by sieves is unsatisfactory, as they are unreliable for small sizes; besides, it is the specific gravity of the particles rather than their size which should be measured. On the other hand, the air elutriator most nearly reproduces the conditions in the chimney and forms a simple means of assessing the performance of the extraction plant. In this connection it is desirable that some unit should be evolved for grading dust in terms of its rate of fall in still air rather than its diameter. Tests show that 50 per cent of the particles in flue gas are less than 20 microns in diameter, i.e., they are fumes rather than dust. They settle very slowly, even in still air, and if they can be discharged into an upward air stream they will be sufficiently diffused not to cause a nuisance. The extraction plant should therefore be designed to eliminate all the larger particles and such a proportion of the smaller that its overall efficiency is not less than 85 per cent. This is possible with electrostatic separators. The emissions will then cause no nuisance if they are discharged into an air stream, which will not come to earth, a condition which depends on the height of the chimney. An examination of the various factors involved shows that this height should be at least 2½ times that of the surrounding buildings with, if necessary, an addition to compensate for the adjacent contours. The position may be modified when the load is increased or the soot-blowers are used.—*Engineering.*

Street Lighting with Sodium Lamps

The installation of a number of sodium lamps for lighting a section of the Croydon by-pass road is an interesting development of the use of a comparatively new source of illumination. The lamp is of the gas discharge type and consists essentially of a cylindrical bulb containing a rare gas and a small quantity of metallic sodium. In the centre of this bulb is a cathode consisting of a filament, with an anode on each side of it. The cathode is supplied with alternating current from a small transformer, which is incorporated in the fitting, while the anodes are fed with direct-current from a separate rectifier, which is connected to the existing three-phase current system. The lamps are arranged in groups of 30, the anodes of those in each group being connected in series. Lighting up is effected by passing a current through the cathode, so that it begins to glow. A voltage is then applied to the anodes, so that a discharge takes place from them to the cathode through the rare gas. The heat developed by this discharge raises the temperature inside the bulb sufficiently to vaporize the sodium, so that an orange-yellow monochromatic light is emitted, the effect of which is to produce extraordinary visual acuity in the observer, owing to the eye receiving only one sharply defined image of a single colour. Colour differences are, in fact, suppressed completely, only light-dark contrasts being perceived. This is not considered a disadvantage, since with the usual low intensity of an artificially-lighted road the eye is almost insensitive to colour. The result is that it has been found possible to read a letter E measuring 16 inches by 16 inches by 3 inches at a distance of 550 yards, a visibility which is equal to that obtained in the most favourable daylight conditions. Moreover, the sodium lamp only requires 100 watts to produce 5,000 lumens compared with the 300 watts necessary to produce the same result from a gas-filled lamp. The lamps are arranged on the staggered system on each side of the road, asymmetric fittings being used so that the forward distribution is from 75 degrees to 80 degrees to the vertical and the backward about 25 degrees. Messrs. Philips Lamps, Limited, 145 Charing Cross road, London, W.C. 2, carried out the work.—*Engineering.*

Engineering Progress in 1933 Motor Cars

Features in the new model Canadian and American cars tend towards simplification and greater ease of control in both passenger and commercial vehicles.

In engine design the White 12-cylinder, horizontal, engine for bus work and the Duesenberg super-charged engine are noteworthy. Other details are hydraulic valve lifters introduced by Pierce-Arrow, the centre of gravity adjustment of connecting rods for Pontiac, and the Bendix Stromberg carbureter automatic choke and fast idle which is being used on a number of cars. The manual heat control of the intake hot spot is also being supplanted by a thermostat in many cars, and sponsored by Delco-Remy, advances have been made in starter-operating mechanisms. The Bendix clutch has been redesigned and to it has been added a pendulum, clutch control, cushion valve. Design changes have also been made in transmissions such as the shifting of a helical gear on a helical spline; spindle bearings in the transmission, universal joints and steering gear; and the reintroduction of the worm drive axle by Pierce-Arrow.

In wheels the tendency is towards a smaller size and a development by Motor Wheel is that of an artillery type steel spoke wheel. Forerunners in power steering for the heavier commercial vehicles are seen in the White city bus and the Mack street car type, which have hydraulic boosters.

New body features include fender valances, concave rear body panels and the Fisher No-Draft ventilation system for sedans and limousines and the rain-proof cowl ventilator.

The chief metallurgical accomplishments are the Waukesha cylinder alloy iron of which engines are built, developed by the Waukesha Motor Company, and Proferall, an electric furnace cast iron alloy used for camshafts and developed by the Campbell, Wyant and Campbell Foundry Company.—*Abridged from S.A.E. Journal.*

Toronto Building By-law

A joint committee has been formed consisting of representatives of the Toronto chapter of the Ontario Association of Architects, Toronto Branch of The Engineering Institute of Canada, Toronto Board of Trade, Canadian Manufacturers' Association, Toronto Industrial Commission, General Contractors' Association of Toronto, Building Owners' and Managers' Association of Ontario and the Department of the Commissioner of Buildings, city of Toronto, to consider a complete revision of the building by-laws of the city of Toronto.

This committee has obtained the co-operation of other bodies and individuals to act on the various sub-committees which are dealing with parts of the by-law.

The general intention is to make a very thorough study of the Toronto building by-law and also the building codes of other cities and to develop for Toronto a by-law which will be complete, convenient for reference and will permit advantage to be taken of the development in the art of construction since the last thorough revision was made.

Constructive suggestions for points worthy of consideration will be gladly received by the committee and should be addressed either to Mr. L. A. Lee, c/o Commissioner of Buildings, City Hall, Toronto, or Mr. J. Morrow Oxley, M.E.I.C., 372 Bay Street, Toronto.

The Barrett Co. Ltd. have recently published an attractive 64-page "Architect's and Engineer's Reference Manual," containing specifications and detailed drawings treating of the following: Built-up Roofing—for flat roof decks and for steep roof decks, Roof flashing, Roof drainage, and Waterproofing.

This data is presented in five sections, under the above headings, and comprises the most practical methods and procedures, based on 75 years of the company's experience.

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All correspondence should be addressed to

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

Situation Vacant

SALESMAN OF INDUSTRIAL ENGINEERING SERVICES. Only a man with demonstrated selling ability will be considered. Liberal commission paid based on fees received. Location Montreal. Apply to Box No. 902-V.

Situations Wanted

MECHANICAL ENGINEER, Canadian, with tecbnical training and executive experience in both Canadian and American industries, particularly plant layout, equipment, planning and production control methods, is open for employment with company desirous of improving manufacturing methods, lowering costs and preparing for business expansion. Apply to Box No. 35-W.

YOUNG ENGINEER, B.A., B.SC., A.M.E.I.C., R.P.E., Ont. Competent draughtsman and surveyor. Eight years experience including design, superintendence and layout of pulp and paper mills, hydro-electric projects and general construction. Limited experience in mechanical design and industrial plant maintenance. Apply to Box No. 150-W.

PURCHASING ENGINEER, graduate mechanical engineer, Canadian, married, 34 years of age, with 13 years' experience in the industrial field, including design, construction and operation, 8 years of which had to do with the development of specifications and ordering of equipment and materials for plant extensions and maintenance; one year engaged on sale of surplus construction equipment. Full details upon request. Apply to Box No. 161-W.

CIVIL ENGINEER, age 44, open for employment anywhere, experience covers about 20 years' active work, including 7 years at municipal engineering, 2 years as Town Manager, 3 years at railway construction, 3 years on the staff of a provincial highway department, 2 years as contractor's superintendent on pavement construction. Apply to Box No. 216-W.

REINFORCED CONCRETE ENGINEER, B.SC., P.E.Q., eight years experience in construction design of industrial buildings, office buildings, apartment houses, etc. Age 30. Married. Apply to Box No. 257-W.

MECHANICAL ENGINEER, B.SC., McGill 1919, A.M.E.I.C., P.E.Q., 12 years experience oil refinery and power plant design, factory maintenance, steam generation and distribution problems, heating and ventilation, etc. Available at once. Location immaterial. Apply to Box No. 265-W.

ELECTRICAL ENGINEER, B.SC., '28, Canadian. Age 25. Experience includes two summers with power company; thirteen montbs test course with C.G.E. Co.; telephone engineering, and the past thirty months with a large power company in operation and maintenance engineering. Location immaterial and available immediately. Sales or industrial engineering desirable. Apply to Box No. 266-W.

ELECTRICAL ENGINEER, B.SC., A.M.E.I.C., AM.A I.E.E., age 30, single. Eight years experience H.E. and steam power plants, substations, etc., shop layouts, steel and concrete design. Location immaterial. Available immediately. Apply to Box No. 435-W.

CIVIL ENGINEER, B.A.SC., A.M.E.I.C., JR.A.S.C.E., age 28, married. Experience: construction, design, cost estimating on hydroelectric and storage work, also railway. Desires work in engineering, industrial or commercial fields. Available at once. Apply to Box No. 447-W.

CIVIL ENGINEER, B.SC., A.M.E.I.C., with six years experience in paper mill and hydro-electric work, desires position in western Canada. Capable of handling reinforced concrete and steel design, paper mill equipment and piping layout, estimates, field surveys, or acting as resident engineer on construction. Now on west coast and available at once. Apply to Box No. 482-W.

Situations Wanted

MECHANICAL ENGINEER, B.SC. Age 28, married. Four and a half years on industrial plant maintenance and construction, including shop production work and pulp and paper mill control. Also two and a half years on structural steel and reinforced concrete design. Located in Toronto. Available at once. Apply to Box No. 521-W.

CIVIL ENGINEER, Canadian, married, twenty-five years' technical and executive experience, specialized knowledge of industrial housing problems and the administration of industrial towns, also town planning and municipal engineering, desires new connection. Available on reasonable notice. Personal interview sought. Apply to Box No. 544-W.

ELECTRICAL ENGINEER, A.M.E.I.C., University graduate 1924. Experience includes one year test course and five years on design of induction motors with large manufacturer of electrical apparatus. Four summers as instrumentman on highway construction. Several years experience in accounting previous to attending university. Available at once. Apply to Box No. 564-W.

MECHANICAL ENGINEER, A.M.E.I.C., with twenty years experience on mechanical and structural design, desires connection. Available at once. Apply to Box No. 571-W.

MECHANICAL ENGINEER, B.A.SC., '30, desires position to gain experience, and wbich offers opportunity for advancement. Experience in pulp and paper mill and one year in mechanical department of large electrical company. Location immaterial. Available immediately Apply to Box No. 577-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.

MECHANICAL ENGINEER, Canadian, technically trained; eighteen years experience as foreman, superintendent and engineer in manufacturing, repair work of all kinds, maintenance and special machinery building. Location immaterial. Available at once. Apply to Box No. 601-W.

CHEMICAL ENGINEER, S.E.I.C., B.SC., University of Alberta, '30. Six seasons' practical laboratory experience, three as chief chemist and three as assistant chemist in chemical plant; one year's p.g. work in physical cbemistry; three years' experience teaching. Desires position in any industry with chemical control. Age 31. Single. Available immediately. Apply to Box No. 609-W.

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

CIVIL ENGINEER, A.M.E.I.C., R.P.E., Ontario; three years construction engineer on industrial plants; fourteen years in charge of construction of hydraulic power developments, tower lines, sub-stations, etc.; four years as executive in charge of construction and development of harbours, including railways, docks, warehouses, hydraulic dredging, land reclamation, etc. Apply to Box No. 647-W.

MECHANICAL ENGINEER, A.M.E.I.C., Canadian, technically trained; six years drawing office. Office experience, including general design and plant layout. Also two years general shop work, including machine, pattern and foundry experience, desires position with industrial firm in capacity of production engineer or estimator. Available on short notice. Apply to Box No. 676-W.

Situations Wanted

ELECTRICAL ENGINEER, B.SC., '29, JR.E.I.C. Age 26. Undergraduate experience in surveying and concrete foundations; also four months with Canadian General Electric Co. Thirty-three months in engineering office of a large electrical manufacturing company since graduation. Good experience in layouts, switching diagrams, specifications and pricing. Best of references. Available immediately. Apply to Box No. 693-W.

MECHANICAL ENGINEER, B.SC., '27, JR.E.I.C. Four years maintenance of high speed Diesel engines units, 200 to 1,300 h.p. Also maintenance of D.C. and A.C. electrical systems and macbinery. Draughting experience. Westinghouse apprenticeship course. Practical mechanical and electrical engineer with a special study of high speed Diesel engine design, application and operation. Location in western or eastern Canada immaterial. At present in Montreal. Apply to Box No. 703-W.

COMBUSTION ENGINEER, R.P.E., Manitoba, A.M.E.I.C. Wide experience witb all classes of fuels. Expert designer and draughtsman on modern steam power plants. Experienced in publicity work. Well known throughout the west. Location, Winnipeg or the west. Available at once. Apply to Box No. 713-W.

YOUNG ENGINEER, B.A.SC., (Univ. Toronto '27), JR.E.I.C. Four years practical experience, buildings, bridges, roadways, as inspector and instrumentman. Available at once. Present location, Montreal. Apply to Box No. 714-W.

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

MECHANICAL ENGINEER, age 41, married. Eleven years designing experience with project of outstanding magnitude. Machinery layouts, checking, estimating and inspecting. Twelve years previous engineering, including draughting, machine shop and two years chemical laboratory. Highest references. Apply to Box No. 723-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.

DESIGNING ENGINEER, M.SC. (McGill Univ.), D.L.S., A.M.E.I.C., P.E.Q. Experience in design and construction of water power plants, transmission lines, field investigations of storage, hydraulic calculations and reports. Also paper mill construction, railways, highways, and in design and construction of bridges and buildings. Available at once. Apply to Box No. 729-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.

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

ELECTRICAL AND RADIO ENGINEER, B.SC. '31, S.E.I.C. Age 25. Nine months experience on installation of power and lighting equipment. Eight months on extensive survey layouts. Two summers installing telephone equipment. Specialized in radio servicing and merchandising. Available at once. Location immaterial. Apply to Box No. 740-W.

CIVIL ENGINEER, graduate '2). Married. One year building construction, one year bydro-electric construction in South America, fourteen months resident engineer on road construction. Working knowledge of Spanisb. Apply to Box No. 744-W.

SALES ENGINEER, B.SC., McGill, 1923, A.M.E.I.C. Age 33. Married. Extensive experience in building construction. Tboroughly familiar witb steel building products; last five years in cbarge of structural and reinforcing steel sales for company in New York state. Available at once. Located in Canada. Apply to Box No. 749-W.

Situations Wanted

DESIGNING ENGINEER, graduate Univ. Toronto '26. Thoroughly experienced in the design of a broad range of structures, desires responsible position. Apply to Box No. 761-W.

MECHANICAL ENGINEER, graduate, '23, A.M.E.I.C., P.E.Q., age 32, married. (English and French.) Two years shop, foundry and draughting experience; one year mechanical supt. on construction; six years designing draughtsman in consulting engineers' offices (mechanical equipment of buildings, heating, sanitation, ventilation, power plant equipment, etc.). Present location Montreal. Available immediately. Montreal or Toronto preferred. Apply to Box No. 766-W.

CIVIL ENGINEER, S.E.I.C., B.Sc. Queen's Univ. '29. Three years experience as construction supt. and estimator for contracting firm. Experience includes general building, bridges, sewer work, concrete, boiler settings, sand blasting of bridges and spray painting. Age 25. Married. Available at once. Apply to Box No. 767-W.

WORKS ENGINEER, A.M.E.I.C. Twenty-four years experience, responsible for the design and building of extensions to mill buildings, specifying and installing of equipment and maintenance of plant of large manufacturing company. Good references. Will take position abroad. Apply to Box No. 768-W.

ELECTRICAL ENGINEER, B.Sc. (McGill Univ. '29), S.E.I.C. Married. Experience in pulp and paper mill mechanical maintenance, estimates and costs and machine shop practice. Desires position with industrial or manufacturing concern. Location immaterial. Available on short notice. References. Apply to Box No. 770-W.

ELECTRICAL ENGINEER, Queen's Univ. '24, JR.E.I.C., age 32, married. Experience includes, student Test Course, Can. Gen. Elec. Co., four years dial system telephone engineering with large manufacturing company. Available at once. Apply to Box No. 772-W.

CIVIL ENGINEER, B.Sc., '25, JR.E.I.C., P.E.Q., married. Desires position, preferably with construction firm. Experience includes railway, monument and mill building construction. Available immediately. Apply to Box No. 780-W.

DRAUGHTSMAN, experience in civil engineering, forestry engineering, land surveying and house construction. Good references. Apply to Box No. 781-W.

SALES REPRESENTATIVE. Electrical engineer with ten years experience in power field interested in representing established firm for electrical or mechanical product in Montreal territory. Excellent connections. Apply to Box No. 795-W.

CIVIL ENGINEER, S.E.I.C., graduate '30, age 23, single. Experience includes mining surveys, assistant on highway location and construction, and assistant on large construction work. Steel and concrete layout and design. Apply to Box No. 809-W.

CIVIL ENGINEER, college graduate, age 27, single. Experience includes surveying, draughting concrete construction and design, street paving both asphalt and concrete. Available at once; will consider anything and go anywhere. Apply to Box No. 816-W.

CIVIL ENGINEER, B.E. (Sask. Univ. '32), S.E.I.C. Single. Experience in city street improvements; sewer and water extensions. Good draughtsman. References. Available at once. Location immaterial. Apply to Box No. 818-W.

CIVIL ENGINEER, S.E.I.C., B.Sc. (Queen's '32), age 21. Three summers surveying in northern Quebec. Interested in hydraulics and reinforced concrete. Available at once. Location immaterial. Apply to Box No. 822-W.

Situations Wanted

CIVIL ENGINEER, B.Sc., A.M.E.I.C., with fifteen years experience mostly in pulp and paper mill work, reinforced concrete and structural steel design, field surveys, layout of mechanical equipment, piping. Available at once. Apply to Box No. 825-W.

ELECTRICAL ENGINEER, S.E.I.C., grad. '29, age 24, married; experience includes one year Students Test Course, sixteen months in distribution transformer design and eight months as assistant foreman in charge of industrial control and switchgear tests. Location immaterial. Available at once. Apply to Box No. 828-W.

SALES ENGINEER, M.E.I.C., graduate civil engineer with twenty years experience in the structural, sales, and municipal engineering fields, and as manager of engineering sales office. Available at once. Apply to Box No. 830-W.

CIVIL ENGINEER, B.A.Sc., D.L.S., O.L.S., A.M.E.I.C., age 46, married. Twelve years experience in charge of legal field surveys. Owns own surveying equipment. Eight years on technical, administrative, and editorial office work. Experienced in writing. Desires position on survey work, assisting in or in charge of preparation of house organ, on staff of technical or semi-technical magazine, or on publicity, editorial or administrative office work. Available at once. Will consider any salary, and any location. Apply to Box No. 831-W.

AERONAUTICAL ENGINEER, B.Sc. (McGill), M.Sc. (Mass. Inst. Tech.). Canadian. Age 26, recent graduate. Capable of aeroplane design and stress analysis. Apply to Box No. 838-W.

CIVIL ENGINEER, M.Sc., R.P.E. (Sask.). Age 27. Experience in location and drainage surveys, highways and paving, bridge design and construction city and municipal developments, power and telephone construction work. Available on short notice. Apply to Box No. 839-W.

CIVIL ENGINEER, S.E.I.C., B.Sc. '32 (Univ. of N.B.). Age 25, married. Two years experience in power line construction and maintenance; one year of highway construction; one summer surveying for power plant site, location and spur railway line construction. Available at once. Location immaterial. Apply to Box No. 840-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.

CIVIL ENGINEER, B.Sc. (Alta. '31), S.E.I.C., age 24. Experience, three summers on railroad maintenance, and seven months on highway location as instrumentman. Willing to do anything, anywhere, but would prefer connection with designing or construction firm on structural works. Available immediately. Apply to Box No. 846-W.

MECHANICAL ENGINEER, JR.E.I.C., technical graduate, bilingual, age 30. Two years as designing heating draughtsman with one of the largest firms of its kind on this continent handling heating materials; three years designing draughtsman in consulting engineers' office, mechanical equipment of buildings, heating, ventilation, sanitation, power plant equipment, writing of specifications, etc. Present location Montreal. Available at once. Apply to Box No. 850-W.

BRIDGE AND STRUCTURAL ENGINEER, A.M.E.I.C., McGill. Twenty-five years' experience on bridge and structural staffs. Until recently employed. Familiar with all late designs, construction, and practices in all Canadian fabricating plants. Desirous of employment in any responsible position, sales, fabrication or construction. Apply to Box No. 851-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.

MECHANICAL ENGINEER, B.Sc. '32, S.E.I.C. Good draughtsman. Undergraduate experience:—One year moulding shop practice; two years pipe fitting and sheet metal work; one year draughting and tracing on paper mill layout; six months machine shop practice; and eight months fuel investigation and power heating plant testing. Desires position offering experience in steam power plants or heating and ventilating design. Will go anywhere. Apply to Box No. 858-W.

Situations Wanted

MECHANICAL ENGINEER, age 31, graduate Sheffield (England) 1921; apprenticeship with firm manufacturing steam turbine generators and auxiliaries and subsequent experience in design, erection, operation and inspection of same. Marine experience B.O.T. certificate thoroughly conversant with Canadian plants and equipment. Available on short notice. Any location. Box No. 860-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.

ENGINEER, McGill Sci. '21-'25, S.E.I.C., aerial mapping, stereoscopic contour work; lumber classification; highway, railway and transmission line locations; estimates; water storage investigations, etc. Five years ground surveys; three years aerial mapping. Bilingual. Available on short notice. Apply to Box No. 872-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.Sc., Montreal 1930, age 26, single, French and English, desires position technical or non-technical in engineering, industrial or commercial fields, sales or promotion work. Experience includes three years in municipal engineering on paving, sewage, waterworks, filter plant equipment, layout of buildings, etc. Available immediately. Apply to Box No. 891-W.

ELECTRICAL ENGINEER, grad. Univ. of N.B. '31. Experienced in surveying and draughting, requires position. Available at once. Will go anywhere. Apply to Box No. 893-W.

CIVIL ENGINEER, B.A.Sc., JR.E.I.C., age 29, single. Experience includes two years in pulp mill as draughtsman and designer on additions, maintenance and plant layout. Three and a half years in the Toronto Buildings Department checking steel, reinforced concrete, and architectural plans. Available at once. Location immaterial. At present in Toronto. Apply to Box No. 899-W.

ENGINEER, JR.E.I.C., specializing in reconnaissance and preliminary surveys in connection with hydro-electric and storage projects. Expert on location and construction of transmission lines, railways and highways. Capable of taking charge. Location immaterial. Apply to Box No. 901-W.

MECHANICAL ENGINEER, Canadian, age 25, B.Sc. (Queen's '32). Since graduation on supervision of large building construction. Undergraduate experience in electrical, plumbing and heating, and locomotive trades. Available at once. Apply to Box No. 903-W.

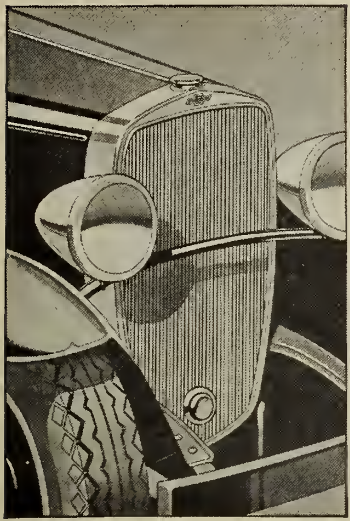
DESIGNING ENGINEER, A.M.E.I.C. Permanent and executive position preferred but not essential. Fifteen years experience in designing power plants, engine and fan rooms, kitchens and laundries. Thoroughly familiar with plumbing and ventilating work, pneumatic tubes, and refrigeration, also heating, electrical work, and specifications. Apply to Box No. 913-W.

INDUSTRIAL ENGINEER, B.Sc. in M.E., age 25, married, is open for a position of a permanent nature with an industrial concern. Experience includes three years in various divisions of a paper mill and two years in an electrical company. Apply to Box No. 917-W.

ENGINEER, B.Sc., A.M.E.I.C., R.P.E. (N.B.), age 35, married. Seven years' mining experience as sampler, assayer, surveyor, field work, and foreman in charge of underground development; two years as assistant engineer on highway construction and maintenance. Available on short notice. Apply to Box No. 932-W.

CIVIL ENGINEER, B.Sc., '25, McGill Univ., JR.E.I.C., P.E.Q., age 32, married. Experience as rodman and instrumentman on track maintenance. Seven and one-half years with Canadian paper company, as assistant office engineer handling all classes of engineering problems in connection with woods operations, i.e., road buildings, piers, booms, timber bridges, depots, dams, etc. Apply to Box No. 933-W.

LEADER IN SALES* AND VALUE



CHEVROLET

offers an improved line of six-cylinder

TRUCKS

- ½ to 5-ton Capacities ...Chevrolet-Built Bodies ...The Most Economical Trucks Money Can Buy!

CHEVROLET—leader in sales—goes marching into 1933 with greater truck values than ever! A complete new line of low-priced, six-cylinder trucks—made in Canada—with new Chevrolet-built bodies and a capacity range from ½ to 5 tons.

Last year, Canada's truck buyers gave Chevrolet outstanding leadership* in the entire truck industry. Value was the reason—and it's extra value that puts these new trucks far ahead in 1933!

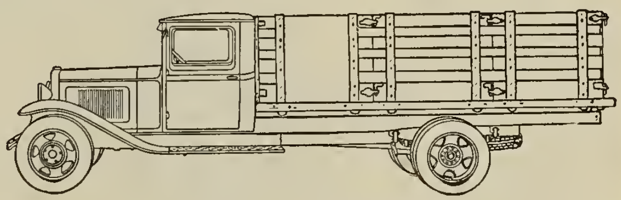
Your Chevrolet dealer has full details. It will pay you to get his advice on your particular haulage problems before you put a dollar on *any* new truck.

*CHEVROLET LEADERSHIP

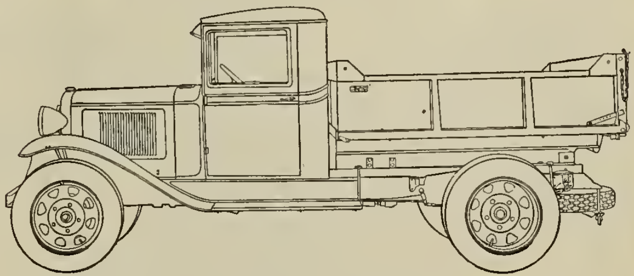
Chartered from official registration figures as at December 31, 1932

CHEVROLET	34.61%
TRUCK "A"	29.33%
TRUCK "B"	9.33%
TRUCK "C"	6.53%

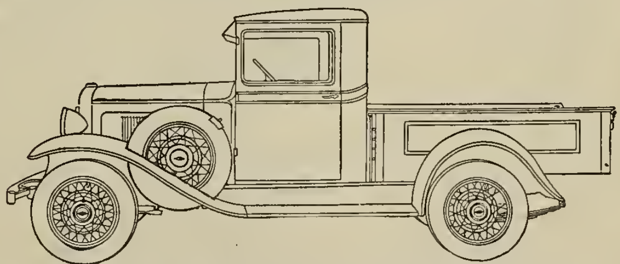
. . . In a year when VALUES were paramount CHEVROLET assumed OUTSTANDING LEADERSHIP in the ENTIRE TRUCK INDUSTRY



Chevrolet Stake Body



Chevrolet Dump Truck



Chevrolet Pick-up with Enclosed Cab

CHEVROLET

GENERAL MOTORS PRODUCTS

THE GREAT CANADIAN TRUCK VALUE

The advertiser is ready to give full information.

Purchasers' Classified Directory

A Selected List of Equipment, Apparatus and Supplies

For Alphabetical List of Advertisers see page 28.

A

Acids:
Canadian Industries Limited.
Aerial Survey:
Canadian Airways Ltd.
Angles, Steel:
Bethlehem Steel Export Corp.
Canadian Tube & Steel Products Ltd.
U.S. Steel Products Co.
Ash Handling Equipment:
Babcock-Wilcox & Goldie-McCulloch Ltd.
Combustion Engineering Corp. Ltd.
Crude Oil Engine & Engineering Co. Ltd.
E. Long Ltd.

B

Ball Mills:
Dominion Engineering Works Limited.
Balls, Steel and Bronze:
Can. S.K.F. Co. Ltd.
Barking Drums:
Canadian Ingersoll-Rand Company, Limited.
Bars, Steel and Iron:
Bethlehem Steel Export Corp.
Canadian Tube & Steel Products Ltd.
U.S. Steel Products Co.
Bearings, Ball and Roller:
Can. S.K.F. Co. Ltd.
Billets, Blooms, Slabs:
Bethlehem Steel Export Corp.
Dominion Steel & Coal Corp.
U.S. Steel Products Co.
Bins:
Canada Cement Co. Ltd.
Blasting Materials:
Canadian Industries Limited.
Blowers, Centrifugal:
Can. Ingersoll-Rand Co. Ltd.
Blue Print Machinery:
Montreal Blue Print Co.
Boilers:
Babcock-Wilcox & Goldie-McCulloch Ltd.
Combustion Engineering Corp. Ltd.
Foster Wheeler Limited.
Wm. Hamilton Ltd.
E. Leonard & Sons Ltd.
Vulcan Iron Wks. Ltd.
Boilers, Electric:
Can. General Electric Co. Ltd.
Dominion Engineering Works Limited.
Northern Electric Co. Ltd.
Boilers, Portable:
E. Leonard & Sons Ltd.
Bolt Cutters:
The Jno. Bertram & Sons Co. Ltd.
Bolts and Nuts:
Canadian Tube & Steel Products Ltd.
Bolts, Galvanized:
N. Slater Co. Ltd.
Boring Mills:
The Jno. Bertram & Sons Co. Ltd.
Boxes, Cable Junction:
Northern Electric Co. Ltd.
Braces, Cross Arm, Steel, Plain or Galvanized:
Northern Electric Co. Ltd.
Brackets, Ball Bearing:
Can. S.K.F. Co. Ltd.
Brakes, Air:
Can. General Elec. Co. Ltd.
Brakes, Magnetic Clutch:
Northern Electric Co. Ltd.
Brick, Acid Proof:
National Sewer Pipe Co. Ltd.
Bridge-Meggers:
Northern Electric Co. Ltd.
Bridges:
Canada Cement Co. Ltd.
Dominion Bridge Co. Ltd.
Bucket Elevators:
Jeffrey Mfg. Co. Ltd.
Building Papers:
The Barrett Co. Ltd.
Buildings, Steel:
Dominion Bridge Co. Ltd.

C

Cables, Copper and Galvanized:
Northern Electric Co. Ltd.
Cables, Electric, Bare and Insulated:
Can. Westinghouse Co. Ltd.
Can. General Electric Co. Ltd.
Northern Electric Co. Ltd.
U.S. Steel Products Co.
Caissons, Barges:
Dominion Bridge Co. Ltd.
Cameras:
Associated Screen News Ltd.
Capacitors:
Can. Westinghouse Co. Ltd.
Cars, Dump:
E. Long Ltd.
Castings, Brass:
The Superheater Co. Ltd.
Castings, Iron:
Babcock-Wilcox & Goldie-McCulloch Ltd.
Dominion Engineering Works.
Wm. Hamilton Ltd.
E. Leonard & Sons Ltd.
E. Long Ltd.
The Superheater Co. Ltd.
Vulcan Iron Wks. Ltd.
Castings, Steel:
Vulcan Iron Wks. Ltd.
Catenary Materials:
Can. Ohio Brass Co. Ltd.
Cement Manufacturers:
Canada Cement Co. Ltd.
Chains, Silent and Roller:
The Hamilton Gear & Machine Co. Ltd.
Jeffrey Mfg. Co Ltd.
Channels:
Bethlehem Steel Export Corp.
Hamilton Bridge Co. Ltd.
U.S. Steel Products Co.
Chemicals:
Canadian Industries Limited.
Chemical Stoneware:
National Sewer Pipe Co. Ltd.
Chemists:
Milton Hersey Co. Ltd.
Chippers, Pneumatic:
Canadian Ingersoll-Rand Company, Limited.
Choke Coils:
Ferranti Electric Co.
Circuit Breakers:
Can. General Elec. Co. Ltd.
Can. Westinghouse Co. Ltd.
Northern Electric Co. Ltd.
Clay Conduits:
National Sewer Pipe Co. Ltd.
Clutches, Ball Bearing Friction:
Can. S.K.F. Co. Ltd.
Clutches, Magnetic
Northern Electric Co. Ltd.
Coal Handling Equipment:
Babcock-Wilcox & Goldie-McCulloch Ltd.
Combustion Engineering Corp. Ltd.
E. Long Ltd.
Combustion Control Equipment:
Bailey Meter Co. Ltd.
Compressors, Air and Gas:
Babcock-Wilcox & Goldie-McCulloch Ltd.
Canadian Ingersoll-Rand Company, Limited.
Foster Wheeler Co.
Concrete:
Canada Cement Co. Ltd.
Condensers, Steam:
Babcock-Wilcox & Goldie-McCulloch Ltd.
Canadian Ingersoll-Rand Company, Limited.
Foster Wheeler Limited.
Smart-Turner Machine Co. Ltd.
Condensers, Synchronous and Static:
Can. General Elec. Co. Ltd.
Can. Westinghouse Co. Ltd.
Harland Eng. Co. of Can. Ltd.
Northern Electric Co. Ltd.
Conduit:
Can. General Elec. Co. Ltd.
Can. Westinghouse Co. Ltd.
Northern Electric Co. Ltd.
Conduit, Underground Fibre, and Underfloor Duct:
Northern Electric Co. Ltd.
Conduit Fittings:
Northern Electric Co. Ltd.
Conduits, Wood Pressure Creosoted:
Canadian Wood Pipe & Tanks Ltd.
Construction Hardware, Electrical:
N. Slater Co. Ltd.
Controllers, Electric:
Can. General Elec. Co. Ltd.
Can. Westinghouse Co. Ltd.
Northern Electric Co. Ltd.
Counterbores:
Pratt & Whitney, Co. of Canada Ltd.
Couplings:
Canadian Tube & Steel Products Ltd.
Dart Union Co. Ltd.
Dresser Mfg. Co. Ltd.
Couplings, Flexible:
Dominion Engineering Works Limited.
Dresser Mfg. Co. Ltd.
The Hamilton Gear & Machine Co. Ltd.
Smart-Turner Machine Co. Ltd.
Cranes, Hand and Power:
Dominion Bridge Co.
Smart-Turner Machine Co., Ltd.
Cranes, Locomotive:
Dominion Hoist & Shovel Co. Ltd.
Shovel, Cranes, Gasoline Crawler, Pillar:
Dominion Hoist & Shovel Co. Ltd.
Creosote Oils:
The Barrett Co. Ltd.
Canada Creosoting Co. Ltd.
Creosoted Products:
Canada Creosoting Co. Ltd.
Crowbars:
B. J. Coghlin Co. Ltd.
Crushers, Coal and Stone:
Canadian Ingersoll-Rand Company, Limited.
Jeffrey Mfg. Co. Ltd.

D

Dies:
Pratt & Whitney Co. of Canada, Ltd.
Dimmers:
Northern Electric Co. Ltd.
Disposal Plants, Sewage:
W. J. Westaway Co. Ltd.
Ditchers:
Dominion Hoist & Shovel Co. Ltd.
Drills:
The Jno. Bertram & Sons Co. Ltd.
Pratt & Whitney Co. of Canada, Ltd.
Drills, Pneumatic:
Canadian Ingersoll-Rand Company, Limited.
Dynamite:
Canadian Industries Limited.

E

Economizers, Fuel:
Babcock-Wilcox & Goldie-McCulloch Ltd.
Combustion Engineering Corp. Ltd.
Foster Wheeler Limited.
Ejectors:
Darling Bros. Ltd.
Elbows:
Dart Union Co. Ltd.
Electric Blasting Caps:
Canadian Industries Limited.
Electric Railway Car Couplers:
Can. Ohio Brass Co. Ltd.
Electric Trucks:
The Can. Fairbanks-Morse Co. Ltd.
Electrical Supplies:
Can. General Elec. Co. Ltd.
Can. Ohio Brass Co. Ltd.
Can. Westinghouse Co. Ltd.
Northern Electric Co. Ltd.
Electrification Materials, Steam Road:
Can. Ohio Brass Co. Ltd.
Elevating Equipment:
E. Long Ltd.
Elevators:
Darling Bros. Ltd.
Engines, Diesel and Semi-Diesel:
The Can. Fairbanks-Morse Co. Ltd.
Canadian Ingersoll-Rand Company, Limited.
Crude Oil Engine & Engineering Co. Ltd.
Harland Eng. Co. of Can. Ltd
Engines, Gas and Oil:
Canadian Ingersoll-Rand Company, Limited.
Engines, Steam:
Babcock-Wilcox & Goldie-McCulloch Ltd.
Crude Oil Engine & Engineering Co. Ltd.
Harland Eng. Co. of Can. Ltd.
E Leonard & Sons Ltd.
Evaporators:
Foster Wheeler Limited.
Expansion Joints:
Darling Bros. Ltd.
Foster Wheeler Limited.
Explosives:
Canadian Industries Limited.

F

Feed Water Heaters, Locomotive:
Foster Wheeler Limited.
The Superheater Co. Ltd.
Fencing and Gates:
Dominion Steel & Coal Corp.
U.S. Steel Products Co.
Filtration Plants, Water:
W. J. Westaway Co. Ltd.
Finishes:
Canadian Industries Limited.
Fire Alarm Apparatus:
Northern Electric Co. Ltd.
Floodlights:
Can. General Elec. Co. Ltd.
Can. Westinghouse Co. Ltd.
Northern Electric Co. Ltd.
Floor Stands:
Jenkins Bros. Ltd.
Floors:
Canada Cement Co. Ltd.
Flue Linings, Vitrified Clay:
National Sewer Pipe Co. Ltd.
Forcite:
Canadian Industries Limited.
Forgings:
Bethlehem Steel Export Corp.
N. Slater Co. Ltd.
Foundations:
Canada Cement Co. Ltd.

G

Galvanizing, Hot Dip:
Canadian Tube & Steel Products Ltd.
N. Slater Co. Ltd.
Gaskets, Asbestos, Fibrous, Metallic, Rubber:
The Garlock Packing Co.
Gasoline Recovery Systems:
Foster Wheeler Limited.
Gates, Hydraulic Regulating:
Dominion Bridge Co. Ltd.
Gauges, Draft:
Bailey Meter Co. Ltd.
Gear Reductions:
The Hamilton Gear & Machine Co. Ltd.
Gears:
Dominion Bridge Co. Ltd.
Dominion Engineering Works Limited.
The Hamilton Gear & Machine Co. Ltd.
E. Long Ltd.
Smart-Turner Machine Co.
Generators:
Can. General Elec. Co. Ltd.
Can. Westinghouse Co. Ltd.
Harland Eng. Co. of Can. Ltd.
Northern Electric Co. Ltd.
Governors, Pump:
Bailey Meter Co. Ltd.
Governors, Turbine:
Dominion Engineering Works Limited.
Grates:
Smart-Turner Machine Co., Ltd.
Gratings, M. & M. Safety:
Dominion Bridge Co. Ltd.
Grease Extractors:
Smart-Turner Machine Co. Ltd.

H

Hangers, Ball and Roller Bearing:
Can. S.K.F. Co. Ltd.
Headlights, Electric Railway:
Can. General Elec. Co. Ltd.
Can. Ohio Brass Co. Ltd.
Can. Westinghouse Co. Ltd.
Heat Exchange Equipment:
Crude Oil Engine & Engineering Co. Ltd.
Foster Wheeler Limited.
Hoists, Air, Steam and Electric:
Canadian Ingersoll-Rand Company, Limited.
Dominion Hoist & Shovel Co. Ltd.
Humidifying Equipment:
W. J. Westaway Co. Ltd.

Purchasers' Classified Directory

Hydraulic Presses:
The Jno. Bertram & Sons Co. Ltd.

I

Incinerators:
Canada Cement Co. Ltd.
Indicator Posts:
Jenkins Bros. Ltd.
Industrial Electric Control:
Can. General Elec. Co. Ltd.
Can. Westinghouse Co. Ltd.
Northern Electric Co. Ltd.
Injectors, Locomotive, Exhaust Steam:
The Superheater Co. Ltd.
Inspection of Materials:
J. T. Donald & Co. Ltd.
Milton Hersey Co. Ltd.
Instruments, Electric:
Can. General Elec. Co. Ltd.
Can. Westinghouse Co. Ltd.
Ferranti Electric Ltd.
Moloney Electric Co. of Canada, Ltd.
Northern Electric Co. Ltd.
Insulating Materials:
Canadian Industries Limited.
Insulators, Porcelain:
Can. Ohio Brass Co. Ltd.
Northern Electric Co. Ltd.
Intercoolers:
Foster Wheeler Limited.

J

Jigs and Fixtures:
Pratt & Whitney Co. of Canada, Ltd.
Jointing Compound:
National Sewer Pipe Co. Ltd.
Journal Bearings and Boxes, Railway:
Can. S.K.F. Co. Ltd.

L

Lacquers:
Canadian Industries Limited.
Lantern Slides:
Associated Screen News Ltd.
Lathes:
The Jno. Bertram & Sons Co. Ltd.
Leading Wire:
Canadian Industries Limited.
Library Films:
Associated Screen News Ltd.
Lighting Equipment, Industrial and Street:
Can. General Elec. Co. Ltd.
Can. Westinghouse Co. Ltd.
Northern Electric Co. Ltd.
Lightning Arresters:
Can. General Elec. Co. Ltd.
Can. Westinghouse Co. Ltd.
Ferranti Electric Ltd.
Northern Electric Co. Ltd.
Line Materials:
Can. Ohio Brass Co. Ltd.
Northern Electric Co. Ltd.
N. Slater Co. Ltd.
Liner Plates, Vitrified Clay:
National Sewer Pipe Co. Ltd.
Locomotives, Electric:
Can. General Elec. Co. Ltd.
Can. Westinghouse Co. Ltd.
Lumber, Creosoted:
Canada Creosoting Co. Ltd.

M

Machine Work:
Smart-Turner Machine Co., Ltd.
Machinery, Hydraulic:
Dominion Engineering Works Limited.
Machinery, Metal Working:
The Can. Fairbanks-Morse Co. Ltd.
Jno. Bertram & Sons.
Dominion Engineering Works Limited.
Smart-Turner Machine Co.
Machinery, Woodworking:
The Can. Fairbanks-Morse Co. Ltd.
Jno. Bertram & Sons.
Dominion Engineering Works Limited.
Smart-Turner Machine Co.
Magnetic Separators:
Northern Electric Co. Ltd.
Material Handling Equipment:
Jeffrey Mfg. Co. Ltd.
E. Long Ltd.
Meters, Boiler, and Coal:
Bailey Meter Co. Ltd.
Meters, Electric:
Can. General Elec. Co. Ltd.
Can. Westinghouse Co. Ltd.
Ferranti Electric Ltd.
Northern Electric Co. Ltd.
Meters, Flow:
Bailey Meter Co. Ltd.
Neptune Meter Co. Ltd.
Meters, Liquid (Hot or Cold):
Bailey Meter Co. Ltd.
National Meter Co. of Canada Ltd.
Neptune Meter Co. Ltd
Milling Cutters:
Pratt & Whitney Co. of Canada, Ltd.
Mine Cars:
E. Long Ltd.
Mining Machinery:
Canadian Ingersoll-Rand Company, Limited.
Dominion Engineering Works Limited.
Wm. Hamilton Ltd.
Mortar, Acid Proof:
National Sewer Pipe Co. Ltd.
Motion Pictures:
Associated Screen News Ltd.
Motors, Electric:
The Can. Fairbanks-Morse Co. Ltd.
Can. General Elec. Co. Ltd.
Can. Westinghouse Co. Ltd.
Harland Eng. Co. of Can. Ltd.
Northern Electric Co. Ltd.
Moulded Goods, Rubber and Asbestos:
The Garlock Packing Co.

N

Nickel, Chrome Steel:
Thos. Firth & Sons Ltd.

O

Oil Burning Equipment:
Bethlehem Steel Export Corp.
The Can. Fairbanks-Morse Co. Ltd.
Oil Refining Equipment:
Foster Wheeler Limited.
Ornamental Iron:
Vulcan Iron Wks. Ltd.

P

Packings, Asbestos, Cotton and Flax, Metal, Rubber:
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Paints, Metal Protectives:
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Canadian Industries Limited.
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Canadian Ingersoll-Rand Company, Limited
Can. Westinghouse Co. Ltd
Dominion Engineering Works Limited.
Harland Eng. Co. of Can. Ltd.
Wm. Hamilton Ltd.
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National Sewer Pipe Co. Ltd.
Penstocks:
Wm. Hamilton Ltd.
Penstocks, Wood-Stave:
Canadian Wood Pipe & Tanks Ltd.
Phase Rotation Indicators:
Ferranti Electric Ltd.
Photographs, Commercial and Portrait:
Associated Screen News Ltd.
Piling, Steel Sheet:
Bethlehem Steel Export Corp.
U.S. Steel Products Co.
Pillow Blocks, Ball and Roller Bearing:
Can. S.K.F. Co. Ltd.
Pinions:
The Hamilton Gear & Machine Co. Ltd.
Pipe, Steel and Wrought Iron:
Canadian Tube & Steel Products Ltd.
Pipe, Wood Stave:
Canadian Wood Pipe & Tanks Ltd.
Pipe Coils:
The Superheater Co. Ltd.
Pipe Couplings and Nipples:
Canadian Tube & Steel Products Ltd.
Dart Union Co. Ltd.
Pipes, Vitrified Clay:
National Sewer Pipe Co. Ltd.
Planers:
The Jno. Bertram & Sons Co. Ltd.
Plasterers Corner Bead:
The Pedlar People, Ltd.
Plates, Steel:
Bethlehem Steel Export Corp.
U.S. Steel Products Co.
Pneumatic Tools:
Canadian Ingersoll-Rand Company Ltd.
Pole Line Hardware:
Can. Ohio Brass Co. Ltd.
Northern Electric Co. Ltd.
N. Slater Co. Ltd.
Poles, Creosoted:
Canada Creosoting Co. Ltd.
Polishes:
Canadian Industries Limited.
Powder, Black and Sporting:
Canadian Industries Limited.
Power Switchboards:
Can. General Elec. Co. Ltd.
Can. Westinghouse Co. Ltd.
Harland Eng. Co. of Can. Ltd.
Northern Electric Co. Ltd.
Preheaters, Air:
Babcock-Wilcox & Goldie-McCulloch Ltd.
Combustion Engineering Corp.
Foster Wheeler Limited.
Projectors:
Associated Screen News Ltd
Pulleys, Ball Bearings, Loose:
Can. S.K.F. Co. Ltd.
Pulverized Fuel Systems:
Babcock-Wilcox & Goldie-McCulloch Ltd.
Bethlehem Steel Export Corpn.
Combustion Engineering Corp. Ltd.
Foster Wheeler Limited.
Pump Valves, Rubber:
The Garlock Packing Co.
Pumps:
Babcock-Wilcox & Goldie-McCulloch Ltd.
The Can. Fairbanks-Morse Co. Ltd.
Canadian Ingersoll-Rand Company, Limited.
Darling Bros. Ltd.
Foster Wheeler Limited.
Harland Eng. Co. of Can. Ltd.
Smart-Turner Machine Co. Ltd.
Punches:
The Jno. Bertram & Sons Co. Ltd.
Pratt & Whitney Co. of Canada, Ltd.
Purifiers, Centrifugal:
Crude Oil Engine & Engineering Co. Ltd.
Purifiers, Water:
W. J. Westaway Co. Ltd.

R

Radiator Air Vents and Traps:
Darling Bros. Ltd.
Jenkins Bros. Ltd.
Radiator Valves:
Can. Ohio Brass Co. Ltd.
Darling Bros. Ltd.
Jenkins Bros. Ltd.
Radio Receiving Sets:
Can. General Elec. Co. Ltd
Can. Westinghouse Co. Ltd.
Northern Electric Co. Ltd.
Radio Transformers:
Ferranti Electric Ltd.
Rail Bonds:
Can. Ohio Brass Co. Ltd
U.S. Steel Products Co.
Rail Braces and Joints:
B. J. Coghlin Co.
Rails:
Dominion Steel & Coal Corp.
U.S. Steel Products Co.
Railway Equipment:
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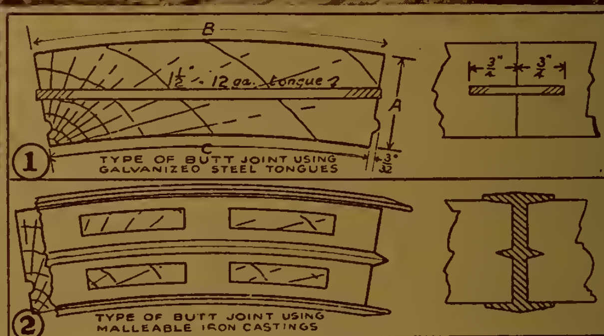

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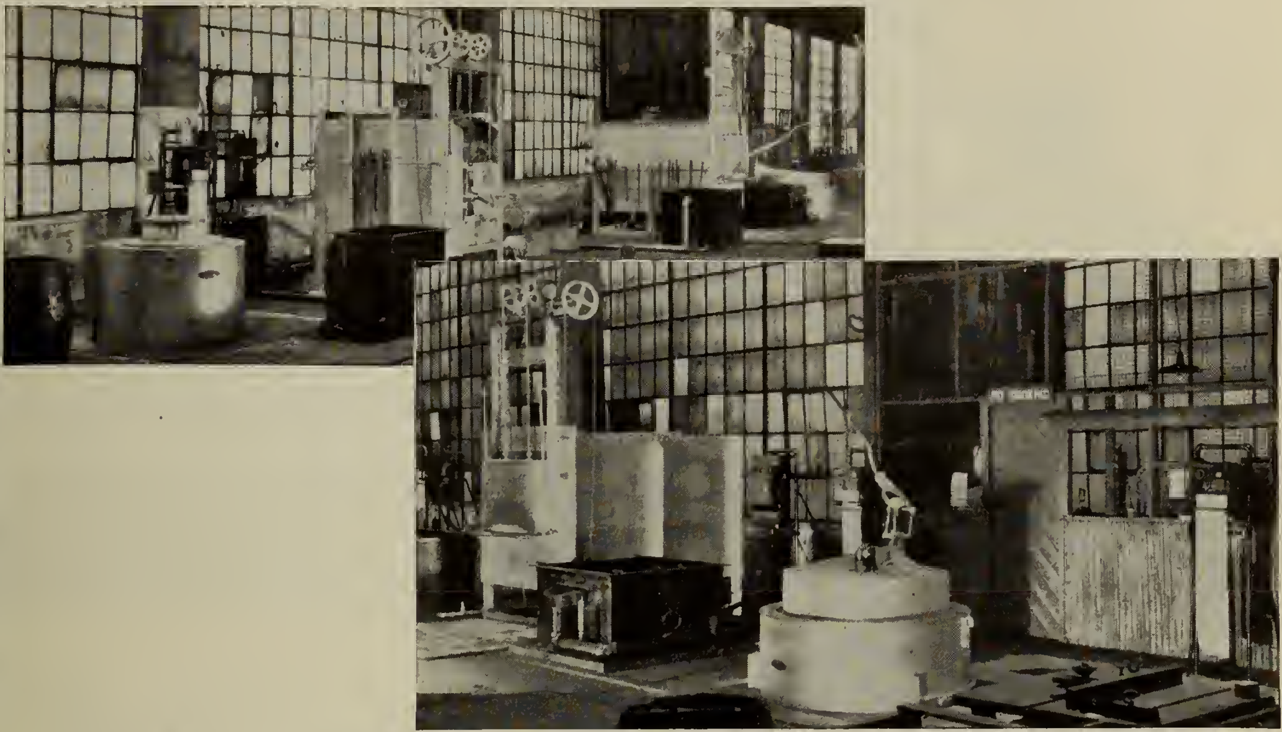

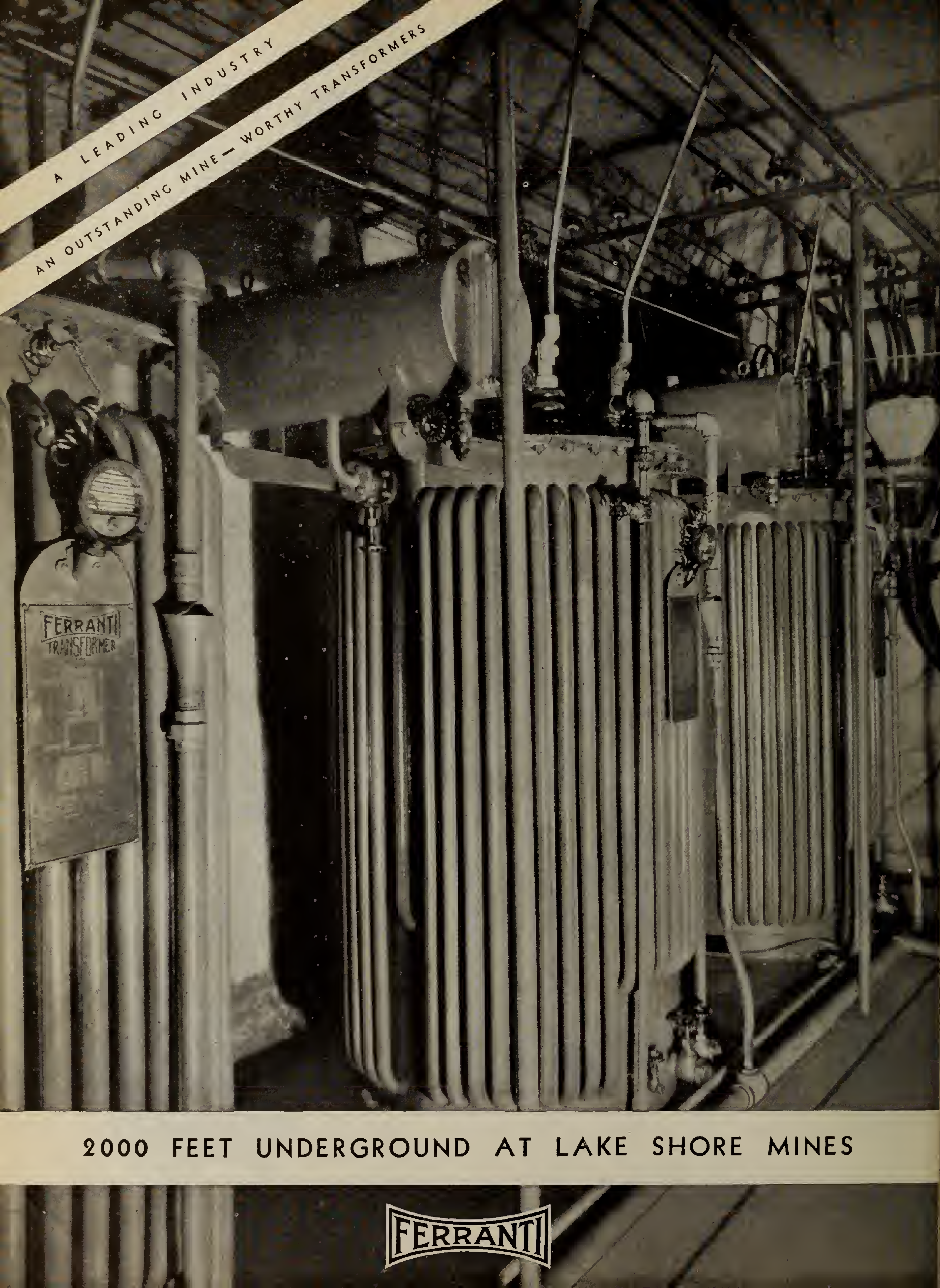
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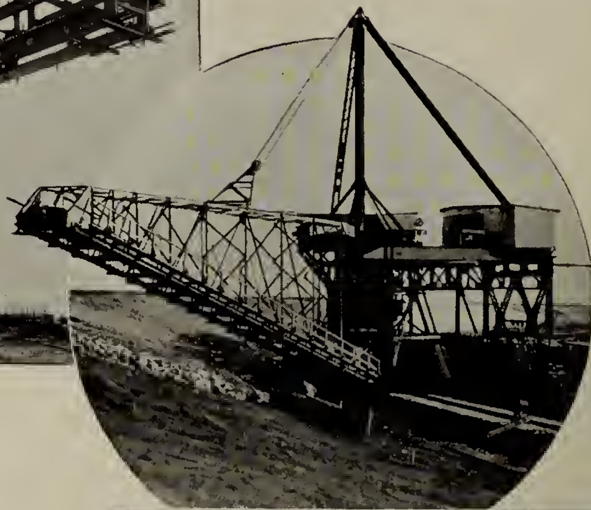

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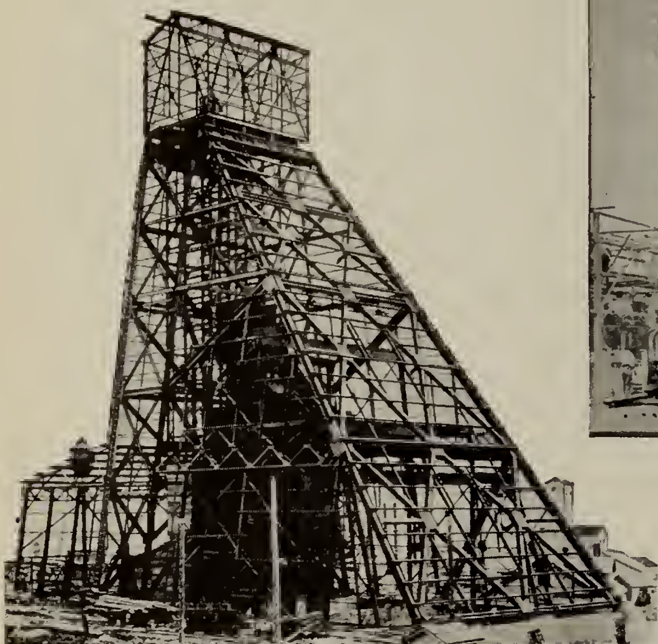

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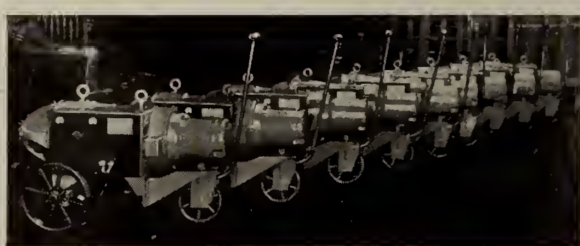

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Trans-Canada Highway
Construction of the Ontario Section as an Unemployment Relief Measure

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Paper presented at the General Professional Meeting of The Engineering Institute of Canada, Ottawa, Ont., February 8th, 1933.

SUMMARY.—The construction of a portion of the Trans-Canada Highway through northern Ontario during the winters of 1931-1932 and 1932-1933 was undertaken as an Unemployment Relief measure. The paper deals with the general policy, organization, construction and methods of securing and distributing labour and supplies.

The location selected for the road was based on topographic surveys and the work so far accomplished has covered some three hundred miles of new construction and about the same mileage of reconstruction. During the fiscal year 1931-1932 the total expenditure amounted to just over six million dollars. The maximum number of men employed was twelve thousand.

Ontario's contribution to the mileage of the Trans-Canada Highway is about one-third of the entire amount or roughly fourteen hundred miles. Of this mileage the section from the Quebec boundary to Pembroke is well known as King's Highway No. 17 and these 174 miles come under the jurisdiction of the Department of Public Highways of Ontario.

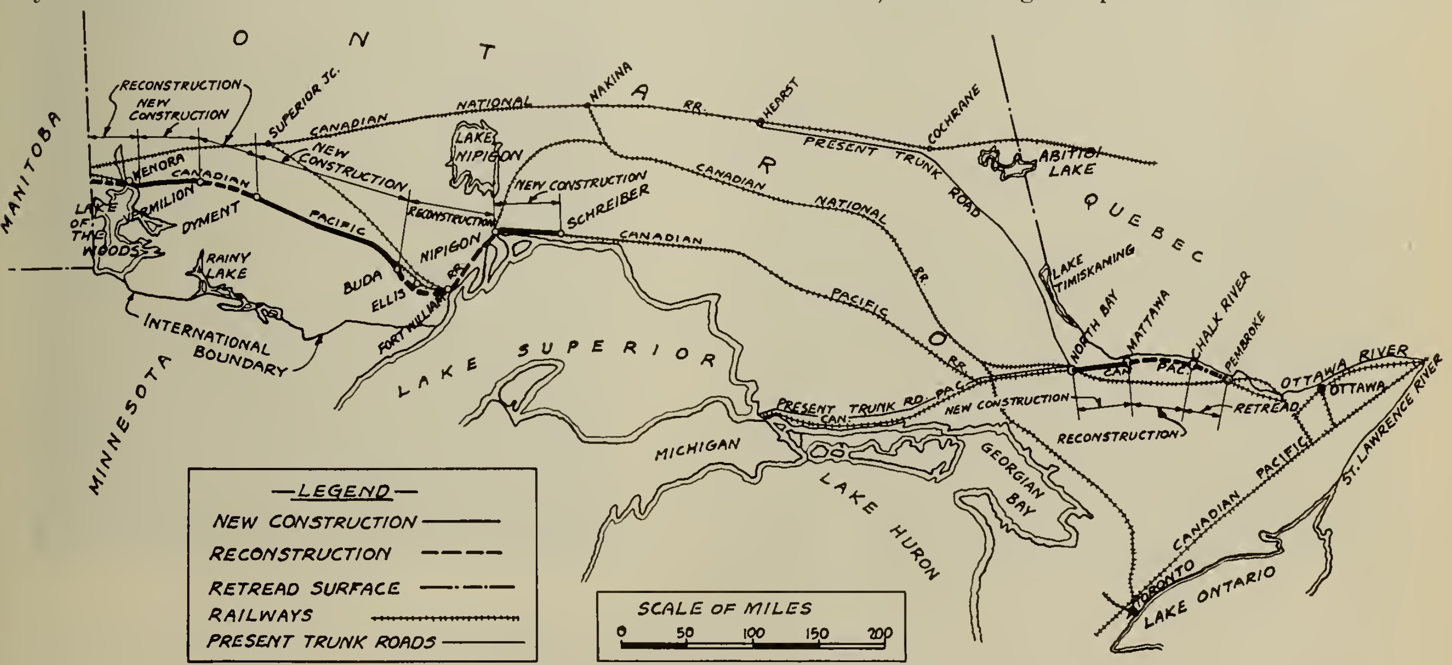

Fig. 1—Trans-Canada Highway Across Northern Ontario.

From Pembroke right through to the Manitoba boundary, a distance of 1,200 miles, approximately, the road will run through what is commonly known as Northern Ontario which, with its 300,000 square miles, has been designated as the territory under the jurisdiction of the Department of Northern Development of Ontario, over which the Honourable Wm. Finlayson is the presiding Minister, and C. H. Fullerton, A.M.E.I.C., the Deputy Minister.

Land settlement in Northern Ontario, coupled with the steady increase each year in the number of visitors to this area, made it imperative that many miles of road be constructed, and during the past two decades or so this natural expansion made it possible to motor through the north for hundreds of miles in an easterly and westerly direction.

A continuation of King's Highway No. 17 from Pembroke to North Bay, 133 miles, has been travellable for a number of years, and at North Bay this road forks, providing an excellent gravel surface in a south westerly direction for over three hundred miles to Sault Ste Marie and the north shore of Lake Superior, and an equally excellent gravel road for 416 miles in a north westerly direction to Cochrane and Hearst.

In the Thunder Bay and Kenora districts long stretches of road have existed for years, which were each year being improved with the thought that they might some day become part of a great trans-Canada route. Thunder Bay,

Fig. 2—Camp Buildings.

before present operations commenced, had nearly one hundred miles of road from Nipigon to a point 35 miles west of Fort William and Port Arthur, while Kenora had about seventy miles running from Dyment to Vermillion and from Kenora west towards the Manitoba boundary.

The decision arrived at in 1931 that the Dominion government would go into partnership with the provinces in the completion of a trans-Canada highway, and that the work was to proceed without unnecessary delay as an Unemployment Relief measure, was approved by all those interested in highway development, and although difficulties immediately began to arise, the task of carrying into effect the wishes of the two governments was tackled by the Department of Northern Development, Ontario, without a fear for the success of the undertaking.

It was decided by Order-in-Council that the route would only be designated through the Ottawa Valley to North Bay, and from Schreiber to the Manitoba boundary until such time as aerial and ground surveys uncovered sufficient information in regard to the alternative routes made available by the forks from North Bay in a westerly direction.

The route having been partially designated, plans were immediately made for reconstruction of the old parts of the road to trans-Canada standard, and construction of the new sections in the designated area.

Camps were constructed in September 1931, approximately four miles apart, over a distance of about three hundred miles of reconstruction and nearly three hundred miles of new construction, a total of some ninety-six camps in all, while arrangements were made for the carrying on of much of the reconstruction by gangs of settlers who boarded at their own homes and rendered the erection of camps in those sections unnecessary. It may be interesting to note that over $350,000 had to be expended on camp erection before any men could be started on to the actual work of road construction.

The organization necessary to carry out an undertaking of this kind—especially for winter construction—called for a large amount of preliminary work in the selection of personnel, engineers, camp superintendents, foremen, and others, and the securing of equipment and materials such as tents, lumber and tools in quantities, seeing that it was decided to do the work by day labour rather than letting it out by contract.

As an instance of the method adopted in the securing of materials the matter of tent supplies may be taken—it was early seen that a great number of tents would be required and the first step was to call in the two large manufacturers of duck in ten ounce and twelve ounce weights and arrange that all their output would be available for any manufacturer making tents for the department and that no manufacturer was to be permitted to "corral" the available supply.

The tent manufacturers were then invited to a conference—reasonable prices arranged—and all put to work to the limit of their capacity so that the Department could be assured that all tents required would be available before the first day of October.

Somewhat similar methods were adopted for the supply of scrapers, wheelbarrows, plows, etc., and to secure a continuous supply of small tools, such as picks, shovels, and axes, (hundreds of dozens of each of which were required) arrangements were made that although the department could secure these direct at manufacturers' list prices less twenty per cent, they would be purchased from local wholesalers at list price less fifteen per cent, giving the local wholesaler five per cent for the carrying of the stock and supplying the Department in small quantities as required.

This worked out to the advantage of both the local wholesaler and the Department and gave universal satisfaction throughout the territory.

Fig. 3—Survey Line.

In the early stage of preliminary arrangement, a difficult problem arose in the matter of commissariat, and after long negotiations a contract was entered into with the only firm considered capable of catering successfully to the needs of thousands of men to be hurriedly placed in Unemployment Relief camps. Messrs. Crawley and McCracken had been handling contracts of this kind for lumber firms in the north, for the Canadian Pacific Railway and also for the Canadian National Railways, as well as many others, and their offer to board the men during the winter of 1931-1932 and supply all blankets, steel cots, heaters, etc., at a rate of eighty cents per day per man, was accepted by the Department and resulted in a measure of satisfaction beyond the hopes of anyone concerned with the undertaking.

The Department of Labour of Ontario was charged with the responsibility of securing the men to be placed in the camps and they were shipped north in batches of one hundred to each district; the movement of these thousands of men was carried out with the utmost smoothness after each man had been medically examined and declared fit for the work.

Fig. 4—Burning Right-of-Way.

At this stage it should be mentioned that although at the maximum some twelve thousand men were employed on this trans-Canada work, the Department of Northern Development was also carrying on at the same time similar work on many other roads in Northern Ontario, so that the actual peak of employment resulted in the issue of over forty thousand cheques per month for wages in the months of December 1931 and January 1932. These cheques aggregated a very considerable amount seeing that the rate paid to labourers was thirty cents per hour for an eight hour day less eighty cents per day board.

Sleep camps, 14 feet by 16 feet, housing eight men each, were installed for fifty men in temporary locations, with tent roofs, and for one hundred men in more permanent locations with lumber roofs, and these were placed at intervals of four miles approximately but only after the Department of Health had approved the location and the available water supply, and the precautions taken resulted in a winter's work without even one serious outbreak of disease.

At the first sign of fever—typhoid or scarlet—diphtheria, or small-pox, it was only necessary to isolate the occupants of one eight-man hut and this resulted in the successful checking of every outbreak before it could take possession of any one of the camps.

As to the work accomplished, it is important to note that the work was carried on as an Unemployment Relief measure without the assistance of any of the efficient machinery now used in roadmaking. Every effort was made to use man power and the only actual outlay on machinery was for air compressors for use in larger rock cuts where hand drilling would have been out of the question.

On the entire undertaking, an amount of over six million dollars was spent during the winter of 1931-1932, the maximum number of men employed on the Trans-Canada Highway was over twelve thousand five hundred, the total number of "man days" being 1,551,318.

The first winter's work was discontinued on April 30th, 1932, orders having been issued for the closing down of the camps at that date, but it was found that many of the single men and transients employed in the camps were absolutely homeless, and it was then hurriedly decided by both Federal and provincial governments to permit these young men to remain in camp, working eight hours per day, in return for which they each received their board plus an allowance of $5.00 per month—under this scheme over three thousand men continued on the work from May 1932 until October 1932 inclusive, the cost of board being reduced by the caterers from 80c. to 60c. per man per day.

With the approach of winter it was decided to carry on the board camps and probably enlarge on the scheme giving the men an allowance of $10.00 instead of $5.00 to place them in a position to equip themselves with winter clothing. This has resulted in over nine thousand men taking advantage of the camps and this number is now employed on the Ontario trans-Canada highway work.

For these winter board camps, 1932-1933, the boarding contractors made another reduction in the rate for board which at present stands at 50c. per man per day.

The organization of the work in the fall of 1931—coming at a time when construction work was rapidly becoming a minus quantity—provided a much needed outlet for a large number of engineers who were in need of employment and seeing that there had been practically nothing done previously in the way of location work, the engineers were rushed to the work immediately it was decided that the project was to be entered upon.

The work came immediately under three district engineers of the Department of Northern Development, Mr. G. A. White at North Bay, Mr. A. J. Isbester at Fort William, and Mr. R. T. Lyons at Kenora, and was so arranged that each 24 miles had its divisional engineer, and each 8 miles its resident engineer with the necessary chainmen and rodmen.

Fig. 5—Typical Boulder Section.

In the preliminary location work advantage was taken of the information available in the Dominion Topographical Survey Department where aerial pictures were procured. Lines were established from the air, using Ontario Department of Forestry planes, and the probable route was sketched in on an air map and the information so obtained proved to be a wonderful time saver as well as a guide to the engineer in charge of the ground location.

Complete topography was taken from two hundred to four hundred feet each side of the preliminary line, and in the Kenora district, where most of the air work was done, it was found that only three miles of location out of one hundred and fifty varied greatly from the line established from the air.

Camp erection followed the location closely and as quickly as camp sites were obtained, small crews were organized, composed in most cases of ten good axemen, one team, one cook, and one superintendent and proceeded to erect the buildings which in some cases were portables

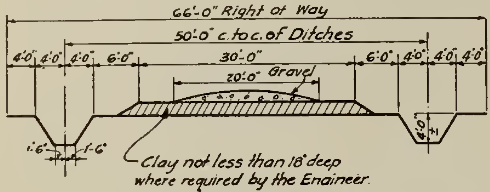

Fig. 6—Cross Section Roadway Through Muskeg.

already constructed at headquarters and in other cases were actually built on the ground.

Altogether ninety-six camps, comprising two thousand four hundred and fifteen buildings, were placed in the space of a few weeks, instructions being issued for the work on September 3rd and thousands of men being housed and fed by the middle of October.

Camps are situated in a majority of cases on lakes which for rugged beauty are second to none in the world and many of the camps when construction is complete will be undoubtedly converted for tourist purposes.

It must be remembered that all these early arrangements had to be made through a country which, especially in the westerly end is rough, rugged and rocky. Such country is difficult to work in when there are not even tote roads, and virgin bush obstructs the view and impedes the progress at every turn.

Construction was commenced on a location which although hurried, resulted in possibly the best the country offers, it being thoroughly realized that the location of a road such as the Trans-Canada Highway, is one of the most important items.

Fig. 7—Finishing Grade and Ditching.

Every effort was made to balance all cuts and fills, eliminating the necessity of borrowing grading material from outside the right-of-way.

The right-of-way is 66 feet wide, the roadway itself following the Ontario provincial standard width of 30 feet from ditch to ditch, with grades where possible held down to six per cent or under.

Horizontal and vertical curves were in most cases laid out so that the motorist would have clear vision for a distance of 500 feet but it will be realized that in sections of the country which are made up of a succession of hills and gulleys, it is found difficult to follow this rule strictly in first construction although it may be accomplished by successive years of improvement.

A great majority of the men shipped in from the urban centres were unskilled in the use of road making tools, but thanks to the tuition of the camp erection crews of experienced men the new comers quickly became efficient.

The cutting of the right-of-way presented few difficulties, and this was followed by the burning of brush which

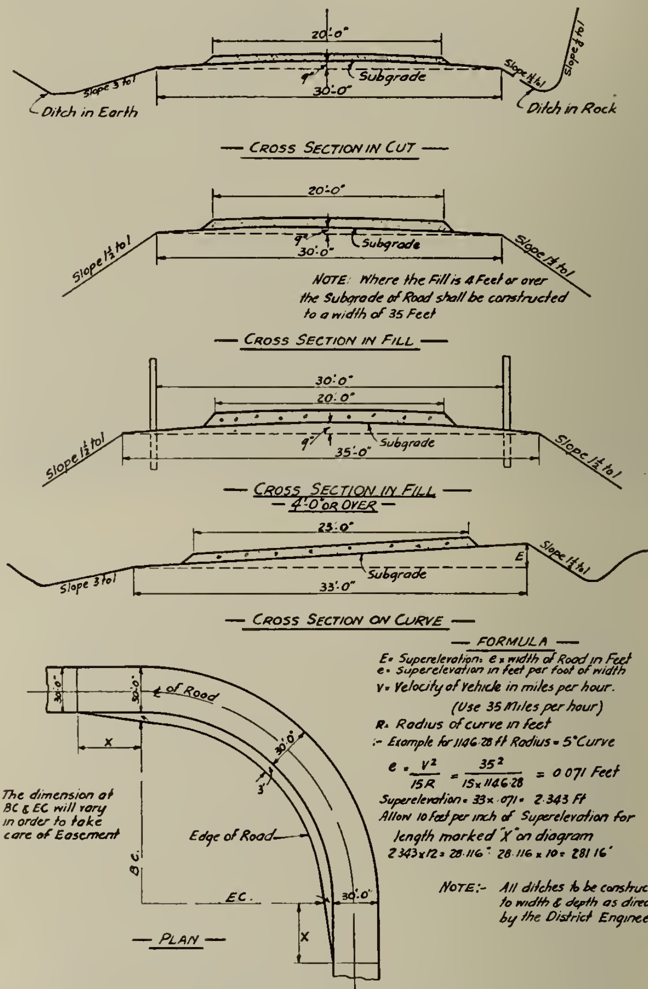

Fig. 8—Standard Cross Sections and Super-Elevation Data for 30-foot Roadway.

was at all times kept under control so that fire would not spread to the dry bush adjoining. Airplanes patrolled all sections when burning was in progress so that the Forestry Department Fire Rangers could be quickly notified and aid secured if a fire began to spread.

Stumping, especially where the right-of-way ran through a heavily timbered section, was accomplished by the placing of stumping powder under about twenty stumps at a time, which were fired in battery, this was followed by grubbing, practically all of which, like the grading that followed, was done by hand, providing a great deal of employment for unskilled hands.

The work of stumping and grubbing may not appear to be of great importance, but in the construction of a highway, experienced engineers place a very high value on excellence in this regard. Many of the troubles showing up in the finished surface of a highway are directly traceable to failure in observing the rule that all stumps and roots must be carefully removed, leaving a sub-grade clear of vegetable matter which in its decay would, if allowed to remain, cause considerable damage to the finished grade.

This undertaking being an Unemployment Relief measure, afforded the engineers of the Department the opportunity to have the stumping and grubbing carried out thoroughly and seeing that the permanent staff of engineers are all experienced in the construction of pioneer roads, this important item was not overlooked.

The Department of Northern Development has for many years added to the mileage of roads in the province at the rate of over a mile per day for every day in the year,

Fig. 9—Completed Gravelled Road.

and this experience eminently fitted the engineering staff of the Department for the carrying out of such a project as the construction of the Trans-Canada Highway through Northern Ontario.

The commencement of grading with the use of only picks, shovels, wheel-barrows, scrapers and the occasional dump cart or waggon, did not appear difficult with hundreds of miles to work on and hundreds of thousands of cubic yards of earth and rock to handle but as fills lengthened out and the men got deeper into the rock and earth cuts problems arose, and became rather acute when it was reported that the wheelbarrow haul was so long that men starting out in the morning with a load had to take their lunch with them.

Engineers who have for many years carried out their construction work along efficiency lines, using only the highest forms of machinery, may find it difficult to realize the practical difficulties encountered in trying to build a modern highway as an Unemployment Relief measure.

Each district, divisional and resident engineer set about the task of overcoming these difficulties, and it was, and still is, interesting to note the various ways in which each engineer and camp superintendent accomplished the seemingly impossible.

It is safe to say that over the entire stretch of highway construction work could be found many miles of bush railway running from the rock or earth cut long distances to the end of the dump or fill.

These railways had to be made up of the materials at hand, logs were peeled and laid down as tracks (with necessary cross overs) and timber stone boats constructed on which the material in the cut was piled and hauled by team to the fill, and unless one could see the work it would be difficult to picture the tremendous volume of material moved in this way at low cost.

The removal of solid rock without mechanical aid is of course possible, but as hand drilling is slow in producing material for mucking it was found necessary in this case to use a few air compressors especially in the large cuts. Some of the four-mile sections were almost entirely rock and had it not been for the use of compressors it would have been impossible to work any appreciable number of men on these particular sections.

Reams have been written in regard to the necessity of adequate drainage to ensure success in any road construction project, and here the engineers found themselves in the happy position of having an abundance of work suitable for hand labour. Nowhere has the ditching been better attended to and the completed stretches of highway are side ditched in excellent shape, with offtakes provided in every case where required.

Underdrainage has not been considered as a factor as it is found that during the years which must elapse before hard surfacing becomes necessary, all the points which require underdrainage will have had abundant opportunity to reveal themselves.

The work accomplished by the hand labour method made necessary by the unemployment situation is rather startling when tabulated, as a glance at the following figures for the period November 1st., 1931 to October 31st, 1932 will show.

Cutting and Burning 66 feet wide	397 miles
Side Brushing Existing Road...	79 miles
Stumping and Grubbing........	277 miles
Grading....................	96 miles
Ditching.....................	545,236 cubic yards
Gravelling....................	124,777 cubic yards
Clay Surfacing on Muskeg......	17.7 miles
Wood Culverts...............	483
Stone Culverts...............	45
Concrete Culverts............	20
Metal Culverts................	565
Timber Bridges................	74
Earth Excavation.............	2,118,498 cubic yards
Rock Excavation.	681,333 cubic yards

It will be noticed that under the head of "Grading" the mileage shown is 96, but it must be mentioned that this only refers to completed grade and does not take into account the partial grading which was carried on over a distance of 550 miles, this being included in the figures for earth and rock excavation.

In the matter of costs it was found on many of the residencies that unit costs were surprisingly low; many of the engineers and camp superintendents were men who had been previously engaged in contracting and these men took particular pride in keeping strict account of their costs and comparing them with previous construction jobs on which they had been engaged.

The actual expenditure for the fiscal year during which the quantities given in a preceding paragraph were handled was $6,070,193.61 and considering the facts that there were few mechanical aids and that the labour was drawn largely from urban centres and was absolutely inexperienced, it must be admitted that the results far exceeded the expectations of those who sponsored as well as those who organized the undertaking.

In presenting this paper no attempt has been made to offer a technical treatise on the subject, this being due to the manner in which the project had to be organized and carried out during a period when employment had perforce to be provided for an army of workmen. It must however be borne in mind that both Federal and provincial governments made it possible not only to attain a long looked for object in the construction of a Trans-Canada Highway, but at the same time to provide an outlet for a great number of engineers who would otherwise have remained amongst the ranks of the unemployed.

In conclusion a tribute should be paid to the manner in which the spiritual needs of the men are being looked after by the representatives of the different churches and by the Frontier College student-teachers, who also assist in the organization of sports into which all the camps enter with zest and enjoyment. Acknowledgment is also due to the Provincial Police who in a most tactful manner are assisting in making the project a success.

The Electrical Design of the Chats Falls Development

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Paper presented at the General Professional Meeting of The Engineering Institute of Canada, Ottawa, Ont., February 8th, 1933.

SUMMARY.—The electrical and building features of the power house and transformer station are described briefly, and the considerations are discussed which led to the selection of the particular equipment employed. Control, switching, cables, transformers, illumination, the ground system, lightning protection and the relay protective system are among the topics considered.

This paper covers a general description of the electrical and building features of the Chats Falls power house and the Chats Falls transformer station. The electrical output of all generators is delivered at 13.2 kv. to the transformer station where it is stepped up to 220 kv. for delivery to the Hydro-Electric Power Commission's 220 kv. transmission system.

Diagram

Fig. 1 shows the electrical diagram for the two stations. The 13.2 kv. diagram was chosen due to its simplicity, load requirements and the fact that quick replacement of generator breakers would be afforded by the use of metal-clad breaker equipment. The 220 kv. diagram is a modified double bus arrangement for operation of the two busses as one system, requiring an average of one and one-half circuit breakers per major element (line or transformer bank). The 600-volt service power is obtained from either of two banks of three 500-kv.-a., 13,200/600-volt transformers, each bank being of sufficient capacity to handle the total service load.

Power House Superstructure

The power house superstructure is 499 feet long, 70 feet wide, and 53 feet high and comprises a generator room, 50 feet in width, and three galleries located between this and the intake structure. Structural steel and reinforced concrete construction have been used throughout, except for the end walls, which are of tile and plaster so that they may be readily removed when building extensions are required for the future units.

The downstream elevation, shown in Fig. 2, has been given a simple classic treatment suitable for concrete construction consisting of fluted pilasters with entablature over, the pilaster caps and entablature being enriched with simple Greek ornament. To effect proper proportions, the facade of superstructure and sub-structure have been treated as a unit, that is, the pilasters extend down to the tail-race deck. Large steel window frames having deep reveals occupy the space between the pilasters. In the spandrel sections below the windows, aluminum louvres are located for the generator air inlets.

The building interior and the interior equipment have been painted in conformity with a general colour scheme, based on dark and light shades of grey-green contrasted with cream. The generator room floor has been covered with 9-inch square red quarry tile.

As shown in Figs. 3 and 4, the main operating floor is at generator room floor level, that is, at elevation 221. The first gallery floor at elevation 223 is divided into two sections by a 13-inch concrete wall the length of the power house. The upstream section forms the cable tunnel for the main power cables to the transformers and is accessible through manholes in the floor above. The other section, open to the generator room, is occupied by the generator switchboards and rheostats, the governor pumping equipment, the station service switching and other auxiliaries. On the second gallery at elevation 236 are located the 13.2-kv. metal-clad circuit breaker structures, the service transformers and control terminal room. On the top gallery at elevation 252 are situated the control room, teletype room, battery rooms, store rooms, and offices. This top gallery extends 12 feet over the intake structure to house the head gate lifting mechanisms.

A temporary machine shop was built on a portion of the intake structure for the future No. 10 unit. In a corresponding position for the future No. 1 unit, a corridor was build to connect the power house to a building known as the pump house. Both the machine shop and the corridor are of tile and plaster construction so as to be readily removed when the power house is extended for the future units.

The pump house, situated adjacent to the east end of the power house, is of structural steel and reinforced concrete construction. In it are located the water pumps for supplying the power house and the transformers, an air compressor, and the transformer oil pumping and filtering equipment.

The crane equipment consists of two 90-ton, electrically-operated cranes and one equalizer beam. Each crane has a 25-ton auxiliary hook. The two cranes, with equalizer beam, are required for handling the generator rotor which weighs 175 tons. Special attachments are provided for connecting the crane hook to the turbine shaft and to the transformer core.

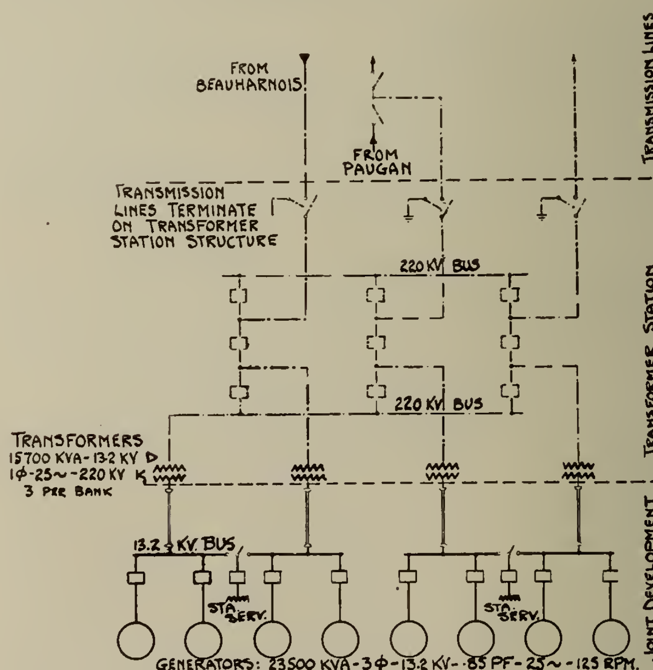

Fig. 1—Electrical Diagram for Generating and Transformer Stations.

The floor space between units is sufficient for handling generator parts and assembly of transformers. An erection bay was, therefore, not provided. In designing the height of the superstructure, clearance was provided to permit a generator rotor with shaft to be removed from its stator and carried past an assembled unit on the downstream side. Fig. 5 shows the assembly clearances. Six openings have been provided in the generator room floor for the assembly

Fig. 2—Power House—Downstream Elevation.

or storage of rotors. The shaft extends through an opening while the rotor is supported on temporary steel supports on the floor. A standard gauge railway track runs the full length of the power house located between the generators and the downstream wall. This track is a continuation of the spur track connecting with the Canadian National Railway at Fitzroy, Ontario. For a distance of 121 feet from the main entrance door at the east end of the station, an 11-foot gauge track is laid to accommodate the motor-operated transformer transfer truck. Between units No. 2 and No. 3, and No. 4 and No. 5, short lengths of rails have been embedded in the floor to permit of placing the transformers for assembly purposes.

To exclude external noises from the control room and teletype room the walls of these rooms are constructed of two thicknesses of 3-inch terra-cotta tile insulated from floor by one inch of cork and with the 2-inch space between tile filled with dry Insulex. The suspended ceilings in these rooms are finished in acoustic plaster, and the floors are covered with 9-inch square rubber tile. These rooms and the three offices are provided with a ventilating system which supplies water washed air treated for winter conditions as to temperature and humidity and capable of changing the air once every seven and one-half minutes.

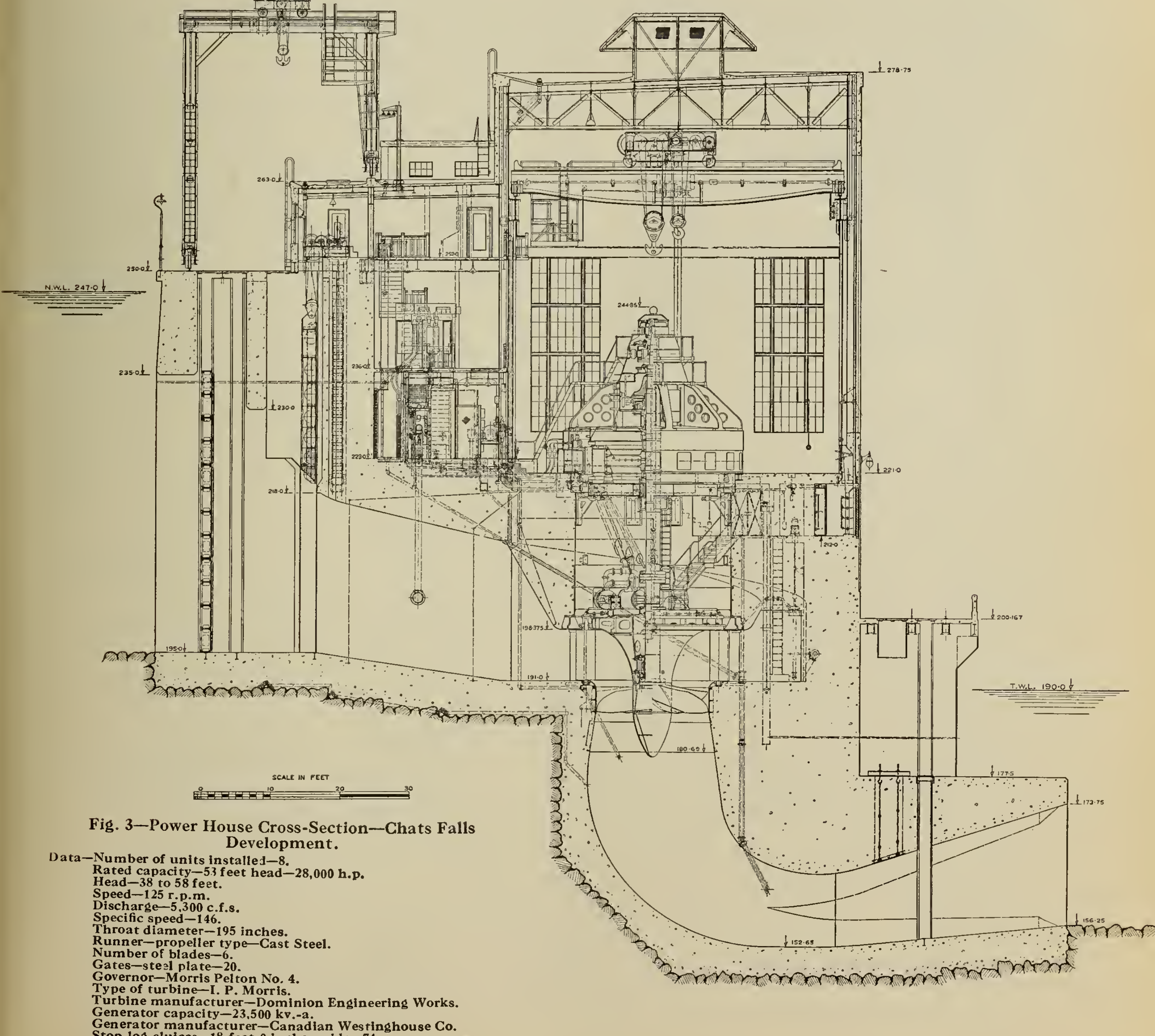

Fig. 3—Power House Cross-Section—Chats Falls Development.

Data—Number of units installed—8.
Rated capacity—53 feet head—28,000 h.p.
Head—38 to 58 feet.
Speed—125 r.p.m.
Discharge—5,300 c.f.s.
Specific speed—146.
Throat diameter—195 inches.
Runner—propeller type—Cast Steel.
Number of blades—6.
Gates—steel plate—20.
Governor—Morris Pelton No. 4.
Type of turbine—I. P. Morris.
Turbine manufacturer—Dominion Engineering Works.
Generator capacity—23,500 kv.-a.
Generator manufacturer—Canadian Westinghouse Co.
Stop log sluices—18 feet 0 inches wide—74.
Sluice gates —40 feet 0 inches wide—4.

As shown in the cross-section of the power house, Fig. 3, air tunnels are provided under the generator room floor which, by means of air dampers, permit outside air, or generator room air, or a mixture of both, to be supplied to the generators for cooling purposes. Each generator requires 67,000 cubic feet of air per minute to carry away heat losses of 450 kw. This heated air provides the only source of power house heating other than for the rooms referred to above. When power house heating is not required, the heated air may be emitted through seven roof monitors having a total cross sectional area of 1,008 square feet. These monitors are equipped at their exits with manually-operated dampers on all four sides.

Generators and Excitation

All the generators (Fig. 6) are identical. Their stators are of the conventional structural design except that cast iron arms are used on the upper bracket. With the thrust bearing depressed in the upper bracket to reduce the overall height of the generator, the cast arms were found to be more advantageous than structural steel. Air is drawn in from below and discharged through the stator by means of fans on the rotor. The generator neutrals are ungrounded.

Main and pilot exciters are direct-connected to each unit. No standby source of excitation is provided due to the entirely satisfactory service experienced in other plants with direct-connected exciters. Spare pilot and main exciter armatures with shafts are provided.

The excitation system is arranged to give quick response to a major drop in generator voltage, such as would accompany line flashover. This quick response assists in maintaining synchronism between generating stations, and between generators in a station, and is especially desirable on the extensive 220-kv. system of which this station forms a part.

Quick response is obtained by exciting the main exciter from a pilot exciter, and by arranging the main exciter shunt field in five parallels. A differential shunt field is also provided on the main exciter, so that its terminal voltage can be reduced below residual value. The voltage regulator is provided with contacts so that upon a major drop in voltage practically all the resistance in the main exciter field can be short circuited, and the whole voltage of the pilot exciter impressed on the main exciter field, thus causing rapid build up of main exciter voltage.

The design of the generator is such that it will deliver approximately 23,500 kv.-a. at zero power factor leading and 10 per cent below rated voltage without becoming self-exciting.

The generator has a high ratio of field ampere turns to armature ampere turns, the short circuit ratio being approximately 1.34.

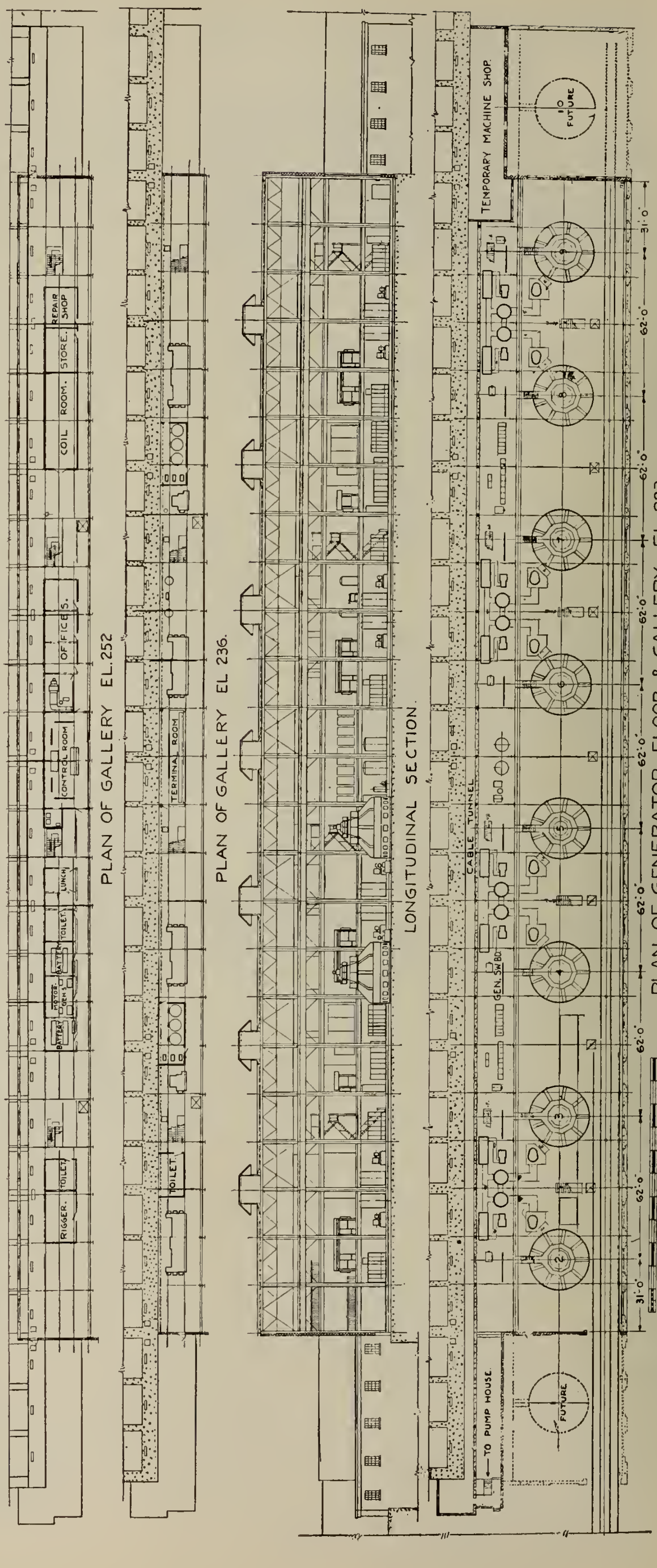

Fig. 4—Generating Station Key Plan—Electrical.

The maximum voltage rate of build up of the main exciter is 520 volts per second and the ceiling voltage is 300 volts.

Main 13.2 kv. Switching

The selection of metal-clad switching equipment was made on account of space limitations, its safety features, and the short time required for its installation. There are four main metal-clad switch structures, one for each pair of generators. These are located on the second gallery opposite the even numbered units of their respective pairs. Each structure has a paralleling bus with two oil circuit breakers, one for each generator. The breakers are rated at 1,500 amperes and have an interrupting capacity of 30,000 r.m.s. amperes at rated voltage. Isolation is obtained by lowering a breaker by a motor-operated mechanism on a truck. Two such trucks are furnished for this purpose and for the removal of breakers for inspection or maintenance. The trucks while in the structure are operated only from the control room.

These metal-clad structures were subjected to a potential test of 60,000 volts for one minute in the factory.

Main 13.2 kv. Power Cables

Two 1,000,000-c.m., single conductor cables per phase connect generators to bus and four similar cables per phase connect bus to transformers. These are rated for 15-kv.

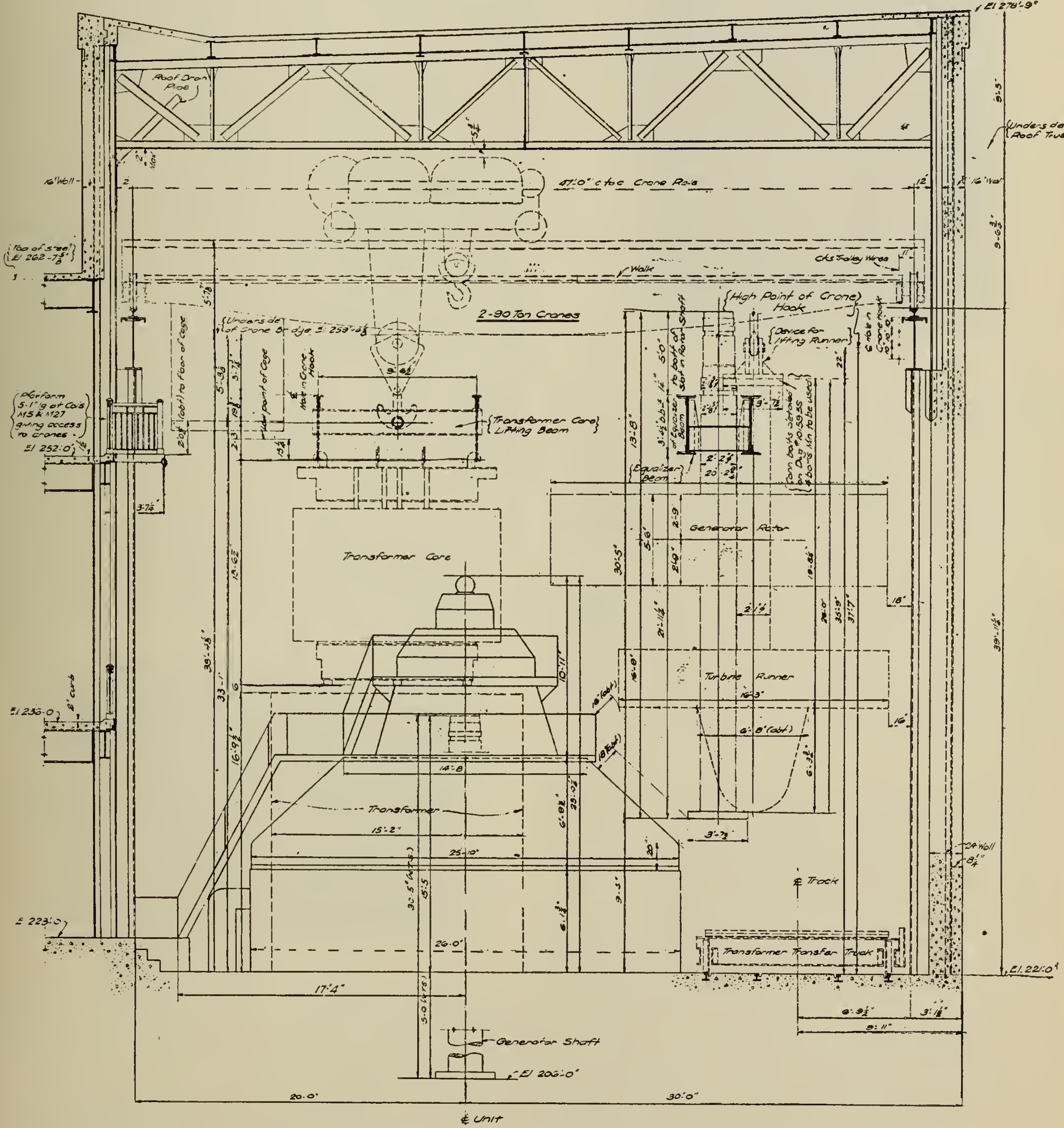

Fig. 5—Power House Assembly Clearances.

service having 13/32-inch paper insulation and ⅛-inch lead sheath. Extensive saving in building costs, without increase in equipment costs, was obtained by using cable for these connections over that required by a rigid bus mounted on porcelain insulators. With the latter type of construction, it would have been necessary to increase the width of the power house and also increase the size of the transformer tunnel. The 13.2-kv. system is designed so

Fig. 6—Generator Room.

that in case of insulation failure two grounds must occur before a short circuit results. The single conductor cable provided this desired condition in a very convenient way.

All cable runs are made with complete lengths of cable in order to omit the possible weakness of cable joints, the greatest run being 600 feet approximately.

Instead of constructing a delta bus at the transformers the single conductor cables connecting the bus to the transformers forms the delta.

Station Service Power

The power supply for the operation of all auxiliaries for the development and transformer station is obtained from the two service transformer banks which are installed on the gallery at elevation 236, one in each half of the generating station. Interconnections are provided so that all service loads may be carried by either bank. The banks are enclosed in separate fire-proof rooms, each with a carbon dioxide fire protection system which is fully automatic.

Water-cooled transformers were adopted mainly for the following reasons. The weight and dimensions of water cooled transformers are less than self-cooled transformers; forced ventilating systems for the transformer rooms would have been required for self-cooled units; lower capacity transformers could be used, as increased rating of water-cooled transformers is obtained in the winter season when oil circuit breaker and other heating is required, due to the temperature of cooling water being well below 25 degrees C.

Adjacent to each transformer bank is its 13.2-kv. bank breaker, and directly below on elevation 223 are the main 600-volt feeder breakers and busses of metal-clad construction. The main feeders are in turn connected to busses in metal-enclosed cubicles which feed through circuit breakers to the individual loads.

The 600-volt transformer breakers and the bus tie breaker are electrically-operated from the control room; all other service breakers are hand-operated. Important auxiliaries may be fed from either service station.

In order to provide an additional safety factor on the service equipment, the transformers are insulated for 25,000-volt service and the 600-volt circuit breakers, busses and cables are insulated for 2,200-volt service.

Lighting

The illumination intensities on the floors in the generating station are approximately as follows:—

Generator Room El. 221	15 foot candles
Gallery El. 223	15 " "
" El. 236	9 " "
" El. 252 (including control room)	13 " "

The variation in lighting intensity on the galleries is proportional to the detail operating requirements. Certain lighting outlets in the control room and generator room and all lighting outlets at stairways and exits are fed from an automatic transfer switch such that on failure of the normal a.c. lighting supply these outlets are fed from the station storage battery. Lighting service is extended from the power house to the farthest stop-log sluices in the dam on either side, a distance of approximately 3,500 feet.

Control and Switchboards

The control of all electrically-operated equipment in the power house and transformer station is centred in the control room located at the centre of the power house. The system adopted allows a compact arrangement of control and indication which is advantageous for operation and suitable to the limited width of the control room. A vertical indicating meter board combined with a control desk having ninety-five controllers has been installed, requiring a floor space of 140 by 40 inches (Fig. 7). The equipment on this switchboard is complete not only for the present installations but for the future additions. The length of the meter board was governed by the installation of the indicating meters for ten generators and three lines. Miniature 48-volt controllers operate interposing relays which in turn operate the equipment from a 250-volt d.c. system. The power supply for this control system is obtained from storage batteries of the sealed-top type. To afford a very reliable supply, duplicate 250-volt and 48-volt batteries are installed with a motor generator charging set for each battery as well as duplicate control busses. One 250-volt and one 48-volt battery are located in each of two rooms with the controlling switchboard and four charging sets in a centre room. Suitable switching facilitates the transfer of either battery to either of its respective chargers

Fig. 7—Control Room.

and to either control bus. This arrangement lends itself to systematic maintenance and upkeep of the equipment involved. The control room is 18 feet by 40 feet and contains the generator regulator boards, the totalizing meter board, and the generator ground detector and annunciator board.

Directly below the control room is the terminal room in which, as the name implies, all cables to the control room terminate. Here is located the switchboard for the generator and transformer bank standby relays.

A generator switchboard is adjacent to each generator. On each switchboard are mounted the main and exciter field breakers, the regulator contactors, the recording meters, the temperature indicator, the interposing and protective relays, and the lighting switches for each unit of power house. Near one end of each switchboard is installed the motor-operated exciter field rheostat.

In the transformer tunnel, directly below the centre transformer of each bank, is a two-panel board for the transformer relays and the temperature indicating equipment. In the centre of the 220-kv. switchyard is the relay building in which is installed a switchboard containing all line, 220-kv. bus, transformer high voltage zone and interposing relays, as well as 250-volt control switching.

Transformer Station

The main power transformers are located on the roof of a concrete tunnel which is divided longitudinally into two sections. The section next to the dam forms the cable tunnel for the 13.2-kv. main power cables to the transformers, and the other portion forms the operating tunnel which connects through the pump house with the generating station. This latter tunnel contains the water and oil piping, switchboards, and cable pans carrying the control cables from the power house to the transformers and to the 220-kv. switchyard.

Four banks of transformers and one spare transformer have been installed, each bank consisting of three 15,700-kv.-a., single-phase, 25-cycle, 127-220Y/13,200-volt, oil-insulated, water-cooled, non-resonating type transformers as shown in Fig. 8. The transformer high voltage windings are connected in star with the neutral points solidly grounded.

For a distance of 85 feet from the power house, a transformer transfer track parallels the railway track on a common centre line and connects to a manually-operated turn table of 164 tons capacity, capable of turning 360 degrees (Fig. 9). At an angle of 52 degrees to these

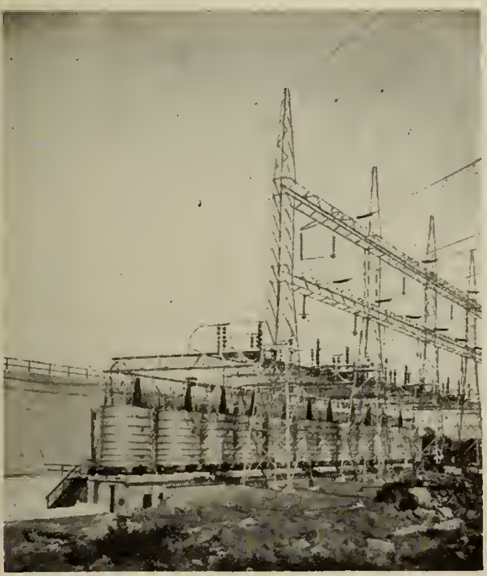

Fig. 8—15,700-kv.-a. Transformers.

tracks is a continuation of the transformer transfer track which parallels the transformer tunnel. A motor-operated transfer truck conveys the completely assembled transformer from the power house to its pocket, an average distance of 355 feet. Seventy minutes are required for three men to perform this transfer which includes placing the transformer on the truck, turning the turntable and pulling the transformer into the pocket. This last operation is done by the truck and requires about twenty minutes of the total time.

Water-cooled transformers are used because their cost is lower and an adequate supply of cooling water is available from the river.

The 220-kv. structures are of typical galvanized structural steel design and may be divided into three sections: the transformer structure at which the transformers

Fig. 9—Turntable for Transformers.

are located; the intermediate structure; and the switchyard structure at which the 220-kv. busses and switching equipment are located.

The electrical layout is on a basis of 12 feet minimum clearance between phases and 7 feet 6 inches minimum to ground. Both these figures are based on 30-inch diameter grading rings being provided; as these rings have not been installed, actual clearances are somewhat higher.

The oil circuit breakers have a current rating of 800 amperes and an interrupting capacity of 6,300 r.m.s. amperes at rated voltage, the arc rupturing time being 0.15 seconds. They are equipped with condenser bushings suitable for operation at 127 kv. to ground, i.e. 220 kv. solidly grounded or 187 kv. isolated neutral system. These breakers are such that bushings for a 220-kv. isolated neutral system may readily replace the lower rated bushings. A potential tap is brought out from each bushing to which is attached a potential device on each line breaker for relay purposes.

Although low cold test oil is used, nine 600-watt immersion heaters are installed in the oil of each breaker tank to ensure maintenance in extreme low temperatures of the speed of opening. A specially designed steel structure with chain block which may readily be assembled on top of the breakers has been provided for replacement of bushings.

The insulation of the disconnecting switches and the bus supported on post insulators consists of six 14½-inch high units. For the strain busses, twenty 10-inch diameter, 5-inch standard suspension units are used and for busses in suspension, eighteen similar units. For all strain busses on which tap connections were not required 795,000 cir. mil. steel reinforced aluminum cable is used, the balance of the strain busses and taps being hollow conductor copper cable having conductivity of 750,000 cir. mil. copper cable and having an outside diameter of 1.249 inches. The rigidly supported bus is 2-inch I.P.S. copper tubing. All bus connections are clamped except the connections of aluminum cable to copper terminals which are compression type.

Ground System

The design of a ground system for the development and transformer station was a difficult problem because the sites are practically solid rock with few basins of soil. To obtain a low ground resistance under such conditions made necessary the installation of seven 5-foot by 5-foot copper plates in the best and most widely separated soil pockets.

Fig. 10—General View of 220-kv. Switch Yard.

These plates are connected through ground test links to a 500,000, c.m. ring ground bus which encircles the transformer station and extends through the power house. The frames of all electrical equipment and the steel structures are connected to this ring ground bus.

In the transformer station No. 4/0 copper lateral busses are installed underground immediately under and, therefore, parallel with the sky wires. These busses are connected to the sky wires at each tower and also to the main ring bus.

The transmission line sky wires are connected to the station ground system through ground test links so that the station ground system may be isolated for test purposes from the transmission line ground system.

Accurate measurements were made to determine the station ground resistance. The results of these measurements gave a resistance of 1.05 ohms, a most gratifying value for the rock conditions encountered. With this value of resistance, it is calculated that the maximum voltage gradient that can be obtained between the station ground system and a remote point will not exceed 1,800 volts.

Lightning Protection

Extensive study was given to the lightning protection of the equipment in the transformer station. Protection has been provided by co-ordinating the insulation of the transmission lines on the sections adjacent to the station with the station insulation and by safety gaps at vital points. An extensive system of overhead ground wires has been installed over the station busses and equipment. The transformers are the non-resonating type.

Special transmission line towers, Fig. 10, have been installed on the lines for a distance of approximately one-half mile from the station. These towers permit two overhead ground wires per circuit, giving a minimum radial clearance between each phase wire and the nearest ground wire of 31 feet which occurs at the towers. The spacing between ground wires and power conductors close to the station was increased over that used on the balance of the lines to make it more difficult for a lightning surge to jump from the ground conductor to the power conductor. These overhead ground wires are carried throughout the station with consistent spacing between them and power conductors. All the main towers of the switchyard, intermediate, and transformer structures are extended 22 feet above the top girders to carry these ground wires. Cross bonding is provided across each row of such towers in order to assist in dissipating lightning surges. These wires are grounded to the station ground system by No. 4/0 copper cable extending down each tower. It is calculated that more than 17,000,000 volts would be required on one of these ground wires before there would be danger of a flashover occurring from ground wire to power conductor.

The overhead ground wires terminate at the transformer structure. Additional protection for the transformers is contemplated by means of two lightning masts approximately 150 feet high, one at each end of the group of transformer banks. The tops of these two masts would be connected by an overhead ground wire. Provision has been made so that an arrester may be installed at each bank of transformers.

The insulation used on the suspension strings on the special line towers consists of sixteen 5-inch units instead of the standard eighteen units used on the balance of the line except on the towers next to the switchyard structure where thirteen units are used with grading rings set to give a 56-inch gap.

Corresponding gaps are installed on each of the suspension strings on the transformer leads at the transformer structure.

Relay Protective System

A complete relay protective system for the generating and transformer stations has been provided with the following characteristics. It is co-ordinated with the system arrangement and relaying of the Niagara 220- and 110-kv. system of the Hydro-Electric Power Commission of Ontario and the generating stations associated therewith so as to form a successful operating system. This requires complete instantaneous zone protection for the Chats Falls equipment and circuits, directional stepped-range impedance distance protection on the 220-kv. lines, and suitably timed back-up protection to operate in case of failure of the instantaneous protection to function completely. Relay settings, ranges and times are suitable for such co-ordination. The complete relay system is installed so as to promote security from accidental or improper operation, to ensure certainty of correct operation and to facilitate testing and maintenance.

The relay system is divided into eight main features, some of which are sub-divided, as follows:—

Feature No. 1—Generator protection.
Feature No. 2—Transformer protection.
Feature No. 3—220-kv. line protection.
Feature No. 4—Generator standby protection.
Feature No. 5—Transformer standby protection.
Feature No. 6—220-kv. bus protection.
Feature No. 7—Station service protection.
Feature No. 8—Annunciator system.

The various relays for each feature are installed close to the equipment to be protected. Due to this fact, the current transformer secondary differential loops are of minimum length and are well balanced as to resistance.

Each individual relay is equipped with an operation indicator and the operation of each feature is announced automatically in the control room by a distinctive light and a general alarm bell. For features that trip breakers, an annunciator plate is provided, hinged to one end of the control and meter board, on which is engraved the single line diagram of the generating and transformer stations with small lights to represent each relay feature.

A separate annunciator system, in the control room, indicates the operation of relays which do not trip breakers and the failure of voltage to the line relays, to the 250-volt d.c. relay bus and to the generator lubricating oil pumps. This also includes indication of various mechanical troubles such as failure of oil pressure, water pressure and abnormal bearing temperature. The signals pertaining to generator troubles are duplicated by a small annunciator at each generator.

The relays installed for the generator and transformer differential protections are of the instantaneous ratio differential type. A voltage timer incorporated in the transformer relays prevents faulty tripping when energizing the transformers. In case of a sudden drop in voltage, there is sufficient contact opening time lag in this timer to permit proper operation of the relay for transformer faults. These relays will operate in approximately one cycle.

The 220-kv. line relaying is of the directional distance type for phase-to-phase and phase-to-ground faults. The phase-to-phase protection contains a directional element and an instantaneous distance element with a range extending as near to the remote end of the line as is possible without actually being effective for terminal faults. This protection is selective with some margin with the instantaneous relaying of the terminal station. The phase-to-ground protection contains a directional element, a ground distance instantaneous element and a ground distance timed element. A test device is also provided which gives temporary instantaneous non-directional protection for the total length of the line while it is being energized or tested. There are three primary phase-to-phase and three primary phase-to-ground relays on each line, each relay having an individual annunciator light in the control room indicating on which phase the fault has occurred.

The distance and directional relays require sources of potential which are proportional, with sufficient accuracy, to the 220-kv. line phase-to-phase and phase-to-ground voltages. These are provided by condenser bushing potential devices operated from the bushings of the 220-kv. circuit breakers. There are two circuit breakers per line connection, either one or both of which may be used. A voltage selector relay automatically supplies potential to the line relays from the devices of the breaker carrying the line. In case of failure of a device itself, the selector relay transfers to the other set of devices. Normal operation is, of course, with both breakers closed.

The standby relays of features No. 4 and No. 5 are impedance distance type with an instantaneous element and a timed element, the contacts of which are in series and with a directional element the contact of which is blocked closed.

The relays for the 220-kv. bus protection are low range instantaneous overcurrent type, there being two sets of relays for each bus, connected to separate sets of current transformers to act as a duplicate protection. These relays operate through their respective auxiliary trip relays connected in series to guard against improper operation.

The station service transformers are protected by instantaneous overcurrent relays set at a current slightly exceeding that which can be obtained by a dead short circuit on the low voltage of the transformers and by a low energy type relay with geared contacts for ordinary overcurrents. The latter are set to be selective with low voltage feeder relays.

Telephone and Signal Systems

A manually-operated telephone switchboard is incorporated in the operator's desk in the control room. The Commission's lines from its Niagara and Madawaska systems, the line from the Gatineau Power Company, and thirty local lines around the plant and from the operators' settlement are centralized at this switchboard. Isolating transformers are inserted in all circuits which extend beyond the station ground mat.

Two signal systems are provided, one for calls within the power house and the other for remote outside points. The former consists of a vacuum operated two-tone horn and a large annunciator in the generator room on which are denoted the numbers of the eight units. Code signals are given on the horn by a key on the operator's desk. Separate keys control the unit designations on the annunciator so that the floorman may be despatched to any desired machine.

The outside signal system comprises five motor-driven horns, one located on each of the four stop log sluiceways and the fifth on the power house roof. These are controlled by keys on the operator's desk and are audible from any point within a mile radius from the power house.

Oil Systems

There are four oil systems each comprising storage, filtering and handling equipment. One system is for the generator lubricating oil and three systems are for the insulating oils.

The generator lubricating oil system consists of individual motor driven pumping units at each generator. An oil reservoir is provided in each generator sufficient to provide gravity lubrication for the time required to replace a pumping unit in the event of failure. For replacing oil in any of the generators and for purifying the oil, two 1,200-gallon tanks and a special pressure filter equipped with an oil pumping unit the same as those at the generators are installed on the first gallery. The oil is handled from a generator to the storage and filtering equipment by flexible hose connecting to separate pipe lines for the used and filtered oil.

Each of the three insulating oil systems consists of a filter and sufficient storage capacity to empty any piece of electrical equipment which it serves and to hold sufficient good oil for replacement. One system is located on the second gallery of the power house for the 13.2-kv. and service equipments. Another system is located adjacent to the 220-kv. switchyard for the 220-kv. oil circuit breakers, and the third system for the transformers has the filtering equipment in the pump house, and the storage tanks located outside adjacent to the power house and transformers.

There is a total of 245,000 Imperial gallons of insulating oil in the various equipments of which amount the 13.2-kv. equipment requires 5,000 gallons, the power transformers 118,000 gallons, and 220-kv. oil circuit breakers 122,000 gallons.

Operators' Houses

Permanent accommodation for the operating staff has been provided by the construction of six brick houses on a site adjoining the village of Fitzroy Harbour. Water supply, electric power and telephone service are available to these houses. The site has been laid out for sixteen houses.

Electrical and Hydraulic Tests at the Chats Falls Development

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Paper presented at the General Professional Meeting of The Engineering Institute of Canada, Ottawa, Ont., February 8th, 1933.

SUMMARY.—The various tests included those made to check the correctness and insulation of wiring and the proper adjustment of equipment, and also those carried out on the generators and turbines to determine their characteristics and efficiency. The methods employed are described and discussed briefly, but actual results for efficiency, power and discharge are not yet available.

The electrical and hydraulic tests described in this paper are those having interest because of the methods applied to solve the particular problem in each case, or for some other reason that will be evident. It is not considered necessary to describe the development, as that has been done in other papers. Descriptions, therefore, are limited to parts under test or test equipment.

Electrical Tests

Tests made in the field on the electrical equipment were of two kinds:—

(1) Those necessary to check the correctness and insulation of wiring and the adjustment of equipment that had been erected in the field.

(2) Those made on the generators to determine if guarantees had been met, and whether the generators were, in fact, as required by the specifications covering them.

A detailed description of the tests made is beyond the scope of this paper, so only those which are considered to have some special interest will be discussed.

Tests made under the first group included: high potential test (momentarily) at 39 kv., on coil groups of stator windings; checking of all control wiring and high potential test on control and power cable; checking and adjustment of all relays and associated current transformers before placing in service, adjustment and test of low voltage and high voltage circuit breakers.

Each main transformer bank received a test run on short circuit for twenty-four hours with transformer oil at 75 degrees C. to release entrapped air in the oil. As it was estimated that the transformer oil would not reach 75 degrees C. with full load current from one generator, two generators were used, paralleled on the low voltage bus. It was found possible to synchronize the generators, by closing them in together on the transformer bank with no excitation, bringing up the fields on each together, and finally making slight adjustment of speed on the units until they pulled in step.

Tests of Protective Relays

Tests were made on line relays by closing in on a metallic short circuit at 220 kv. through 200 miles of line. After relays had been adjusted, a further test was made by closing in on a three-phase short circuit on the Chats Falls high voltage bus, made by placing a 3-ampere fuse across a section of 220-kv. bus, and clearing the fault by relay operation. The latter test was made with the system in normal operation, and checked the selectivity of all relays in the station, as well as the time required by the high voltage circuit breakers to clear faults.

Measurement of Station Ground Resistance

As very special attention had been given to the design of an adequate station ground, and as the facilities for the establishment of this ground were very poor, due to the rocky nature of the site, tests were made to determine station ground resistance. Initially, tests had been made to determine ground conductivity, and to assist in the selection of a suitable location for the ground plates. After the latter had been established, and the grounding system completed, a test by the volt-ammeter method was made, using a telephone lead fifteen miles long to a point of neutral ground potential. The station ground resistance was 1.05 ohms as measured. Potential gradients around the station were measured as well, so as to assist in the proper location of isolating transformers for communication and other circuits extending beyond the area of the station grounding system.

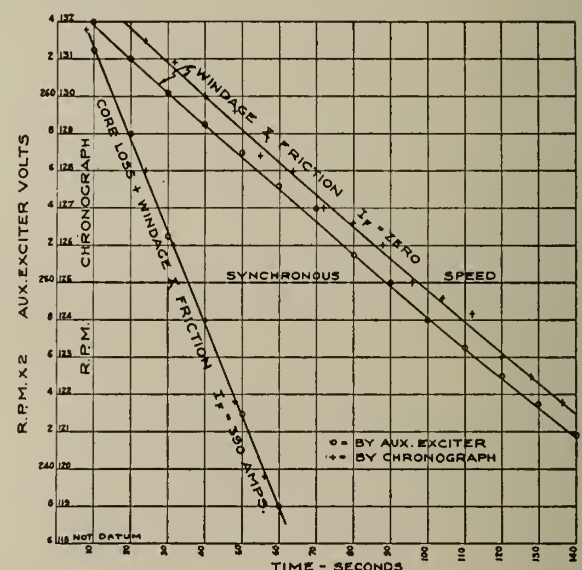

Fig. 1—Typical Retardation Curves.

Generator Acceptance Tests

The tests made on the generators, except high potential tests which were made before each generator was placed in service, were all made after erection of the eight units had been practically completed. The specifications called for complete tests to be made on each unit, but this was not adhered to. Only those tests were made on each unit considered necessary to establish whether all generators could be reasonably assumed to have similar electrical characteristics.

A schedule of tests was drawn up, fitting the tests into the erection schedule on the second four units and arranging it so that the electrical and turbine tests would not conflict. Arrangements were also necessary so that operation could be carried on without interruption, and the requirements of the power contract met.

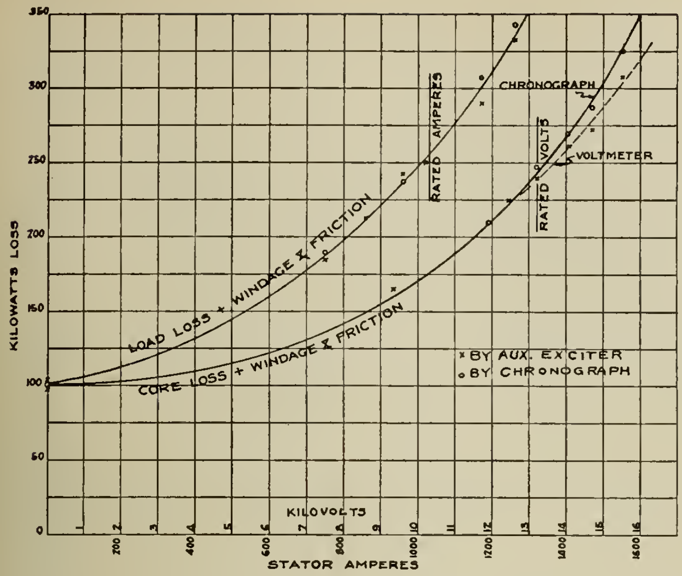

Fig. 2—Generator Losses Determined from Retardation Tests.

Tests Made on All Generators

Tests made on all generators were:—

Cold resistance, stator and field windings.

Open circuit and short circuit saturation.

Insulation test, stator and field.

Check on open circuit saturation, main and auxiliary exciters.

Test and adjustment of voltage regulators.

Check on phase rotation.

Overspeed test (with one exception).

No departure from standard methods of test occurred in any of the above tests, except possibly in the measurement of cold resistance. For this test, a 6-volt battery and low range voltmeter were used, and considerable time saved in the measurement. Results were consistent, and there appears to be no reason why this method should not be used generally, if proper care be taken. However, if the cold resistance measurements are to be used for the determination of temperature rise of a winding on heat run, the same meters should be used for determination of both cold and hot resistances, which prevents the use of low range instruments.

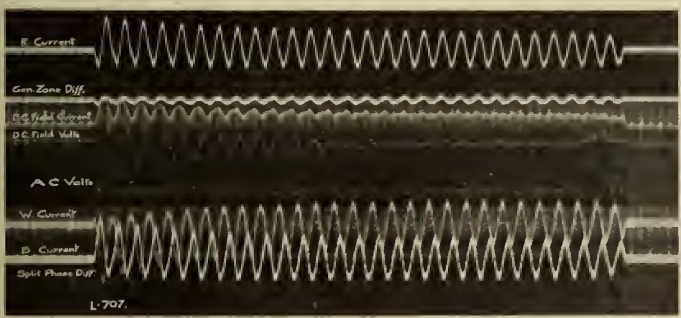

Fig 3—Record from Sudden Short Circuit Test at Rated Voltage.

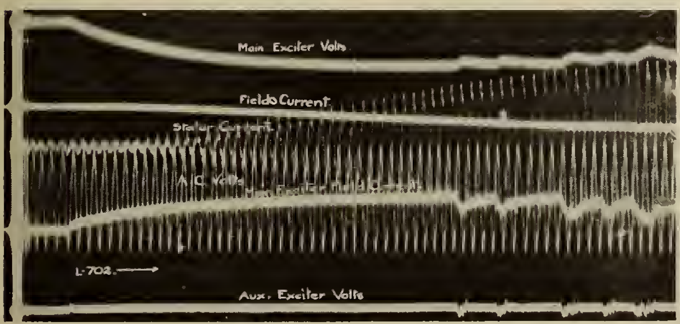

Fig. 4—Record from Test of Excitation Response.

The overspeed test was limited to 1.7 times rated speed, and voltage was built up to 23 kv. on the generator while operating at overspeed, and held at this value for one minute. A curve of gate opening/speed indicated that the maximum speed of the units would occur at 10/10 gate, and would be approximately 221 r.p.m. at normal head.

One generator only received a sudden short circuit test at normal voltage, and the insulation test on its windings was made immediately following the short circuit and overspeed tests.

Tests Made on One Generator Only

Tests made on one generator only were:—

Heat run.

Measurement of core loss, windage and friction, load loss.

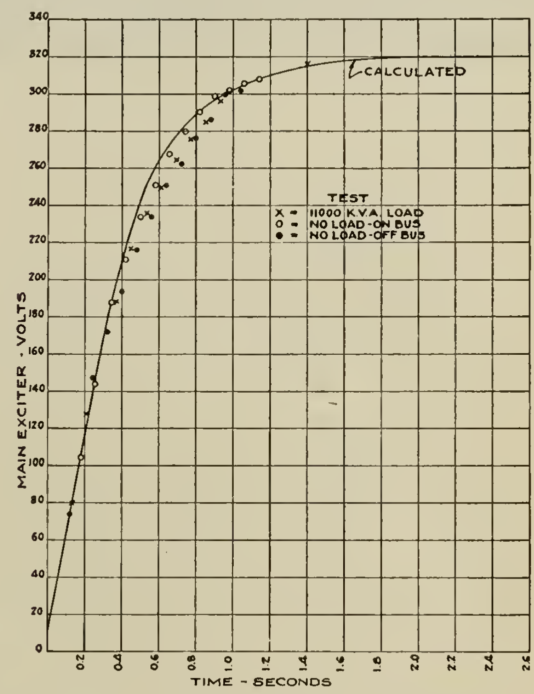

Fig. 5—Voltage Response of Main Exciter.

Zero power factor saturation.

Sudden short circuit test.

Measurement of voltage response of main exciter.

Test to determine sensitivity of split phase relay protection.

Two heat runs were made with commercial load, one at rated load current, the other at 1.1 times rated current, the kilowatt load being the same for both tests. The duration of each test was until constant temperatures of windings and core iron were reached.

Measurement of Losses

Losses were measured by the retardation method. One generator was disconnected from its turbine, and was driven by another generator. The excitation for both was supplied by the main exciter of a third unit, this being necessary so that the unit under test could be started from rest. After the initial start, a great deal of time was saved by synchronizing the generator under test with its driving generator, as the former decelerated through the fixed speed of the latter. This was done by lowering the speed of the driving generator to 10 per cent below normal immediately after the two generators had been separated electrically. At about 8 per cent below rated speed on the generator under test, fields were opened on both, and the main circuit breaker closed, followed immediately by closure of both field breakers. As the field currents built up, the generators synchronized quickly, after which speed was raised, and another retardation test made.

Accurate measurement of speed is absolutely essential on this test. A chronograph was used which records the number of revolutions made by the generator during a short time interval, which is also accurately determined.

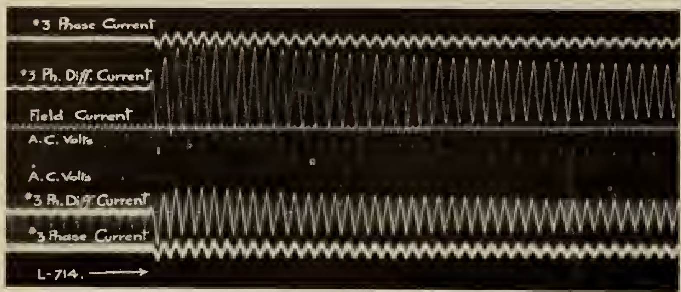

Fig. 6—Record from Test on Split Phase Relay Protection.

The average r.p.m. for the interval can thus be determined. The possibility of using the auxiliary exciter (separately excited) as a tachometer was also investigated, and it was found that, if reasonable care be taken, the exciter can be so used. As chronographs are not usually available, the fact that the auxiliary exciter, or its equivalent, can be used for speed determination is worth noting. The computations from the chronograph records are also tedious, so that the direct measurement saves time, with little or no sacrifice in accuracy.

Fig. 1 shows typical retardation curves, and Fig. 2 the losses as determined by each method.

The zero power factor saturation curve was taken immediately following the measurement of losses. It is usually impossible to circulate full load current at zero power factor between two hydraulic generators of conventional design, because of the relatively high synchronous impedance. No difficulty was experienced in this case, however, as these units have relatively high short circuit ratio (1.34).

Fig. 3 shows the oscillograph record taken on the sudden short circuit test. The transient and sub-transient reactances, as determined from this record, agreed closely with design figures.

As special provision had been made in the specifications covering these generators to obtain a unit with quick response excitation, a number of tests were made on the excitation system of one generator to determine if the response was in fact as the designer had predicted. Fig. 4 is a typical record, and Fig. 5 shows data taken from several such records compared with a curve of voltage response submitted by the manufacturer before the generators were built.

The test on the split phase relay protection was made to determine if this relay would operate if one coil of the stator winding at the neutral end was short circuited. Temporary leads were brought out from one coil at the neutral end to an oil circuit breaker, which was closed and opened manually. The tests were made at reduced voltage to limit the short circuit current to a safe value. Fig. 6 is an oscillogram taken on these tests. The tests indicated that this protection was very sensitive. Relays on one of the sound phases operated as well, due presumably to magnetic coupling between phases causing a circulating current in the sound phase.

Observations made during tests at this and other generating stations indicate the desirability of always conducting as thorough tests as can reasonably be made before a station is turned over for final operation. There are always some defects that can best be remedied when discovered in this manner. The data obtained are often invaluable, both to manufacturers' and utilities' engineers.

The advisability of careful planning beforehand where an extensive series of tests is to be made was well demonstrated during the generator tests at this station. The schedule as laid out could have been met in no other way, and its completion proved that in this, as in other engineering work, the closest co-operation between various departments—operating, erection and testing—was essential to whatever results were accomplished.

Hydraulic Equipment

The turbines at the Chats Falls development are eight in number, of the fixed blade propeller type, rated at 28,000 h.p., 125 r.p.m., 53-foot head, specific speed 140. Each receives its water supply through three intakes, 15 feet wide, and 23 feet to 20 feet high, which unite 28.25 feet downstream from the headgates to form a single rectangular channel which is the beginning of the transition to the scroll case. The guide vanes are twenty in number, 7.33 feet high and have a clear opening at full gate between successive vanes of 22.53 inches. The turbine runner is 16 feet 2½ inches in diameter; the upper edge of the vanes is at elevation 190.25, and the lower edge at elevation 186.25. As

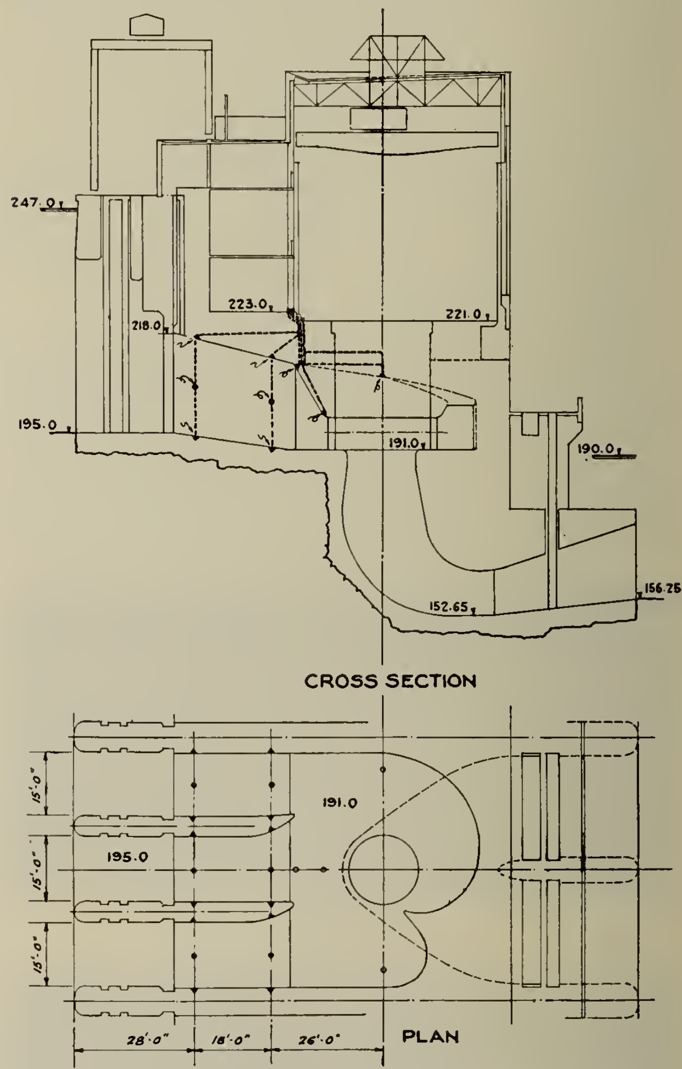

Fig. 7—Piezometer Opening and Piping for Gibson Tests.

minimum tailwater is at elevation 189.0, it will be seen that the turbine runner is at all times partly or completely below tailwater level.

Hydraulic Tests

The hydraulic tests had as their objective the determination of the characteristics of the turbines, and the determination of their capacity, efficiency and water economy. The discharge of one turbine at full gate is about 6,000 cubic feet per second. Methods of measuring this

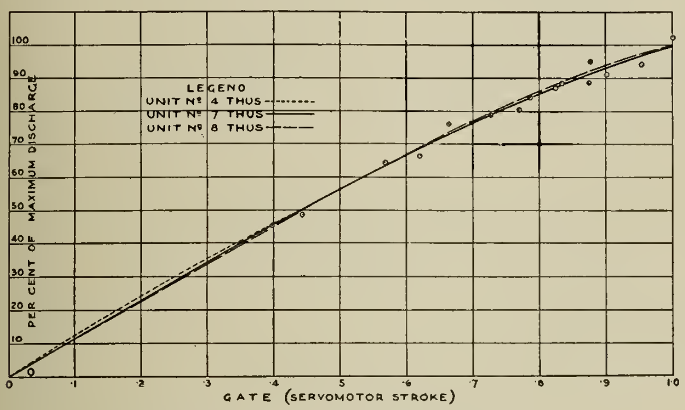

Fig. 8—Gate Discharge Relations.

discharge for the purpose of rating the turbines were considered during the progress of the design of the plant. The supply channels are probably shorter than any others upon which measurements have been attempted by means of the Gibson time-pressure method, but, as very satisfactory and consistent measurements had been made using this method on turbines at the Alexander power development, the decision was reached to apply it also at Chats Falls.

At the Alexander power development the supply pipes are two in number, 30 feet long, 18 feet wide, and 19 feet to 12 feet high. Gibson instrument taps, installed for a differential test, were 22 feet apart. Tests were made on three units, and were unusually consistent with each other and with results derived from model tests, in spite of the restrictions imposed by the length of the supply pipes. Although the available distance between taps was less at Chats Falls than at Alexander, it was considered that the Gibson method possessed certain advantages over other methods that warranted its application in this case.

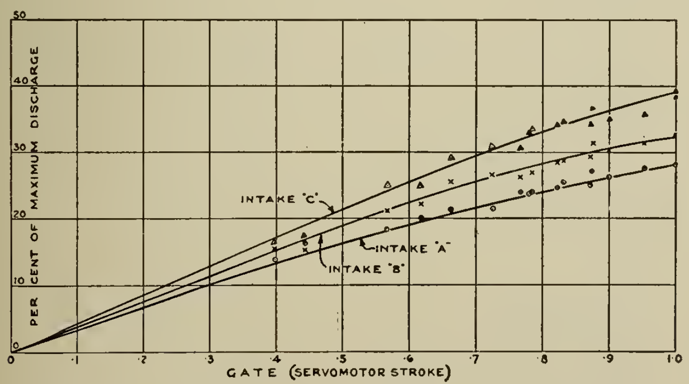

Fig. 9—Distribution of Discharge Between Supply Pipes.

Accordingly, provision was made for the tests by erecting in the concrete around both upper and lower ends of each of the three water passages, a ring of piping with outlets into sides, top and bottom of the passage. Connections from these were carried to outlets on the power house floor at points convenient for placing Gibson instruments. The distance between upstream and downstream outlets was 18 feet. Fig. 7 shows the piping system for the Gibson tests.

The Gibson Time-Pressure Method

Only the briefest explanation of the Gibson time-pressure method of measuring water may be given here. The method is one of the few that are rigidly correct in principle. It is based on Newton's second law of motion, namely: "Change in momentum is proportional to the impressed force. . . ," or, as usually expressed in dynamical units, $Pt = m\ (v - u)$. To effect a discharge measurement in the case of a turbine test, the turbine gates are closed in suitable time, and the pressure changes resulting during the period of closure, as indicated by the movement of a mercury column, are photographed on a moving film. The diagram on the film has time as its horizontal, and force as its vertical scale. Analysis of the record on the film permits the measurement of an area which is proportional to the product of P and t in the above formula. Measurements of the supply pipe give the information from which the mass of water brought to rest may be calculated, and the remaining quantity $(v - u)$, the reduction in velocity in the supply pipe, may then be determined by solution of the equation. The velocity v is that at the time at which the turbine gates commence to move, and u the velocity at the end of their movement, or the velocity corresponding

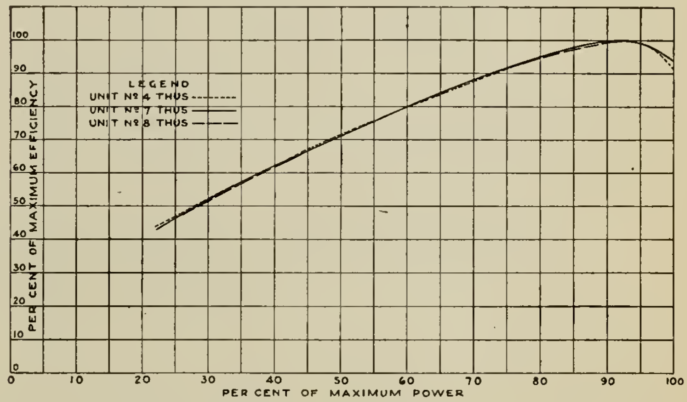

Fig. 10—Power Efficiency Relations.

to turbine gate leakage. If the leakage of the turbine gates when closed is determined, the total flow at the time the gates commence to move is known.

In practice, the connections to the Gibson taps in the supply pipes are led to a U-tube, on one side of which is a calibrated glass tube, and on the other a steel tube of uniform diameter, much larger than the glass tube. The glass tube, with mercury in it, is fixed in front of a slot in the camera, in which the record film is placed, and light cannot pass through that part of the tube filled with mercury. As pressure changes take place in the supply pipes, the mercury moves up and down, its movement being directly proportional to the change in pressure, and the record on the moving film thus records the changes in pressure.

Test Procedure

It was anticipated that the discharge would be different in different supply pipes, and, in any event, it was considered essential that separate measurements of flow should be made in each passage. Three Gibson instruments, therefore, were used. The restricted length available between the Gibson taps and the low velocities in the supply channels introduced a difficulty that was experienced in a minor degree in the Alexander power development tests, namely, that the area of the pressure-time diagram would normally be very small. It was attempted to obtain a larger diagram by substituting acetylene-tetrabromide for mercury. This liquid has a specific gravity of 2.94 and may be coloured red to prevent the passage of light rays of high actinic power. A number of tests were made using this liquid, and compared with similar tests in which mercury was used. The results were the same in both tests, and, as the acetylene-tetrabromide gave difficulty on account of its mobility, and as it tended to form an emulsion at the plane of contact with the water, thus resulting in an indefinite boundary to the pressure-time diagram, mercury was used in all succeeding tests. The results obtained warrant further investigations with this liquid, however.

It is possible, in most cases, to determine the instant of closure of the turbine gates from the Gibson diagram itself with considerable accuracy, but methods ordinarily applicable were not satisfactory in this instance. Special auxiliary shutters were therefore installed in the cameras and operated electrically. A contact was fixed on the servomotor piston rod, which closed the shutter circuit and opened the shutter when the servomotor piston reached the end of its stroke. The light passing through the aperture, controlled by the auxiliary shutter, drew a line at the bottom of the diagram, the beginning of which marked the end of movement of the turbine gates. This, along with the time-stroke diagram of the servomotor movement recorded by a chart-drawing instrument, gave information from which the beginning and end of the pressure-time area were determined accurately.

Readings of headwater and tailwater were taken on five float gauges installed in stilling boxes. Power measurements were made by a calibrated watthour meter and a portable wattmeter, and sufficient additional readings were taken on portable instruments to permit generator losses to be computed for each run. All portable meters were calibrated in the laboratory.

Results of Hydraulic Tests

Figs. 8, 9 and 10 illustrate some of the results of the hydraulic tests. Unusual consistency in measurement of discharge was obtained. Fig. 8, giving the relation between gate opening and discharge for three units, illustrates this. In plotting the results on this and Fig. 9, the observed results have been corrected for head, and these corrected figures have been divided by the discharge of unit No. 7 at full gate to obtain the percentage of maximum discharge. The discharge curves for different units were plotted independently on separate sheets, and the combination of these three separate plots used to make up Fig. 8. The correspondence of the separate results is remarkable. For all practical purposes, a single discharge curve might be used.

The correspondence of the individual discharge measurements with the mean curve for unit No. 7 is shown by the plotted points on Fig. 8, which are all for this unit.

The variation in discharge between supply pipes is shown in Fig. 9. The results here are for unit No. 7. The other units show about the same distribution of discharge between supply pipes. All percentages in Fig. 9 are based on the discharge of unit No. 7 at full gate.

The efficiency curves shown in Fig. 10 exhibit the same consistency as the discharge measurements. Power measurements have not been shown, but these also are very consistent. The efficiency is well sustained at part gate for units of as high specific speed as these.

The writers regret that they are not at liberty at this time to give actual results for efficiency, power and discharge, as final agreement on all tests has not been reached.

Discussion on "Modern Developments in Heating Practice"

Paper by G. Lorne Wiggs, A.M.E.I.C.[1]

Karel R. Rybka, A.M.E.I.C. [2]

Mr. Wiggs stated (on page 462) that research work recently conducted by Professor Allcut of the University of Toronto, "seems to indicate that there is a difference in the amount of heat given off by identical concealed radiators when fed by steam and hot water at identical temperatures. As between these two heating mediums at the same temperatures, the tests indicated a drop in output for hot water. No satisfactory explanation of this rather startling aberration or fact from supposition has yet been adduced but it is thought to reside in the disparate qualities of the two mediums."

It is the object of the writer to show that the above fact is neither an aberration nor startling.

Although the American engineering practice has stubbornly neglected the difference of some 15 per cent between the output of exposed radiators fed by steam and hot water at identical temperatures, its existence has been known for over twenty years to such prominent investigators as Dr. Rietschel, Dr. Brabbée, Dr. Schmidt and many others. This has led to the incorporation of this difference into the German and other European codes of requirements for building heating and has been rigidly adhered to for many years. An abstract of the data pertaining thereto is given in Table 1, and similar data are available in: Rietschel-Brabbées "Heating and Ventilation" (McGraw-Hill Book Company Inc., New York, 1927).

There is no reason to believe that concealed radiation should show a different conduct when tested under the same conditions as exposed radiators. As a matter of fact it is to be expected that the difference should be even more clearly established with finned radiation than with smooth surface, (†) although the values of Table 1 do not indicate it (the apparent discrepancies of some of the values are due to the necessary approximation of test values for the praxis and the second approximation due to the translation.

Table 1*—Heat Transmission Coefficients for Steam and Hot Water Radiation

Type of radiator	Heat emitted per sq. ft. per hour per degree F. difference between average temperature of surrounding air and heating medium.		
	Steam-Temp. diff. 150 deg. F.	Hot-Water-T. diff. 150 deg. F.	Hot-Water-T. diff. 90-110 degF.
One or 2 col. rad. old type:			
26″ high.....	1.75	1.5	1.40
32″ "	1.65	1.44	1.34
45″ "	1.58	1.38	1.28
3 col. rad. old type:			
26″ high.....	1.5	1.36	1.28
32″ "	1.44	1.3	1.25
45″ "	1.38	1.25	1.21
(Test radiators = 10 sections). Finned pipe ¾″ spacing.			
1 pipe	1.24	1.03	0.92
3 pipes above one another	0.92	0.82	0.82
partially interlocking 6 fins........	0.82	0.72	0.61

*Authority: Dr Brabbée, New York; Dr. E. Schmidt, Danzig.

(1) This paper was published in the October, 1932, issue of The Engineering Journal.

(2) 1135 Beaver Hall Hill, Montreal.

(†) Schmidt and Kraussold, "Waermeabgabe von Gliederheizkerpern" Gesundheits-Ingénieur, 1932, p. 77.

Table 2*—Surface Coefficients for Heat Exchangers
(in B.t.u. per sq. ft. per hour per deg. F. temp. diff.)

Still air	0.6 to 6
Air moving	2 to 100
Liquid hot, moving (not boiling)	40 to 1,000
Liquid boiling	800 to 1,200
Condensing steam	1,400 to 2,400

*Authority: Dr. E. Schmidt of Danzig and others.

The apparent reason for the difference in output is the difference in surface coefficients of heating surfaces enclosed in air, hot water or steam shown in Table 2. Even the fact that the inner surface of a radiator heated by steam is partly covered with condensation, does not materially alter the relation between the output of a steam and a hot water radiator, as the surface coefficients of boiling water are much closer to those of steam than to those of hot water.

G. Lorne Wiggs, A.M.E.I.C. [4]

The author wished to thank Mr. Rybka for bringing these facts to the attention of the readers of The Journal and of the author.

He had previously seen the figures shown in Table 1, as well as the values determined by Dr. Rietschel and also the graphs prepared by Professor A. H. Barker, the eminent English authority on hot water heating, but has never seen the figures shown in Table 2 nor any other reason for the difference. These figures are so difficult to determine and to substantiate that, as far as the author knows, they have not been determined by other authorities. The work of Dr. Rietschel was not referred to because the paper was intended to cover primarily the developments of heating practice in Canada.

(4) Consulting Engineer, Montreal.

Discussion on "Construction of a Variable Radius Arch Dam"

Paper by A. G. Graham, A.M.E.I.C.[1] with an Appendix by H. B. Muckleston, M.E.I.C.[2]

B. F. Jakobsen, [3]

In Mr. Jakobsen's opinion the most interesting features of this paper were the facts that the concrete in the dam was cooled during construction and thus the shrinkage largely obviated and that the pressure grouting actually was a success. This was shown by the fact that grout flowed from the telltale pipes and by the further fact that this grout tested nearly 7,000 pounds per square inch.

That concrete shrinks materially in setting might be seen on almost any arched-gravity dam, where it would be found that the contraction joints open up even when the reservoir is full and the downstream deflections of the cantilevers have partly closed the openings. In dams which were built without contraction joints, from three to four major shrinkage cracks and many minor ones could generally be found a few years after the structure has been completed. Shrinkage cracks could also be found in some arch dams when the reservoir is empty.

To offset the undesirable effects of shrinkage and enable a better utilization of the material, which implies a smaller section, pressure grouting was necessary. This had been well understood for many years, but the difficulties of practical application had been many. It would seem to be a relatively simple feat to pressure-grout a dam, but experience had shown that it actually was not so simple. When Mr. Jakobsen designed the nearly 400 feet high Pacoima dam and the 225 feet high Big Santa Anita dam for the Los Angeles County Flood Control District, both of them variable radius dams, he had provided split pipes in the vertical-radial contraction joints for the purpose of pressure grouting. Due to the fact that the concrete was not cooled during construction, it was intended to wait a couple of years before grouting, in order to give the concrete time to cool off and shrink, so that the contraction joints would open up.

Although engineer in charge of construction of these two dams, he had left the district before the concrete had cooled sufficiently to warrant grouting. His successor, however, proceeded to grout, with the outcome that the grout forced into the pipes was less than that required to fill the pipes.* Consequently no grout had got into the contraction joints and the whole operation was a dead loss. In addition the factor of safety was reduced.

(1) City Engineer, Nanaimo, B.C.
(2) Consulting Engineer, Vancouver, B.C.
(3) Consulting Engineer, Central Building, Los Angeles, Calif.
*Transactions, Amer. Soc. C. E., Vol. 95 (1931), p. 593.

The disadvantage of having to wait several years for the concrete to cool and the contraction joints to open up, was obvious, and this was avoided by the Vogt system of pressure grouting. When the dam is completed, it can be grouted and is then ready for service, and with the methods worked out for the Nanaimo dam and described in the paper, the grouting is bound to succeed. Moreover, a check is had on the success of the work.

Mr. Jakobsen observed also that one advantage of the water in the contraction joint was that it cooled the concrete, but it offered another advantage, that namely of keeping the joint wet. One difficulty generally encountered when grouting had been attempted was due to the fact that the grout encounters dry concrete surfaces, which immediately extract the water, so that the grout sets up and fails to penetrate into the joint. As a result the grouting process is a failure.

An examination of Figs. 5 and 6 showed that due to the great overhang of the downstream face at the crown section, the elementary arches in the Nanaimo dam are not horizontal, but approach closely to the true hydrostatic arch, in which the radius of curvature decreases as the water pressure increases. The overhang also permitted of larger central angles, i.e. smaller radii, towards the bottom than could be obtained if the dam was vertical. This was an advantage, since the larger central angles decreased the thickness of arch required. The great overhang was made possible and safe with the method of differential pressure grouting employed, which secured the dam against an excessive downstream deflection, that might produce a crack in the cantilevers at the base.

The advantage of a well designed variable radius arch dam over the usual gravity type was very striking in this case. The dam is practically 100 feet high from bedrock to crest and it varies in thickness from 10.5 feet to 3 feet, while a gravity dam of minimum base width would be about 67 feet wide. And this gravity dam would have no margin of safety and if even a little uplift should occur, the dam must depend upon tension between the concrete and the rock to hold it in place. This well illustrated the great advantage which the arch dam offered, where the site is suitable and when the dam is skilfully designed and constructed.

Mr. Jakobsen had been impressed with the care taken in the construction, in the production of the concrete and in the general handling of the work, and felt that the engineers connected with this work might well be proud of its successful completion.

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A Movement Towards Construction Recovery

At a time when there is almost complete cessation of construction work in Canada, one of the most obvious methods of attempting to relieve unemployment is to embark on a programme of public works. The representations which have been made to the Dominion government regarding this matter resulted in the Unemployment and Relief Acts of 1930, 1931 and 1932, under which various public works have been undertaken and financed jointly by the Dominion government, the provincial governments and the municipalities affected.

During the past three years, some eight million dollars have been spent by the Dominion government on this account, and these funds have been supplemented by correspondingly large outlays on the part of provincial and municipal authorities. So far, however, these endeavours have not proved adequate; in many cases the resulting cost was out of proportion to the results obtained. It is obvious that one very desirable object, the revival of the construction industry, has not been attained, largely because most of the works undertaken have been regarded primarily from the unemployment relief point of view. They have been carried out under great disadvantages, resulting from the necessary employment of inexperienced labour, and but little advantage has been taken of modern construction appliances. Even in the case of the trans-Canada highway, one of the most successful operations of this kind, the effect on the great body of unemployed in Ontario has been relatively small. At all events, there has as yet been no growth of confidence on the part of the private investor, and there await execution many public works which could be beneficially undertaken at this juncture if satisfactory arrangements could be made.

Dissatisfaction expressed with the results of our expenditure on public works as a relief measure has led to the expenditure of increasing sums on direct relief. In view of this past experience, and convinced of the necessity of securing the general co-operation of the construction industry in an effort to promote its recovery, a new development has recently been initiated by the Royal Architectural Institute of Canada, backed by The Engineering Institute of Canada and the Canadian Construction Association, in the form of a National Committee on Construction Recovery. This committee invited a number of other representative organizations to take part in its work, and, after some months of preparation, a three day conference was held in Toronto on February 6th, 7th and 8th, 1933. Seventeen associations interested in the construction industry took part in the conference, which was the first of its kind to include delegates from so many phases of the industry. The Engineering Institute was represented by three members appointed by Council: Messrs. A. H. Harkness, M.E.I.C., J. B. Carswell, M.E.I.C., and E. P. Muntz, M.E.I.C., and others of our members took part on behalf of other associations concerned.

Discussions took place on unemployment, methods of financing construction, stimulation of construction activity, and the conference approved of the formation of a national construction council, to represent all the interests which comprise the entire industry. Pending the establishment of such a permanent body, an Organization Committee was appointed consisting of one representative from each association represented at the conference together with the chairman of the five conference committees.

The following bodies were represented at the conference: The Royal Architectural Institute of Canada, The Engineering Institute of Canada, Canadian Construction Association, Canadian Manufacturers Association, Canadian Chamber of Commerce, Canadian Lumbermen's Association, Brick Manufacturers Association, Canadian Council of International Society of Painters and Decorators, Canadian Founders and Metal Trades Association, Canadian Hardwood Bureau, Canadian Automatic Sprinkler Association, Contracting Plasterers Association of Canada, Structural Clay Tile Association, Canadian Paint, Oil and Varnish Association, Canadian Institute of Steel Construction, Trades and Labour Congress of Canada, and the Canadian Ceramic Society.

The Organization Committee of the National Construction Council of Canada has now made its first move in asking the Prime Minister to confer with representatives of the Council to discuss the situation. It is understood that the request forwarded to Mr. Bennett was accompanied by a memorandum stating thoroughly the Council's objects and suggesting a policy which would further them. The main object is, of course, the revival of the construction industry in Canada, with the great benefits which this would give in relieving unemployment and helping to restore public confidence. The construction industry is of primary importance in the life of the Dominion, as will be realized from the fact that in 1929 it employed, directly or indirectly, about 370,000 workers, whose earnings affected about one-eighth of our entire population. In that year the total expenditure on construction projects, both industrial and engineering, amounted to 576 million dollars, a figure which had shrunk to 315 millions in 1931 and has since then diminished to less than ten per cent of the 1929 total.

The memorandum forwarded to Mr. Bennett advocates the elimination of direct unemployment relief as far as possible, and the formation of a finance corporation, under the auspices of the Dominion government, to pass on projects put forward as being desirable at the present time and assist by financing them. In this regard the memorandum states: "We recognize very acutely the great difficulties in providing funds for construction purposes of any kind, but we are firmly convinced that there is no alternative but for such funds to be procured. We suggest, therefore that a Construction Finance Corporation be formed under the auspices of the Dominion government for the purpose of passing on the merits or necessity of construction projects advanced, and assisting them by banking services or direct financing." It is recommended that certain classes of construction work be undertaken but under conditions differing from those obtaining in such work heretofore. In fact, it is believed that the unsatisfactory results of previous relief construction programmes can be avoided by putting relief construction work on a strictly competitive basis, by using the most modern available methods, and by employing qualified architects and engineers in private practice to plan and direct the works. It is proposed that a comprehensive survey should be made throughout Canada to find out what buildings and improvements are necessary and their relative importance, the ultimate decision as to their commencement to be in the hands of an impartial body, free from political affiliations.

In Canada, as elsewhere, there is much work whose construction is desirable as a matter of public benefit, but which private enterprise will not now undertake. The suggestions of the memorandum are as follows:

> "Realizing the great necessity of obviating any unnecessary duplication of buildings and other construction units, the following types of work are recommended as not involving such duplication:—
>
> (*a*) Self-liquidating works, the selection of which should be in the hands of an impartial body with no political affiliations. We mention such obvious suggestions as cold storage plants, water works and filtration plants, hospitalization and low cost housing.
>
> (*b*) Public works to replace rented premises where the elimination of rentals being paid by the Dominion government would justify a capital expenditure. In certain parts of the country we have post offices and customs houses in this category.
>
> (*c*) The replacement of buildings and other works which are obviously suffering from acute obsolescence and depreciation and which must be replaced within a few years under any conditions. This group would also include government buildings where the necessity of additions is very pressing at the moment. Under this group we suggest penitentiaries, county jails, provincial hospitals, welfare buildings and registry offices.
>
> (*d*) We should suggest that serious consideration be given to the re-establishing of the grade crossing fund and subsequent elimination of many dangerous grade crossings.
>
> (*e*) Our records show that there are in the province of Ontario no less than 114 municipalities with populations of 1,000 or over who are in real need of sewage systems, but who through lack of encouragement or assistance are unable to proceed."

It is interesting to compare these Canadian proposals with what has been undertaken in the United States. Similar representations with regard to the undertaking of public works have been brought forward there and the engineering societies have taken a prominent part in the movement which resulted in the passing of an Emergency Relief Act by Congress in July, 1932. This Act embodies many of the recommendations made by such organizations as the American Society of Civil Engineers and provides for loans by the Reconstruction Finance Corporation, both for direct relief and for the financing of self-liquidating public works. The total sum thus made available exceeds one and a half billion dollars, applicable to works undertaken by states and municipalities, including highway construction; the expenditure of large sums by the Federal government for public works under its own jurisdiction is also contemplated. District advisory committees have been formed in various parts of the United States to assist in regard to local projects and the Reconstruction Finance Corporation has invited more than forty well-known engineers to serve on these committees. Up to November 1st, 1932, according to *Civil Engineering*, loans for twenty-four projects had been approved, aggregating over 130 million dollars, the works including aqueducts, water supply and sewerage systems, irrigation systems and housing schemes. Two-thirds of the loans made so far are for loans less than one million dollars. The United States is thus definitely embarked on a large scheme of adequately secured Federal assistance for public works of a self-liquidating character, employing local labour and to be carried out by state and municipal authorities or private corporations.

The civil engineers of the United States have not only taken a prominent part in formulating the plan, but are individually co-operating by giving local assistance, largely without compensation, and the members of the profession have been generally invited to furnish suggestions and advice. This is particularly necessary to aid smaller communities in presenting their projects to the Reconstruction Finance Corporation, and in demonstrating that the proposals are self-liquidating and properly worked out as regards construction cost, operating and maintenance charges, and earning expectancy. The Corporation will only support projects which are proved to conform, within reasonable limits, with the provisions of the Enabling Act. A great opportunity is thus presented to our confreres in the United States to assist in furthering this important effort to put new life into the construction industry.

When, as is hoped, the representations of our National Construction Council are implemented by government action in Ottawa, a similar opportunity will be within the grasp of Canadian engineers. We believe that they will be prepared to accept it and take an active part in the recovery programme.

Canadian Engineering Standards

We have received advance copies of the first portion of Part II of the Canadian Electrical Code, which has just been issued by the Canadian Engineering Standards Association. It will be remembered that Part I of the Code contains rules and regulations governing the installation of electrical equipment in Canada, and has been generally adopted by public bodies throughout the Dominion. Part II will be supplementary to Part I, will consist of specifications governing the design, construction, manufacture and marking of such electrical equipment, and will prescribe the conditions which must be met to secure Laboratory approval for the sale and use of the various types of electrical equipment in Canada. The three sections just issued cover respectively: Definitions and General Requirements; Construction and Tests of Electrical Signs, and Construction and Tests of Electrical Equipment for Oil Burning Apparatus. These specifications are important as dealing with types of equipment in very general use and of comparatively recent development. Like all specifications issued by the C.E.S.A., they have been prepared on the basis of the fullest consultation with the manufacturers, industrial associations, underwriters and public organizations interested, and if adhered to, afford a very necessary protection to the public, by ensuring proper construction and eliminating unsafe and sub-standard apparatus.

Since January 1st, 1933, the work of approving and testing electrical equipment in Canada has been almost entirely in the hands of the Hydro-Electric Power Commission's Laboratory at Toronto. This Laboratory is now using a label system which indicates that approval is based on Canadian Electrical Code standards as prepared by the Canadian Engineering Standards Association.

Copies of these may be obtained from the Canadian Engineering Standards Association, Ottawa, Ontario.

Olivier Odilon Lefebvre, M.E.I.C.

President of The Engineering Institute of Canada

The Institute has chosen as its President for the coming year one of our prominent French-Canadian members, Olivier Odilon Lefebvre, D.Sc., C.E. In assuming his high office he follows in the footsteps of four other distinguished representatives of French-Canadian culture, Ernest Marceau, 1905, Arthur St. Laurent, 1923, Arthur Surveyer, 1924-1925 and A. R. Decary, 1927.

Dr. Lefebvre's record of active service, both as engineer and administrator, gives assurance that he will worthily uphold the best traditions of the chair. In his professional career he has been responsible for practically all of the important projects initiated by the Quebec Streams Commission to provide effective government regulation of the flow of the great rivers of the province whose power is being developed under private ownership. The Gouin dam, completed in 1917, controlling the flow of the St. Maurice; similar work on the St. Francis river, which was completed in 1918; the dam at Lake Kenogami, feeding the Chicoutimi and Au Sable rivers in the Lake St. John district; the Mercier reservoir at the head waters of the Gatineau, which was put into service in 1927; and the Cedar Rapids dam on the Lievre; all these were designed and constructed and are operated under Dr. Lefebvre's supervision as chief engineer of the Commission. He has also carried out on the larger rivers in practically all parts of the province a comprehensive hydrographic survey of their hydro-electric power possibilities, and has found time for a good deal of expert advisory and consulting work. In addition to all this, Dr. Lefebvre is one of the three Canadian members of the Joint Board of Engineers appointed to investigate and report on the St. Lawrence Deep Waterway. The work of this Board, commenced in 1924 and not yet terminated, resulted in the publication last year of the monumental report on the engineering aspects of the St. Lawrence Waterway scheme, which forms the basis of the negotiations pending between Canada and the United States regarding this great question.

OLIVIER ODILON LEFEBVRE, M.E.I.C.

During his thirty years' connection with The Institute, Dr. Lefebvre has taken an active part in its affairs, having served as councillor for five years and as vice-president for two years. His interest in the work of the Montreal Branch of The Institute has been no less marked, and from the first he has been concerned in the movement for the registration of professional engineers in the province, which culminated in the formation of the Corporation of Professional Engineers of Quebec in 1921.

Dr. Lefebvre was born in 1879 at St. Hugues, Bagot county, in the province of Quebec, and received his early education at Mont St. Louis College, which he left in 1898, proceeding to the Ecole Polytechnique, Montreal. He graduated there with honours in 1902. After some three years in the laboratories of the Department of Public Works in Ottawa, he became assistant to the Ottawa district engineer, and was engaged in river surveys and the construction of wharves, dams and other works carried out by the Department in that locality. In 1912 he was sent to Vancouver to make a complete survey of Burrard Inlet and False Creek. In 1913, leaving the Dominion service, he entered that of the province of Quebec as chief engineer of the Quebec Streams Commission, an appointment which he still holds.

He joined The Institute as a Student in 1903, became an Associate Member in 1912, and a Member in 1920. He is a member of the Corporation of Professional Engineers of Quebec, a Member of the American Society of Civil Engineers, and a member of the Administrative Board of l'Ecole Polytechnique, Montreal. In 1929 he received the Honorary Degree of Doctor of Science from the University of Montreal.

His many friends, both within and outside the government service, will join in congratulating Dr. Lefebvre on the well-earned distinction which has now been conferred upon him in his election as President of The Engineering Institute of Canada.

Address of the Retiring President

Dr. Charles Camsell, M.E.I.C.

Delivered before the Forty-Seventh Annual General Meeting of The Engineering Institute of Canada, Ottawa, Ont., February 7th, 1933.

CANADA'S POSITION IN EMPIRE MINERAL DEVELOPMENT

The present paper is intended to be something in the nature of a sequel to one which was delivered to the Canadian Institute of Mining and Metallurgy about a year ago. The subject of discussion at that time was "The Mineral Position of the Empire"—a subject so broad as to preclude any particular reference to Canada. The purpose now is to carry the examination of the Empire's mineral position somewhat further, but to do so by paying attention principally to the place occupied by this Dominion in respect to what may be termed the mineral economy of the Commonwealth.

Canada Internationally a Mineral Trader

The form which such a discussion as this must take, if it is to be at all useful, may not be as interesting as one could wish. It is necessary to dispense at once with generalities regarding the greatness and diversity of Canada's aggregate mineral wealth and to come to grips with the facts and, to some extent with the figures, that illustrate the Dominion's position with respect to specific mineral commodities. This country, like all others, but more so than most, is internationally a mineral trader—selling where we have a surplus and buying where we have a deficiency to meet—and it is only by considering separately each of the main mineral products that a clear picture of Canada's position can be brought into view.

With the exception of asbestos the Canadian mineral products that are exported in sufficient quantity to influence world prices are all metals. In addition to very large quantities of the major non-ferrous metals, gold, silver, copper, lead, zinc, aluminium, and nickel, Canada also produces an important part of the world's supply of such minor metals as platinum, palladium, cobalt, cadmium, and bismuth. It should be noted, however, that Canada's output of aluminium differs in one respect from that of the other metals mentioned, inasmuch as it is derived entirely from foreign ores, whereas the rest are practically all obtained from domestic ores.

Our Recent Mineral Trade

In 1930, the value of non-ferrous metals exported from the Dominion amounted to $154,319,429, or over 13 per cent of a total export trade in Canadian produce valued at $1,120,258,302. The chief market for Canadian metals has been in the United States which took in 1930 about 66 per cent of the total, as against about 10 per cent by Great Britain. In 1931, the export of Canadian non-ferrous metals, in common with that of other commodities, showed a very considerable falling off due to depressed trade conditions throughout the world, amounting to only $95,652,063, or about 12 per cent of a total export trade valued at $799,742,667. On the other hand, the proportion of non-ferrous metal exports going to Great Britain in 1931 increased to nearly 18 per cent of the total while there was a corresponding decrease to about 61 per cent in those going to the United States. This tendency to seek an outlet for surplus Canadian metal production in Great Britain rather than in the United States has, undoubtedly, been greatly stimulated during 1932 by two things, namely, the recently consummated trade agreements made with Great Britain, and by the practically prohibitive tariffs imposed by the United States on such metals as copper, lead, and zinc.* The change in the last half of 1932 has been most marked.

Among the non-metallic minerals which Canada exports by far the most important is asbestos. Of the total value of the non-metallics exported in 1930, viz. $28,545,069, $12,211,899, or over 40 per cent, is credited to that mineral.

The chief mineral products that Canada finds it necessary to import are iron, petroleum, and coal. In 1930, iron and its products to the value of $316,878,627 were brought into the Dominion, but, since by far the greater part of our importations of iron are in the highly manufactured form of machinery, etc., figures representing their value are not suitable for comparison with those representing the value of our metal exports, which are chiefly in form of commodities in the primary stages of manufacture or of raw material. Iron ore, all her requirements of which Canada secures abroad, was imported in 1930 to the value of $5,020,921; iron in the semi-manufactured forms of pig, ingot, blooms, and billets, to the value of $2,716,924; and rolling mill products, to the value of $61,894,114. Petroleum and its products, largely in the form of crude petroleum for refining, was imported in 1930 to the value of $78,768,061; and coal and its products to the value of $64,183,342. Petroleum and coal account for over 50 per cent of the total value of all imports classified in Canadian returns as of mineral origin, exclusive of iron.

When we consider the international aspect of our mineral industry the number of minerals that must be taken into account is not large. Although there are literally scores of commercial mineral products, most of them are produced and consumed only in relatively small volume. Much the greater portion of the world's mineral consumption, in point of value, is confined to less than a dozen minerals. If we examine our situation in regard to these principal minerals we shall have obtained a broad and fairly adequate view of where this Dominion stands in relation to the mineral development and needs of the Empire at large. Incidentally, it will be found that Canada, in common with every other country, not only in the Commonwealth but in the world, has, in respect to its mineral resources, some very important gaps or deficiencies, as well as many notable points of advantage.

Deficiencies Mainly Coal, Petroleum and Iron

For present purposes coal, petroleum, and iron may be considered together. As a group, these commodities are incomparably the most important items of world mineral consumption—much more so, indeed, than all other industrial minerals combined.

They form the very basis of our present industrialized civilization, accounting, as they do, for probably 80 per cent of the total annual value of the world's output of minerals. There is, also, considerable interdependence in their utilization. For example, coal or its products may, with little inconvenience, be replaced by petroleum, or vice versa, for many important purposes, the choice being determined largely by economic considerations; and, in the production of iron, coal is as essential as iron ore—in ordinary practice about one and a half tons of coal and two tons of iron ore being required to produce a ton of pig iron. In Canada they have a special feature in common inasmuch as the Dominion finds herself deficient in commercial supplies of all three—deficient in available coal, despite enormous reserves, due to the geographical situation of her coalfields, and lack of anthracite; deficient in commercial iron ores, due to the relatively low-grade quality of her known iron deposits; and deficient in petroleum, due to lack of adequate known resources. The fuel deficiency, it is appropriate to point out here, has been made up to a large extent by utilization of water powers; production of energy from this source is now roughly somewhat greater

*Figures used in this paragraph taken or calculated from those in the Canada Year Book, 1932.

than the entire amount of domestic and imported coal consumed annually. In other words were it not for our hydro-electric development, we would require to produce or import an additional amount of coal at least equal to our present consumption.

Of coal, the British Empire possesses within its own borders ample supplies for its own needs, with a heavy annual surplus for export. In regard to iron, the Empire possesses large resources but it has been accustomed to depend to some extent upon foreign supplies. The situation with respect to oil is rather peculiar. If we consider only those territories which are part and parcel of the Empire domain—the position is extremely weak. If, however, oil resources in areas which are under British mandate or in which British interests have acquired a considerable measure of commercial control, be taken into account, it may then be said that the oil supplies of the Empire are reasonably adequate.

Turning from the position of the Empire as a whole to that of Canada, the facts become radically different. In respect to no one of these three major minerals can Canada, in her present stage of development, be regarded as a surplus country. Indeed, quite the reverse is the case. There is a marked deficiency in Canada's capacity to supply her own needs, let alone to replace any foreign supplies which are now being imported by other Empire countries. Whatever may be the course of future development, it is a fact that Canada today fails by a very wide margin to meet her own needs either of coal, or of iron, or of crude petroleum. As to these three commodities the chief significance of Canada's position in relation to that of Empire mining development lies in the extent to which Canada's necessary imports might be obtained from other Empire countries. In other words, Canada looms up much more importantly as an Empire market than as a source of supply. In the interests of intra-Empire trade, it is fortunate that Great Britain is so well endowed with high-quality coals, and that at our very doorstep another British country—Newfoundland—possesses what has been described by a noted American authority as "probably the largest single reserve of high-grade iron ore in the world."

With regard to petroleum the Empire is not so fortunate, the only resources of any considerable importance within its political boundaries being the comparatively small oilfields of Trinidad, India, and British Borneo, of which Trinidad holds the most interest to Canada.

Striking Growth in Canada's Base Metal Industry

Those who have followed developments in Canada's base metal industry in the past decade, especially in respect to the metals, copper, lead and zinc could not have failed to note the decided change in the country's position as a producer of these metals. Though it is a departure from the immediate scope of this paper, a statement or two concerning that change seems imperative.

Some ten years ago, the total production of these metals was barely 100,000 tons; by 1930 this had increased to 400,000 tons. Since the relatively small output of ten years ago for each of the three metals was probably greater than the domestic consumption at that time or even now, it follows that this whole added production, of more than 300,000 tons a year must find a sale in markets outside the country. Canada has been launched, on a considerable scale, into the sharp international competition for metal markets. That has been one of the most significant changes that has occurred in the country's business structure in many years; and is a change which has not been as widely, and as thoroughly grasped as it should be.

Copper

Apart from iron which is quite in a class by itself in respect to the volume of annual mineral consumption, copper is the metal most heavily consumed in the world of industry. And, like iron, it is a mineral of which the Empire possesses great resources but which is imported in some measure from foreign countries. This position of partial dependence upon foreign copper supplies appears to be a purely temporary one, for there is now little doubt that the Empire's resources, if fully developed, are much more than ample to meet the Empire's needs of copper.

The maximum output of copper in Canada in any one year was that of roundly 152,000 tons in 1930. Installed Canadian plants for the refining of copper, backed by ample reserves of ore to keep them fully employed when the need arises, are, however, capable of producing about 200,000 tons of electrolytically refined metal annually, or more than sufficient to supply the normal consumption of Great Britain—the only important Empire market—after full allowance is made for our own domestic needs. If, therefore, we take into consideration the other parts of the Empire that will seek an outlet for their surplus copper in Great Britain, notably Rhodesia, which is just coming into large scale production, it is evident that markets outside the Empire must be found for a considerable portion at least of Canada's copper if her producing plants are to be operated at full capacity. The other chief Empire producer, heretofore, has been Australia with an output in recent years of rather less than 15,000 tons. Southwest Africa, Northern Rhodesia, the Union of South Africa, India and Cyprus have also been producers of copper ore on a scale relatively small compared with Canada.

The major Empire consumption takes place in Great Britain, amounting in fair times to about 147,000 tons yearly. On the record of past years the requirements of the United Kingdom, which itself is not a copper producer, appear to have been sufficiently large to have afforded a potential outlet for almost the entire supply of copper of Empire origin. But, as regards the future, it is not to be inferred that the United Kingdom market could, under any circumstances, be looked upon in that light. Canada's potential capacity for copper production has been greatly increased and, furthermore, the whole world outlook in regard to copper supplies has been vitally changed by the developments that have occurred in another British country—Northern Rhodesia. Immense as are the estimated copper ore reserves of Canada, these reserves, plus those of Australia, are not as great—according to estimates recently published—as the copper ore deposits that lie within British territory along the Rhodesian-Belgian Congo frontier. As these Rhodesian properties come more fully into production they are bound to enhance the strength of the Empire as regards supplies of this vital industrial metal, but they are likely also to lessen the commanding position now held by Canada among Empire copper producers, and to sharpen competition in the copper market of the United Kingdom. An instance of the changing outlook is to be found in the fact that a large refinery is to be brought into operation at Prescot, in Lancashire, to finish processing of Rhodesian copper for the British market. Fortunately for both Canada and Northern Rhodesia, their mines are among the lowest-cost copper producers in the world, and this, perhaps more than the extent of the ore deposits, adds to the strength of their position particularly in these days of over production and intense world competition.

It is to be noted that as a result of the recent Imperial Conference, Great Britain has made provision for granting a preference of 2d. a pound on copper imported from Empire countries. This was intended to assure to Empire copper producers a definite portion of the world's market and partly compensate us for the loss of the market of the United States—the world's largest consumer of copper—which, by the imposition of an import duty of 4 cents a pound, has practically closed its doors to the entry of all foreign copper.

Lead

The element of keen competition presents itself again when we come to consider the Empire situation with respect to lead. Lead is a very important factor in international metal trade. In times of buoyant industry the world's consumption of copper outruns that of lead by a substantial margin, but, on the evidence of the last two or three years, lead appears to be less subject than copper to the ups and downs of general business. The total tonnage of lead consumed in the world in 1931 is estimated to have been practically on a par with that of copper, although two years earlier, with industrial activity at a much higher level, the industries of the world were able to absorb roundly 200,000 tons more of copper than of lead.

Within the Empire, three countries—Australia, Canada, and India—are especially prominent in lead production, and there is also a material output in South-west Africa, and Newfoundland, and even in the United Kingdom itself. The annual output of lead from Empire sources has increased remarkably in the last decade and it is perhaps significant of the possibilities in this direction that the rate of expansion has been considerably greater than the rate of world increase in the same period. While world output was doubling the output of Empire lead more than trebled as is shown by the production in Australia increasing from roundly 63,000 tons in 1921 to 195,000 tons in 1929, in Canada in the same period from 34,000 to 159,000 tons, and in India (Burma) from 38,000 to 90,000 tons. World production in the same interval increased from 974,000 to 1,972,000 tons, figures which indicate very clearly the expanding requirements for this metal in world industry. More recent figures indicate that the production of lead fell off only very moderately in Empire countries up to 1931.

Prophets a few years ago predicted a lead famine would take place before 1929 because of the steady increase in industrial consumption coupled with the failure to discover new ore deposits of magnitude. What upset the prophecies and gave the world a plenitude of lead supplies was the general application of the process known as selective flotation to the extraction of the metal. This method of treatment of ores enabled higher recoveries of lead to be made and at the same time permitted successful exploitation of complex ores which had previously defied commercial treatment. It was the application of this metallurgical process which brought Canada steadily forward in lead production and placed her in fourth position in world output. A notable feature of Canada's development as a lead producer is that provision of refining facilities has kept pace with production and upwards of ninety per cent of the output is in the form of the refined electrolytic metal.

While the rise in lead production in Canada during the last decade has been more pronounced than in any one of the other major producing countries, increasing output has been the general experience and thus productive capacity has grown to an enormous extent. Considering the British Empire only, the annual lead production may be placed at roughly one-quarter greater than the consumption and under these circumstances a large tonnage of Empire lead now must find a market in foreign countries.

To sum up the position very briefly it may be said that Canada contributes greatly to the Empire's strength in regard to supplies of this important metal, but it might also be added with almost equal truth and point that the Empire's present surplus over its own requirements is so heavy that it would not fall very far short of meeting its own needs if Canadian exports were left wholly out of consideration. The latter statement is meant solely to emphasize the highly competitive position which Empire lead producers occupy in respect to Empire markets for their products.

Zinc

Zinc is a close running-mate of lead in many ways—in natural occurrence, in price, and in volume of world consumption. And it happens also that the Empire's position relative to zinc is essentially similar to that in respect to lead—that is, Empire countries produce collectively a substantial surplus over and above their own needs. Great Britain is, of course, the dominant zinc consumer within the Commonwealth, while production is pretty well divided among the overseas members. Canada holds a commanding lead in the output of refined zinc but, as regards the production of zinc ore, her leadership is shared with Australia. The other principal ore producers are India, Rhodesia and Newfoundland.

Probably the most significant statement that can be made about Canada's position in zinc is to point out that the Dominion is confronted with the problem of marketing more than four-fifths of her output outside of the country, a proportion which would be appreciably increased if production was brought up to the full extent of capacity. The picture of Canadian zinc production during the last decade is one of increase from 26,000 tons in 1921 to 119,000 tons in 1931, the latter figure representing probably 65 per cent of the British Empire's output of electrolytically refined metal. Canada has zinc refineries at Trail, British Columbia, and Flin Flon, Manitoba, the former of which, with a capacity of 146,000 tons annually, is the largest plant of its kind in the world. The two refineries have a capacity for producing electrolytic zinc of around 170,000 tons annually. Relative to the great expansion that has taken place in productive capacity, the increase in apparent domestic consumption of zinc has been small, the total requirements being normally well under twenty-five thousand tons annually.

Considered in relation to other producing countries, Canada has had a rise in zinc production in recent years no less meteoric than in the case of lead. Similarly most of the other countries have experienced a great expansion though in smaller ratio than in this Dominion. World production grew from roundly 493,000 tons in 1921 to 1,621,000 tons in 1929 and fell off to 1,116,000 tons by 1931.

It is to be remembered that in both zinc and lead output Canada has come along very rapidly in recent years. Our position is wholly different from what it was eight or ten years ago, and so too, is the position of the Commonwealth. Ten years ago the group of British countries were certainly not self-sustaining in regard to zinc, and it is highly doubtful whether they were in relation to lead. *Today they are, or can be, much more than self-supporting in both cases, and that change has been due in large measure to the advances of mining and metallurgical industries in this Dominion.*

Canada's Position in Other Minerals

Time permits only the most inadequate reference to other minerals. Special mention has been made of coal, iron, petroleum, copper, lead, and zinc, because, after all, they are the outstanding items of mineral consumption. Other minerals, and particularly other industrial metals, are not necessarily to be regarded as being of less importance, for many of them are absolutely vital to modern industrial processes and to other human needs, and are in some cases very widely used. But in discussing the different items of mineral production there is a real difficulty and a real need for care in trying to preserve a proper perspective. When we refer to coal, iron and petroleum we are speaking of minerals which are consumed every year, in good times and bad, in stupendous quantities; and when we consider such metals as copper, lead and zinc we are still dealing with commodities of which the industrial world normally requires in each case between one and two million tons annually. But when we leave this latter group we enter a range of mineral products which are relatively restricted in use. They may be, comparatively, very high in price but they are consumed only in terms of thousands of tons or pounds or ounces, as contrasted with millions or tens of millions of tons. In respect to many of these less-used but still immensely valuable minerals, the Empire is exceptionally well placed, and this Dominion has contributed in no small degree to the strength of that position.

Nickel

Nickel is an instance of this nature which at once presents itself. The whole world output of nickel seldom reaches 60,000 tons a year, and around 90 per cent of that output is of Canadian origin. The strength of the Empire's position, and the degree to which Canada accounts for that strength, need little further comment.

The importance of the nickel-producing industry in Canada and the changed conditions which have surrounded the industry in the last few years, however, suggest that a few further remarks concerning this metal and Canada's dominating position in its production may not be out of place.

The old conception of nickel as a war-time metal, useful mainly for armour plate, ordnance and projectiles, has been displaced by that of a metal of multiple peace-time uses. Research has now firmly established nickel as a basic metal of industry, a metal which is inseparable from every-day life, and probably quite as broad in its applications as any one of the base metals such as copper, lead or zinc. This development during the past decade is of the greatest significance; where once munition and armament manufacturers took about 90 per cent of the world's nickel production, producers of the metal now tell us that they take less than five per cent of a normally larger production.

Canadian nickel began to be an influence in the world markets for this metal in the early days of the present century and was soon the dominating influence. Production rose to 46,254 tons in 1918 only to fall away after the Great War to a low point in production of 8,799 tons in 1922. Thereafter through the energy and initiative of Canadian nickel producers the new demands for the metal began to be felt and the output from the Canadian industry once more rose rapidly, reaching a new peak of 55,138 tons in 1929. Production was only slightly less in 1930 at 51,884 tons but by the following year, owing to the reduced demands of industry, it had fallen to 32,833 tons.

In any consideration of the Canadian nickel industry in its relation to Empire mineral strength it is necessary to point out that the ore reserves on which the industry is founded assure not only predominating strength in nickel but a substantial addition to Empire strength in copper. Moreover, from the same resources, Canada has become the Empire's largest source of the platinum metals, because of the presence of these rare metals in the nickel-copper ore bodies. Production of nickel thus automatically brings into the market for metals large quantities of copper and important amounts of gold, silver and the platinum metals, including platinum, palladium, iridium, rhodium, ruthenium and osmium.

Few, if any, other Canadian mineral products have to be exported to the same extent as nickel. It is stated by the producers that the Canadian market absorbs less than one per cent of the output and that Empire countries as a whole use only approximately 15 per cent of the Canadian production. With relatively little production from other countries—New Caledonia remains the principal source of nickel outside of Canada—the Canadian metal finds its markets practically throughout the world and the exports are a very important item in Canada's international mineral trade. These exports are in the form of electrolytic nickel, nickel oxide and nickel in matte, and to produce the first two products, which are refined forms, Canada has a large refining industry situated at Port Colborne, Ontario. Other refining of Canadian nickel takes place in the United Kingdom, and at Kristiansand, Norway. The Canadian nickel industry is well equipped to take care of future demands with ore reserves, which may be counted on to last for a great many years, and productive capacity for an annual output of roundly 100,000 tons of the metal in the various forms in which it reaches the markets.

Cobalt

Cobalt also is a metal with which Canada's name has been closely associated for a number of years. The Canadian output, however, has been won almost entirely as a by-product of silver mining, and with the gradual depletion of the silver deposits of northern Ontario, Canada has been superseded as the world's chief producer of cobalt by the Belgian Congo. She is still, however, the only important source of cobalt within the Empire.

Tin

Tin is, of course, consumed in much greater quantity than nickel, but only to the extent of about 10 per cent of the use of copper. Nevertheless, it is one of the extremely valuable industrial metals. So far as tin is concerned, Canada figures solely as an Empire market, rather than as an Empire source. Fortunately the Empire's position is very satisfactory. Three British countries—the United Kingdom, British Malaya and Australia—ordinarily account for more than 80 per cent of the world's smelter output of this metal, although in regard to ore production the leadership of British countries is less pronounced.

Aluminium

Aluminium is another metal which should not be overlooked. The world output of aluminium has never reached as high as 300,000 tons in any one year, but it is one of the metals for which rapidly extending use is anticipated; and, already, the production of this comparative newcomer in the ranks of important metals is materially greater than that of tin. This is a case in which Canada during recent years has acquired a prominent position through the development of a large industry based upon cheap hydro-electric energy with the use of imported ores of Empire origin. Great Britain is also a substantial producer of aluminium but the Canadian industry accounts for a substantially higher output than does that of the United Kingdom, and Canada has consistently been for the last five years second only to the United States among the aluminium-producing countries of the world.

Asbestos

While the mineral asbestos does not rank as one of the major items of mineral consumption, it has been singularly important to Canada by virtue of the leading position so long occupied by this Dominion in the world's production of asbestos. Apart from Canada, there are valuable sources of asbestos in other Empire countries, notably in Southern Rhodesia, the Union of South Africa, and Cyprus. The chief foreign producer is Russia. Although the total tonnage of foreign output is very small as contrasted with that of Empire countries, the Canadian asbestos industry is one more instance of Canadian mining development which is compelled to meet strong competition not only from within but also from beyond the confines of the Commonwealth. World consumption of asbestos is increasing, but Canadian production, especially of the high-priced long fibres, is not increasing proportionally. A shortage of long fibre in Canada in 1928 caused a rise in prices that both encouraged production in foreign fields and enabled foreign producers to get a firm foothold in the market. Rhodesian producers, through the lowering of costs by increased production, are now able to market grades of asbestos that formerly it did not pay them to ship, and competition from this source and from Russia is having a serious effect on the Canadian industry, the prosperity of which depends largely on ability to market large quantities of low-grade material.

Precious and Rare Metals

Gold

Gold differs economically from all other metals inasmuch as its use in industry is to all intents and purposes negligible. The arts, however, consume about 50 per cent of the annual production. Its chief function—the great importance of which in international trade has been brought home to us during the last few years—is to serve as a universal standard of value and medium of exchange. Being itself the standard of value, the price of gold normally remains unchanged, but the uneven distribution of the world's stock resulting from the Great War has left many countries with supplies insufficient for their needs, and in these gold now commands a premium. Consequently there is a feverish activity both in the production of the metal and in the search for new sources of supply. This has been one of the most marked features of our own mineral industry within recent months.

Well over 70 per cent of the world's annual gold production comes from Empire countries, chiefly from South Africa which produces about one-half the world total. Canada, whose output is something over one-fourth that of South Africa, is the world's second largest gold producer. Production is increasing both in South Africa and in Canada, but at a higher rate in the latter than in the former, so that Canada seems destined to occupy, relatively, an even higher place in the future than at present.

Silver

Silver, though used more extensively in the arts and industries than gold, has in the past depended largely on monetary use for its value, and with the gradual demonetization of silver in all the chief countries of the world, except China, has fallen on evil days. The situation is further complicated by the fact that the major portion of the world's annual output of silver is obtained as a by-product of mining carried on primarily for some other metal or metals—chiefly gold, copper, lead and zinc. For example Canada's greatest silver producer is the Sullivan lead-zinc mine in British Columbia. Consequently, world output of silver depends, to a very large and increasing extent, on conditions in the base metal and gold mining industries rather than on demand.

Empire countries contribute about 18 per cent of the world's annual output of silver; and, in turn, Canada, the world's third largest silver producer, accounts for over 50 per cent of Empire production. Next to Canada, the largest silver producer within the Empire is Australasia (Australia and New Zealand), the total output of which amounts to about one-half that of Canada.

Platinum

Platinum is a metal that for the last five or six years had had to face steadily falling prices, due, in part, to the development of substitutes in its use, and, in part, to the advent of Canada and South Africa as important producers. It is estimated that the world's potential capacity for producing platinum is now at least double consuming capacity.

About 30 per cent of the world's production of platinum originates within the Empire—in Canada and South Africa. Canada's output is probably exceeded only by that of Russia, and it is also probable that at the present price of platinum, operators in Canada, where the metal is obtained as a by-product recoverable at very small cost, are the only ones making a profit on its production.

A similarly favourable position is held by Canada in the production of palladium, rhodium, iridium, ruthenium and osmium, other rare metals of the platinum group, recovered with platinum as by-products in the nickel-copper industry.

Radium

Radium may be mentioned as a final example of the diversified nature of the contributions Canada is making to Empire mineral development. The only radium refinery in the British Empire has come into operation just recently at Port Hope, Ontario, and there Canadian pitchblende ore is going through the processes of extraction which will give to the world a new source of radium. At this stage, it can only be conjectured what will be the importance of Canada's entry into the field of production of this element, which is known chiefly for its curative properties in treatment of cancer. It can be stated with some assurance however that within a reasonably short time Canada will be in a position not only to provide her own needs in radium for remedial, scientific and industrial purposes, but we hope will be able to enter world markets in competition with any other known source of supply.

Nothing except the limits of space could justify the omission of specific reference to other mineral products which, both singly and collectively, play no small part in Canadian mineral development and which, in future years, may be expected to contribute materially to the volume of intra-Empire trade. Enough has been said, however, to make it clear that the relation of this Dominion's mineral resources and industry to those of the Commonwealth at large is one of far-reaching significance. That relationship is not, and in the very nature of the case could not possibly be, a uniform relationship all along the line of important minerals. In regard to certain vital mineral needs other Empire countries are better equipped than Canada. In many other respects Canadian production is either wholly responsible for the Commonwealth's collective strength or is a main factor in helping to close what would otherwise be a wide breach between Empire supplies and needs. The two things that stand out most impressively are these, namely (1) that the collective mineral strength of the Empire as a whole far surpasses that of any other nation in the world, and (2) that the advances made by Canada in mining and metallurgical enterprises have within comparatively recent years added enormously to the mineral status of the Empire as a whole, so that today from the variety of its products Canada occupies in a mineral sense the strongest position in the whole Empire. The latent mineral wealth of the newer countries of the Empire has emerged into view much more slowly and more recently than their agricultural wealth, and there is good ground for the belief that it has not yet become fully apparent. That may mean, in the future, additional minerals of which the Empire will possess a surplus, and it may mean keener competition between Empire countries; but it will also mean greater and more varied industrial strength in the aggregate.

The outlook which faces producers of practically all metals except gold, in Empire and non-Empire countries alike, is not only a period of temporary over-production, but also the fact that potential world supplies are probably larger than ever before as compared with prospective world demand even under what may be considered normal economic conditions. Within the present century many fresh sources of supply have been made available, both through the discovery of new deposits and by advances in metallurgical practice—nor can the progressively increasing importance of reclaimed or secondary metal, as a source of supply in the metal trades, be overlooked. During the same time, it is true, consumption also has increased rapidly, but it is very unlikely that the sharp upward trend shown in recent years can be maintained indefinitely; indeed, it is a question whether from now on production and consumption curves for primary metal will not, in many cases, show a distinct flattening. The tendency is to seek new uses for the major industrial metals as much as to seek new sources of supply, and there is already more or less competition between different metals. Aluminium, for instance, competes with copper for the transmission of electricity; and copper, zinc, aluminium and nickel vie with each other in the building trades and for household equipment. The future growth of Canada's metal mining industries—with the exception of gold—will depend on their ability to obtain and to hold an even larger share of the world's markets than they do at present, probably in the face of more intensive competition than they have ever met before. For this they are, for the most part, excellently equipped with ample supplies of raw material and production costs that are among the lowest in the world.

The Forty-Seventh Annual General and General Professional Meeting

Convened at Headquarters, Montreal, January 26th, 1933, and adjourned to the Chateau Laurier, Ottawa, Ont., on February 7th, 1933

The Forty-Seventh Annual General Meeting of The Institute was held at Headquarters on Thursday, January twenty-sixth, nineteen hundred and thirty-three, at eight o'clock p.m., with Vice-President O. O. Lefebvre, M.E.I.C., in the chair.

The Secretary having read the notice convening the meeting, the minutes of the Forty-Sixth Annual General Meeting were submitted, and on the motion of C. K. McLeod, A.M.E.I.C., seconded by E. A. Ryan, M.E.I.C., were taken as read and confirmed.

Appointment of Scrutineers

On the motion of J. L. Busfield, M.E.I.C., seconded by E. G. Fiegehen, M.E.I.C., Messrs. J. G. Hall, M.E.I.C., and Raoul Langlois, A.M.E.I.C., were appointed scrutineers to report the result of the Officers' Ballot.

There being no other formal business, it was resolved, on the motion of Gordon McL. Pitts, A.M.E.I.C., seconded by Gordon Sproule, M.E.I.C., that the meeting do adjourn to reconvene at the Chateau Laurier, Ottawa, Ontario, at ten o'clock, a.m., on the seventh day of February, nineteen hundred and thirty-three.

Adjourned General and General Professional Meeting at the Chateau Laurier, Ottawa

The adjourned meeting was called to order by President Charles Camsell, M.E.I.C., at ten o'clock a.m. on Tuesday, February 7th, 1933. After messages of regret had been submitted, received from members and guests unable to be present, the Secretary announced the membership of the Nominating Committee appointed to nominate the officers of The Institute for 1934 as follows:

Nominating Committee 1933

Chairman: C. H. Wright, M.E.I.C.

Branch	*Representative*
Halifax Branch	A. F. Dyer, A.M.E.I.C.
Cape Breton Branch	W. C. Risley, M.E.I.C.
Saint John Branch	F. M. Barnes, A.M.E.I.C.
Moncton Branch	F. O. Condon, M.E.I.C.
Saguenay Branch	G. F. Layne, A.M.E.I.C.
Quebec Branch	Philippe Methe, A.M.E.I.C.
St. Maurice Valley Branch	J. H. Fregeau, A.M.E.I.C.
Montreal Branch	F. S. B. Heward, A.M.E.I.C.
Ottawa Branch	K. M. Cameron, M.E.I.C.
Peterborough Branch	A. L. Killaly, A.M.E.I.C.
Kingston Branch	A. Jackson, A.M.E.I.C.
Toronto Branch	J. J. Spence, A.M.E.I.C.
Hamilton Branch	J. Stodart, M.E.I.C.
London Branch	W. R. Smith, A.M.E.I.C.
Niagara Peninsula Branch	C. G. Moon, A.M.E.I.C.
Border Cities Branch	W. J. Fletcher, A.M.E.I.C.
Sault Ste. Marie Branch	J. H. Jenkinson, A.M.E.I.C.
Lakehead Branch	H. G. O'Leary, A.M.E.I.C.
Winnipeg Branch	N. M. Hall, M.E.I.C.
Saskatchewan Branch	H. R. Mackenzie, A.M.E.I.C.
Lethbridge Branch	G. S. Brown, A.M.E.I.C.
Edmonton Branch	F. K. Beach, A.M.E.I.C.
Calgary Branch	B. L. Thorne, M.E.I.C.
Vancouver Branch	Frank Lee, M.E.I.C.
Victoria Branch	J. P. Forde, M.E.I.C.

Award of Medals and Prizes

In asking the Secretary to announce the winners of the various prizes and medals of The Institute the President stated that the formal presentation of these would take place at the Annual Dinner of The Institute. The following awards were then announced:

The Past-Presidents' Prize to B. H. Steeves, A.M.E.I.C., for his paper on "The Effect of the Development of the Electronic Valve upon Electrical Engineering and Industry."

Leonard Medals as follows: Gold Medals to W. B. Boggs and J. N. Anderson, MM.C.I.M.M., for their paper on "The Anode Department of Noranda"; A Silver Medal to R. D. Parker, M.C.I.M.M. for his paper on "Ventilation of the Frood Mine."

The Martin Murphy Prize to J. H. Mowbray Jones, Jr.E.I.C., for his paper on "The History and Development of Fourdrinier Paper Making Machines".

Report of Council and Report of Finance Committee

In passing to the Report of Council and the financial statement for the year 1932, the President remarked that as the Report of Council included several topics which would later be dealt with in the reports of individual committees it might be well to postpone the discussion of such portions of the report to a later period of the meeting. The Secretary then read the Report of Council, as published in full on pages 68 and 69 of The Engineering Journal for February 1933, and Mr. Busfield presented the report of the Finance Committee and the financial statement as published on pages 69, 70 and 71 of the same issue. Mr. Busfield observed that the financial year had been completed with a small surplus, this being the first annual surplus in five years. He hoped the members would refer to the explanatory notes given in the report of the Finance Committee and he would be glad to answer any questions arising therefrom. There being no discussion, it was resolved, on the motion of John Murphy, M.E.I.C., seconded by L. W. Wynne-Roberts, A.M.E.I.C., that the reports of Council and of the Finance Committee be adopted.

Reports of Committees

With regard to the reports of other committees, the President suggested that in view of the lengthy discussion which was likely to arise on the reports of the Committee on Development and the Unemployment Committee, it might be desired to take the others together, and on the motion of J. B. Challies, M.E.I.C., seconded by Hector Cimon, M.E.I.C., it was resolved that the reports of the following committees be taken as read and adopted:— Past-Presidents' Prize Committee, Gzowski Medal Committee, Plummer Medal Committee, Leonard Medal Committee, Students' and Juniors' Prizes, Membership Committee, Papers Committee, Publication Committee, Library and House Committee, Legislation Committee, Report of the E.I.C. Members of the Main Committee of the Canadian Engineering Standards Association, Honour Roll and War Trophies Committee, Board of Examiners and Education, Committee on Biographies, Committee on Engineering Education, and Employment Service Bureau.

Report of Committee on Development

The next item of business being the report of the Committee on Development, the President remarked that before requesting the chairman of the committee, Mr. Busfield, to speak to the committee's report, he would ask the Secretary to present a number of written communications which had been received, in regard to which special requests had been made for their presentation at this meeting. The Secretary accordingly read the following communications:

(1) A memorandum dated January 31st, 1933, from seven members in Toronto, forwarded by Professor E. A. Allcut, M.E.I.C., in which attention was drawn to the fact that while publicity had been given by the Committee on Development to their arguments in favour of their Interim Report, little prominence had so far been given to the views of those opposed to the recommendations of the committee. In the view of the signatories to this memorandum the principal objections to the proposed scheme of re-organization were:—

(*a*) The merging of Members and Associate Members into one group is wrong in principle, and the proposed standard of membership is too low, being likely to result in a lowering of status, both of The Institute and its members.

(*b*) The proposal that the incoming president should be nominated by the three immediate past-presidents, it is believed, has dangerous potentialities, and this procedure should be discontinued.

(*c*) The proposed deletion of the Code of Ethics from the By-laws is unwise, for The Engineering Institute is the only engineering society that covers the whole of the Dominion, and should lead in this respect, not follow.

(*d*) The committee's proposals are objectionable, for, if and when they come into effect, a considerable number of members will withdraw from The Institute, and the number of younger men entering The Institute as Students will be considerably reduced.

For the above reasons the signers of the memorandum hope that when the final report of the Committee on Development is presented it will differ materially in substance from the Interim Report.

(2) The next communication, dated January 20th, 1933, was from the Victoria Branch, in the form of a synopsis of the proposals of the Committee on Development with a statement of opinion on each. The executive committee of the Victoria Branch concurred in some of the recommendations of the Committee on Development, but in the following instances differed from them.

(*a*) As regards grades of membership, the Branch would recommend the retention of two grades of practising corporate members as at present, but they should be styled "Fellow" and "Member," instead of "Member" and "Associate Member."

(*b*) The qualifications for the various grades of Membership for Fellows and Members should be the same as at present for Members and Associate Members, except that for Fellow ten years responsible charge should be required, and, further, it should be required that an applicant for corporate membership must be a member of the Association of Professional Engineers in his province.

(*c*) The present time is not opportune for an increase in fees, and the provision for compounding of fees by members should be retained.

(*d*) It is also advisable to retain the Code of Ethics (with amendments, if considered necessary).

(3) A communication, dated February 1st, 1933, from the executive committee of the Saguenay Branch was next read, in which the proposal of the Committee on Development for a change in fees was opposed, and the opinion was expressed that it would be a great mistake to make it mandatory on Council to accept candidates because they are members of Provincial Professional Associations. That Branch considers that three grades of membership would be ample, namely, Honorary Members, Members and Juniors.

(4) A communication from the executive committee of the Saint John Branch, dated February 3rd, 1933, stressed the desirability of not only maintaining, but strengthening the professional aspect of The Institute, and desired that no expression of opinion by ballot or questionnaire be requested from members until the membership has had ample opportunity to study the report of the discussion at the Annual Meeting.

After the reading of these communications Mr. Busfield remarked that since the publication of the Interim Report of the Committee on Development, published in the October 1932 issue of The Journal, from which a number of expressions of opinion had resulted, the committee had held further meetings, and as a result of the opinions submitted the recommendations of the committee had been modified in several respects. He had heard suggestions made by members, not fully acquainted with the facts, that the recommendations of the Committee on Development had been intended principally as a means for increasing the revenue of The Institute. He could assure the meeting that at no time in the discussions of the committee had the question been considered from that point of view. It was quite incorrect to say that the recommendations had been dictated by the desire for an increase in revenue. Another suggestion which had been made in letters received was that there should have been a minority report. He desired to say, as chairman of the committee, that at no time had there been any suggestion of a minority report from any members of the committee. After describing the way in which the working group of the committee had carried out its discussions, and their subsequent submission to the other members of the committee during the spring and summer of 1932, Mr. Busfield pointed out that the meeting now had before it the committee's revised proposals, and the way was clear for full discussion. He would be glad to answer any questions that might be asked.

Hector Cimon, M.E.I.C., said that he had been directed, on behalf of the Quebec Branch, to submit its views as embodied in a memorandum dated January 25th, 1933, and addressed to the officers and members attending the Annual General Meeting. He read this memorandum, which opposed many of the changes advocated by the Committee on Development, and stated that many expressions of opinion made it clear that in the opinion of many members nothing but a re-organization of The Institute along strictly professional lines was admissible. A re-organization of this kind would not only make The Institute effective as an association for the diffusion of engineering knowledge, but would develop it so as to make it the "heart of the Canadian professional engineering body." In such a case the membership "must eventually be restricted to professional engineers," and the Quebec Branch believed that some means would eventually be found whereby the "total membership of all Provincial Associations will join The Institute."

Referring to the report presented at the Annual Meeting in 1930 by Past-President S. G. Porter, M.E.I.C., on the relations of The Institute with the Provincial Associations of Professional Engineers, the memorandum noted that the conclusions of Mr. Porter's report were based on the strictly professional point of view, which the Branch was now advocating. Unfortunately, the present proposals of the Committee on Development were "based on quite a different conception of the role of this Institute," and, if accepted, are believed to be "such as to render impossible any future consolidation of the provincial professional associations with The Institute." In the opinion of the Quebec Branch, any changes in the By-laws should be such as to develop The Institute as a "truly professional Dominion-wide body." The Quebec Branch would therefore recommend, for the present, a decision that:—

"(*a*) The Institute must be the national organization representative of the Canadian Engineering Profession.

(*b*) The admission of persons resident in Canada to corporate membership in The Institute be made *conditional upon their being registered members* of one or the other of the provincial associations of professional engineers, with such exceptions as are provided in the provincial Acts *and subject to such further qualifications as may be necessary* to maintain the corporate membership at a high standard.

(*c*) The present requirements for admission to corporate membership as outlined in Section 8 of the present By-laws should be retained as a minimum standard of qualifications for just so long as the co-ordination of all provincial associations is not effectively consummated.

(*d*) The present grade of Affiliate be abolished."

Group-Captain E. W. Stedman, M.E.I.C., desired to sum up the opinions of the executive committee of the Ottawa Branch as follows:

(*a*) There should be no lowering of the standards required for admission to The Institute.

(*b*) There should be no increase in fees.

(*c*) Nothing should be done which would tend to put the control of The Institute too much in one place.

Alex. Lariviere, M.E.I.C., stated that in the absence of any representative from Vancouver, he had been requested to present to the Annual Meeting the views of the Executive committee of the Vancouver Branch, and had prepared a statement embodying the opinions of that Branch as contained in a letter dated November 30th, 1932.

Mr. Lariviere fully concurred with the views expressed in the Vancouver communication, and was in active disagreement with the Committee on Development with regard to certain principles in its report. These might be summarized as follows:

(*a*) Is the object of the re-organization of The Institute to be the development and maintenance of a strong engineering profession in Canada?

(*b*) Is The Institute to be a professional or non-professional body?

(*c*) Would organization on non-professional lines produce better engineers in Canada than organization on a strictly professional basis?

From the objectives of the Committee on Development, as printed in the October Journal, it seemed evident that that committee advocated developing The Institute "on its own logical lines" for the benefit of its own members, with the possibility of future federation with the professional associations "relegated somewhat to the background." Of this course the Vancouver Branch thoroughly disapproved, because they recognized that "the interests of the profession must be paramount at all times." That Branch held that the semi-professional organization proposed by the Committee on Development could, from its very nature, never be anything but non-professional, and could not possibly function with the professional associations. The Vancouver Branch believed that there could be no compromise on this point, and that the fundamental issue was therefore "a choice between re-organization of The Institute with a view to its eventual recognition as to the body politic of the engineering profession in Canada,—or re-organization as a mere technical society having no definite relation to the engineering profession." This question "would have to be decided *now*, before the details of the proposed re-organization are drawn up for submission to ballot of the present membership."

Regarding the question as to which organization—a non-professional or a strictly professional one—would produce better engineers, the Executive committee of the Vancouver Branch affirmed without hesitation that the strictly professional ideal has infinitely greater promise of success in producing highly qualified engineers than any non-professional plan could possibly afford. Mr. Lariviere considered that this had been amply proved by the success of the efforts of the Association of Professional Engineers in the training of engineers in British Columbia.

Summing up, Mr. Lariviere stated that the Executive committee of the Vancouver Branch is convinced that the value of the Interim Report of the Committee on Development "is completely nullified by the failure of this committee to limit future admissions to The Institute to properly accredited members and juniors of the provincial professional associations, with only such exceptions as are provided in the various Engineering Profession Acts and Amendments." The Executive committee of the Vancouver Branch further believes that "any plan of Institute development which does not definitely provide a basis for closer relations with the provincial associations on strictly professional lines, is doomed to failure."

P. C. Perry, A.M.E.I.C., sketched the situation in the Saskatchewan Branch and pointed out that the decline in membership in Saskatchewan, while partly caused by financial troubles, was largely due to the necessity of joining the Association of Professional Engineers, and in his opinion co-ordination of the work of The Institute with that of the associations of professional engineers was essential.

G. McL. Pitts, A.M.E.I.C., drew attention to the effective organization of the architectural profession in Canada, the Dominion body being the Royal Architectural Institute of Canada, which gave general direction to the proceedings of the several provincial organizations.

E. V. Caton, M.E.I.C., speaking for Manitoba, stated that in Winnipeg opinion regarding the proposals of the Committee on Development had not yet been definitely formed, but there was a strong feeling that any development proposed should be with a view of closer co-operation with the professional associations.

J. B. Challies, M.E.I.C., complimented the Committee on Development on the work they had done and on their Interim Report, with which he had not agreed, although, in view of the modifications which had now been made in the original proposals, he did not think his present views differed very widely from those of Mr. Busfield. In any case, the development of The Institute was a matter of prime importance and, in his opinion, should have the attention of a Plenary Meeting of Council. He was aware of the financial difficulties attaching to this, but, in consultation with Mr. Murphy, had looked over the reports of the Branches and had found that many of them had substantial cash balances, and he believed that, in view of the importance of such a Plenary Meeting of Council, the Branches would be prepared to make contributions to its cost.

Mr. Challies then proposed the following resolution:—

WHEREAS the proposals of the Committee on Development are of prime importance to The Institute and to the engineering profession in Canada, and

WHEREAS conflicting and confusing viewpoints thereon have been and are still being submitted to Headquarters from branches and members all over the Dominion, and

WHEREAS it is essential that all such viewpoints be carefully considered by a committee fully representative of all classes and branches of The Institute,

BE IT THEREFORE RESOLVED that it is the sense of this Annual Meeting—

(1) That further action on the Interim Report of the Committee on Development be suspended until the whole subject matter thereof can be considered at a Plenary Meeting of Council,

(2) That no general series of amendments to existing by-laws should be submitted to the membership at large until recommendations from a Plenary Meeting of Council regarding the Development Committee's proposals have been considered by all the branches and also discussed at the next Annual General Meeting, and

(3) That in view of the strong financial position of the branches and the weak financial position of The Institute, Council suggest to the various branches that they assist in meeting the expenses of a Plenary Meeting of Council.

John Murphy, M.E.I.C., in seconding this motion, heartily supported Mr. Challies's suggestions.

F. W. Paulin, M.E.I.C., hoped that there would be adequate discussion of this important matter before this resolution was voted on. He believed that it would be possible to have local discussions of the question prior to the proposed Plenary Meeting of Council, under the direction of the vice-presidents of the various zones. Mr. Paulin also expressed regret at the action of the Council of The Institute in refraining from formal adoption of the Standard Forms of Contract prepared by the Canadian Construction Association.

A. B. Lambe, A.M.E.I.C., pointed out that the formation of the Ontario Association of Professional Engineers, like that of most of the others, was due to the initiative of The Engineering Institute of Canada, whose action in this respect was one of the best things that had ever been done for the engineers of Ontario. The Ontario Association was most anxious to co-operate in every way with The Institute. He desired to compliment Mr. Busfield on the thought and energy which had gone into the preparation of the Interim Report.

Professor F. R. Faulkner, M.E.I.C., referred to the conditions in Nova Scotia, where opinion did not favour any proposal to limit the membership of The Engineering Institute of Canada merely to whose who are qualified professional engineers. The Institute served a definite purpose, which the Associations of Professional Engineers could not carry out, and was particularly valuable in providing junior grades of membership for those entering the profession.

As regards the Interim Report of the Committee on Development, he would have liked to have seen the class of Fellow retained, but with strict qualifications and a stipulation that a candidate must have rendered some genuine service to The Institute. At the present time, the several professional associations, through a committee of their own, were endeavouring to co-ordinate their requirements and activities and he had no doubt that when this had been done they would be found ready to work with The Institute. He thought that the Interim Report of the Committee on Development did not adequately stress the necessity for *two* qualifications for admission, namely, education and experience, and he was emphatic in advocating a high standard for admission.

B. Ottewell, A.M.E.I.C., remarked that the Peterborough Branch agreed with some recommendations in the Interim Report and disagreed with others. They were particularly opposed to any increase in fees. He hoped that the expressions of opinion which had been sent to the Committee and to Council would all be published in The Journal or in some other form, for the information of the membership, before Branch opinions were placed before a Plenary Meeting of Council.

In June, 1931, the census reports indicated that there were over 14,000 professional engineers in Canada. Membership in The Institute totalled only 30 per cent of these. He felt that this feature indicated the possibilities for future growth of The Institute. He thought that no time should be lost in holding a Plenary Meeting of Council so as to present definite recommendations to the membership.

Mr. Lariviere saw no reason why The Engineering Institute should not adopt a minimum standard of requirements even although the requirements for admission to the various professional associations showed considerable divergence. If some of the professional acts made no provision for the younger members of the profession, these acts could no doubt be amended.

J. L. Rannie, M.E.I.C., urged that no time should be lost in completing the discussion on the report of the Committee on Development. He hoped that the present committee would carry on and receive and consider suggestions from the membership. He would move that the Council instruct the present Committee on Development to continue the consideration of this problem and to take advantage of the discussions following the adoption of the report as they may find advisable, all with a view to the submission of proposals to a Plenary Meeting of Council.

The President asked if this was intended as an amendment to Mr. Challies's motion, and Mr. Rannie said it was. The amendment having been seconded by W. McG. Gardner, A.M.E.I.C., Mr. Challies suggested that Mr. Rannie had possibly misunderstood the purpose of the original motion, the intent of which was that a Plenary Meeting of Council be called as soon as possible. Mr. Rannie's point might be met if the first clause in his original motion were changed so as to end:—"a Plenary Meeting of Council to be held as soon as practicable." Mr. Rannie said that his point was that further consideration should be given to the matter by the present Committee.

Mr. Paulin inquired how the membership at large were to get their views before the Committee.

Mr. Busfield thought that the logical course would be for the consideration of the various discussions that had taken place, and the recommendations that had been made, to be carried on by the Committee on Development, as this was a task for a small number of men who could sit round a table. Such a group could then formulate definite proposals for the consideration of a Plenary Meeting of Council, which that body should deal with, and, if thought proper, put forward as proposed amendments to the By-laws. He understood that the incoming President would probably be able to visit the Branches during 1933 and obtain their points of view, but if a Plenary Meeting of Council were called at an early date, there would not be time for this to be done.

Mr. Pitts hoped that, in any reorganization, examination requirements would be given prominence, as the stability of the profession depended upon the legal qualifications of its members. Such examination requirements should be in accordance with those of the professional associations.

Dr. T. H. Hogg, M.E.I.C., had been struck by Mr. Busfield's remarks and believed that the original amendment and Mr. Busfield's views could all be taken care of by a slight change of the wording of Mr. Challies's resolution, which would make it possible for Mr. Rannie to withdraw his amendment. Mr. Challies having agreed to some changes in his motion, with the concurrence of his seconder, handed a revised copy to the Secretary, which read as follows:—

WHEREAS the proposals of the Committee on Development are of prime importance to The Institute and to the engineering profession in Canada, and

WHEREAS conflicting and confusing views thereon have been and are still being submitted to Headquarters from branches and members all over the Dominion, and

WHEREAS it is essential that all such views be carefully considered by a committee fully representative of all classes and branches of The Institute,

BE IT THEREFORE RESOLVED that it is the sense of this Annual Meeting—

(1) That the Interim Report of the Committee on Development be considered at a Plenary Meeting of Council to be held as soon as practicable,

(2) That no general series of amendments to existing by-laws should be submitted to the membership at large until recommendations from a Plenary Meeting of Council regarding the Development Committee's proposals have been considered by all the branches with a view to their discussion at the next Annual General Meeting, and

(3) That in view of the strong financial position of the branches and the weak financial position of The Institute, Council suggest to the various branches that they assist in meeting the expenses of that Plenary Meeting of Council.

Dr. A. Frigon, M.E.I.C., thought there should be a definite expression of the view that no action should be taken by Council before final statements of opinion were obtained from the various Branches by means of a questionnaire, or otherwise.

Mr. Challies pointed out that Dr. Frigon's suggestion involved some difficulty, as it would rather tie the hands of the Council. He thought the Plenary Meeting should be held as soon as possible and would urge the adoption of his resolution as now changed.

The President pointed out that full representation of the Branches would be obtained at the Plenary Meeting of Council, where they would all be represented by their Councillors.

C. G. Moon, A.M.E.I.C., hoped that the suggestions brought forward at this meeting would be placed before the committee so that they might submit to the Plenary Meeting whatever conclusions had been arrived at.

Dr. O. O. Lefebvre, M.E.I.C., reminded the meeting that a great deal would have to be done before a Plenary Meeting could deal with this matter, and he thought that the committee should continue its activities, studying the matter in the light of opinions from the membership at large and making a final recommendation to Council for consideration at the Plenary Meeting which, he thought, should be held about September.

Mr. Lambe hoped the Council would prepare definite recommendations which could be acted upon at the General Meeting in 1934 which, he understood, was the earliest time at which changes in the By-laws could be made.

After some further discussion, Mr. Rannie's amendment was withdrawn, and Mr. Challies's motion, with the changes to which he had agreed, was carried unanimously.

The meeting adjourned for lunch at 12.30 p.m.

On reconvening, at 2.30 p.m., the report of the Committee on Unemployment was presented by D. C. Tennant, M.E.I.C., who outlined the action which had been taken by The Institute's Committee and by the various Branch Unemployment Committees regarding the unemployment of Institute members. Exhibiting a tabulated statement* showing for each of the twenty-five Branches of The Institute the latest figures as to members' unemployment which were available, he pointed out that substantial sums had been collected in Montreal, Toronto, and in Vancouver, the unemployment work in the latter city having been undertaken by the Professional Engineers' Club, with the co-operation of the Vancouver Branch of The Institute. Mr. Tennant believed that if employment were to be considered from a general point of view, regarding its causes and cure, there was no better preparation that could be made than by showing, in the various Branches, through the Branch Unemployment Committees, a real and sympathetic interest in those who are out of work.

Mr. Thomas inquired whether unemployed engineers who had not been able to keep up their membership in The Institute were included in the figures given. He thought that if this were not so the proportion of unemployed might be raised above the proportion given.

In reply, Mr. Tennant stated that each Branch had been notified that, in providing for cases of distress, those whose membership had lapsed through the non-payment of fees would still be considered members of The Institute as far as relief was concerned.

*See page 141.

C. A. Mullen, M.E.I.C., inquired whether The Institute's Unemployment Committee proposed to study in a broad way the subject of unemployment and its causes, thus going further than the mere relief of our own members.

Mr. Pitts asked permission to present to the meeting a communication which he had prepared on the subject of unemployment as related to the country at large, indicating the desirability of stimulating the further circulation of business. Permission having been given, Mr. Pitts read a memorandum on unemployment control, which he had already presented at a meeting of the Montreal Branch, and which advocated the formation of a "National Service Corps" to be recruited from all classes of citizens who are unemployed.

This gave rise to considerable discussion, during which the proposals put forward by Mr. Pitts received sympathetic consideration, though attention was drawn to the many difficulties, particularly financial ones, involved in their application.

On the conclusion of this discussion, the next item of business being the reports of the Branches, it was resolved, on the motion of C. K. McLeod, A.M.E.I.C., seconded by J. R. Dunbar, A.M.E.I.C., that the reports of the Branches be taken as read and accepted.

Following this, the retiring President, Dr. Charles Camsell, M.E.I.C., delivered his address on "Canada's Position in Empire Mineral Development," which is printed in full on pages 129 to 133 of the present issue of The Journal.

On its conclusion, he called upon the Secretary to read the report of the Scrutineers appointed to canvass the Officers' Ballot for 1933, and the officers named therein were declared elected, as follows:—

President	O. O. Lefebvre
Vice-Presidents:	
Zone A	R. S. L. Wilson
Zone C	E. Brown
Councillors:	
Halifax Branch	A. F. Dyer
Saint John Branch	W. J. Johnston
Saguenay Branch	C. N. Shanly
St. Maurice Valley Branch	B. Grandmont
Montreal Branch	J. L. Busfield
	J. A. McCrory
Ottawa Branch	G. J. Desbarats
Kingston Branch	L. F. Goodwin
Toronto Branch	C. S. L. Hertzberg
London Branch	J. A. Vance
Border Cities Branch	O. Rolfson
Lakehead Branch	G. H. Burbidge
Saskatchewan Branch	D. A. R. McCannell
Edmonton Branch	H. J. McLeod
Vancouver Branch	A. S. Wootton

Following this, on the motion of L. W. Wynne-Roberts, A.M.E.I.C., seconded by Dean E. Brown, M.E.I.C., it was unanimously resolved that a vote of thanks be tendered to the Scrutineers for their services and that the ballot papers be destroyed.

Past-President Camsell then asked Past-President A. R. Decary, M.E.I.C., and Past-Vice-President G. J. Desbarats, M.E.I.C., to conduct the newly elected President to the chair, and this was accordingly done.

President Lefebvre, in thanking the members for the great honour conferred upon him, which he would prize very highly, said that he was very mindful of the responsibility attaching to the presidency of The Institute, particularly at a time of difficulty like the present. During the past year, under the presidency of Dr. Camsell, The Institute had weathered the storm by practising the most rigid economy. He was sure that with the aid of the newly elected councillors and the members who had experience of last year's work, equally successful results would be obtained during the coming year.

Under the next item on the agenda, "New Business," J. R. Cockburn, M.E.I.C., presented a resolution passed by the Toronto Branch, suggesting that the entrance fees for admission to The Institute should be payable in yearly instalments of $5.00 each. The Executive Committee of the Toronto Branch felt that if this were possible it would facilitate favourable action in the case of a number of prospective members who were severely affected by the present hard times.

Mr. Cockburn's suggestion was supported by W. S. Wilson, A.M.E.I.C., and Mr. Cockburn pointed out that the payment of the entrance fee in addition to the first year's annual fee, made the first year's outlay for a new member very considerable.

The President drew attention to the provision in the wording of Section 32 of the By-laws which appeared to exclude payment of entrance fees otherwise than in full at the time of application. If the Toronto Executive Committee thought proper, they could submit this proposal in the form of an amendment to Section 32 of the By-laws. He did not believe that this meeting or Council had the power to take action which controverted an existing By-law.

The Secretary pointed out that any group of members who desired a change of this kind could present it in writing to the Council, signed by at least twenty corporate members and reaching the Secretary not later than October 1st.

Mr. Cockburn agreed that this should be done and, with the permission of his seconder, withdrew his motion.

Mr. Challies said that it gave him great pleasure to move that the hearty thanks of The Institute be accorded to the retiring President for his services in the chair and for his thoughtful Presidential address, and also to the retiring members of Council, in appreciation of their services during the past year. Mr. Challies pointed out that 1932 had been one of the most difficult years in the history of The Institute and there had never been a period when the Council had worked harder and to better advantage. He believed that Mr. Busfield, apart altogether from his work as chairman of the Committee on Development, had rendered invaluable service to The Institute as chairman of the Finance Committee.

Mr. Pitts, in seconding the motion, desired to support Mr. Challies, and to point out that while it is easy to serve an organization like The Institute when conditions are tranquil, it is a very different matter when economic pressure exists from every direction. The motion was carried by acclamation.

On the motion of Dean Brown, seconded by Professor H. E. T. Haultain, M.E.I.C., it was unanimously resolved that the thanks of The Institute be conveyed to the Ottawa Branch in recognition of their hospitality and activity in connection with the holding of the Forty-seventh Annual General and General Professional Meeting.

The Secretary having announced that the first meeting of the newly elected Council would be held at 5.15 p.m., and there being no further business, the meeting terminated at 4.50 p.m.

Social Functions

Group-Capt. E. W. Stedman, M.E.I.C., chairman of the Ottawa Branch, presided at the luncheon on Tuesday, February 7th, which was largely attended and at which the members of The Institute were welcomed to Ottawa by His Worship Mayor Allen.

The Mayor was followed by the Hon. R. J. Manion, Minister of Railways and Canals, who gave an illuminating discourse on world conditions, pointing out that there is no single remedy or cure-all for the present condition of affairs. He urged that we should avoid being led astray by agitators and wreckers who had no constructive plan for rehabilitation. It was important to retain our faith in Canada and its institutions and, finally, he urged international action, because no one country can work out a solution for present world conditions. He had great hopes, in this respect, in the coming World Economic Conference.

On the same day the annual dinner of The Institute took place at 7.30 p.m. in the Ball-room, under the chairmanship of President O. O. Lefebvre, M.E.I.C., and The Institute was honoured by the presence of the Governor-General, His Excellency the Right Honourable the Earl of Bessborough, and the Countess of Bessborough. With the President and Madame Lefebvre at the head table were Their Excellencies, Past-President and Mrs. Camsell, Past-President and Mrs. Grant, Past-Presidents M. J. Butler and A. R. Decary, Vice-Presidents R. S. L. Wilson and E. Brown, the Chairman of the Ottawa Branch and Mrs. Stedman and The Mayor of Ottawa and Mrs. Allen.

After dinner, the President, on behalf of The Institute, presented His Excellency with an Honorary Member's badge following which the Past-Presidents' Prize, awarded to B. H. Steeves, A.M.E.I.C., was handed to the recipient by Her Excellency. The occasion was marked by a graceful speech from His Excellency, who took the opportunity of complimenting The Institute on the selection of a distinguished French Canadian engineer as their President for 1933. He touched on the colourful history and growth of the engineering profession in Canada, from the French period onwards, and expressed the greatest confidence in the future of The Institute and the profession.

The dinner was followed by a reception and dance, which proved very popular, the members and guests being received by President and Madame O. O. Lefebvre, and by Group-Captain and Mrs. E. W. Stedman.

On Wednesday, the 8th, the luncheon meeting held in the Ballroom was addressed by the Honourable Hugh Guthrie, Minister of Justice, who explained that he was acting as a substitute for the Prime Minister, whose attendance was rendered impossible by illness. Mr. Guthrie's address dealt with questions of the day, more particularly as to the many pressing problems in Canadian policy which have formed the subject of discussions between representatives of the Dominion and provincial governments. Touching on the difficult situation as regards unemployment relief, he passed on to international relations and appealed for active support of the movement for limitation of armaments. If the present increases in armaments continued, said Mr. Guthrie, it was difficult to see how ultimate conflict could be avoided.

First Technical Session

The professional sessions were held on Wednesday, February 8th, the papers presented and discussed in the morning being the following:

In the Banquet Hall, under the chairmanship of G. G. Gale, M.E.I.C.:

> "General Description of the Chats Falls Development and Organization for Construction," by T. H. Hogg, C.E., D.Eng., M.E.I.C.
>
> "Construction Features of the Chats Falls Development," by H. L. Trotter, D.S.O., M.E.I.C., and James Dick, A.M.E.I.C.
>
> "Hydraulic and Electrical Tests at the Chats Falls Development," by G. D. Floyd, B.Sc., and J. J. Traill, M.E.I.C.

In Salons B and C, under the chairmanship of W. Hamilton Munro, M.E.I.C.,

> "The Illumination of the Welland Ship Canal," by L. P. Rundle, B.Sc., M.E.I.C.
>
> "The Electrical Design of the Chats Falls Development," by E. T. J. Brandon, B.A.Sc., A.M.E.I.C.

In Salon D, with G. J. Desbarats, M.E.I.C., as chairman, "The Relation of Aeronautical Research to General Engineering," by Squadron-Leader Alan Ferrier, M.C., B.Sc., A.M.E.I.C.

The Institute's Committee on Engineering Education also held a meeting in Salon A, the President in the chair.

Second Technical Session

In the afternoon papers were presented and discussed as follows:

In the Banquet Hall, F. Newell, M.E.I.C., in the chair, "The Hydraulic Design of the Chats Falls Development," by Otto Holden, B.A.Sc., A.M.E.I.C.

"Hydraulic Stability," by A. W. F. McQueen, B.A.Sc., A.M.E.I.C.

In Salons B and C under the chairmanship of John Murphy, M.E.I.C.,

"The Trans-Canada Highway as an Unemployment Relief Measure," by James Sinton.

"The Development of the Hudson Bay Project," by D. W. McLachlan, B.Sc., M.E.I.C.

The Ladies Committee, under Mrs. Charles Camsell as chairman, arranged an attractive series of entertainments for the ladies. On the afternoon of Tuesday the 7th, the visiting ladies had the honour of being received at Rideau Hall by Her Excellency the Countess of Bessborough. On Wednesday, they paid a visit to the Parliament Buildings where a programme of music was played on the carillon. Tea was served in the Quebec Suite at the Chateau Laurier.

One of the outstanding features of the gathering was a lecture by Dr. A. S. Eve and Dr. D. A. Keys of the Department of Physics, McGill University, given, by kind permission of the President of the National Research Council, in the auditorium of the National Research Laboratories, Sussex Street. The subject was "Exploration for Ore by Magnetic and Electrical Methods" and a large and appreciative audience was delighted by the remarkable success of the experimental demonstrations in which ore (previously buried by the lecturers in sand boxes) was actually discovered by them. Following the lecture, the laboratories were thrown open for inspection, and members and ladies were able to form an idea of some of the many investigations which are being carried out on such subjects as the causes of damage to fabrics in laundry work, the effect of freezing on the milling and baking qualities of wheat, the utilization of short fibre asbestos, radio interference, and a host of others.

This visit to the Research Council Laboratories was the closing event in a most successful meeting.

OBITUARIES

Allan Campbell MacKenzie, M.E.I.C.

Deep regret is expressed in recording the death at Montreal on January 24th, 1933, of Allan Campbell MacKenzie, M.E.I.C.

Mr. MacKenzie was born at Inverness, Scotland on April 19th, 1881 and was educated in that country.

In 1901-1903, Mr. MacKenzie was assistant engineer with a consulting engineer in general practice, and, coming to Canada in 1903, he entered the service of the Canadian Pacific Railway Company. From 1903 to 1905 he was draughtsman, instrumentman and assistant resident engineer on maintenance; in 1905-1907 he acted as resident engineer on construction; until 1909 he was resident engineer on maintenance, and in that year was appointed as assistant to the engineer, maintenance of way, Eastern Lines, holding that position until 1911 when he became engineer of maintenance of way, Eastern Lines. From 1917 to 1919 Mr. MacKenzie was occupied in the same position on Western Lines, and in 1919 resumed the position of engineer of maintenance of way, Eastern Lines, holding that office until the time of his death.

Mr. MacKenzie joined The Institute (then the Canadian Society of Civil Engineers) as a Student on May 21st, 1903, transferred to Associate Membership on October 24th, 1907, and became Member on May 22nd, 1922.

John Alfred Spreckley, A.M.E.I.C.

Members of The Institute will learn with regret of the death of John Alfred Spreckley, A.M.E.I.C., in Calgary, on January 25th, 1933.

Mr. Spreckley was born in London, England, on June 10th, 1875, and from 1896 to 1903 was assistant to the city engineer of Hereford. During the years 1904-1912, he was borough engineer and surveyor of Ludlow, being engaged on the construction of roads and sewer extensions, reconstruction of water supply system and sewage disposal works, local improvements and general administration. In 1913 Mr. Spreckley came to Canada, and entered the service of the Irrigation Division, Department of the Interior, as water administration engineer, being located at Ottawa until 1919, when he went to Calgary. He remained in the service until two years ago, when the natural resources were transferred to the province, and Mr. Spreckley was superannuated. Since that time he had been engaged on an intensive study of weather conditions and their relation to business.

Mr. Spreckley was an Associate Member of the Institution of Civil Engineers.

He joined The Institute as an Associate Member on August 12th, 1921, and took an active part in Institute affairs. having acted as secretary-treasurer and also as Branch News editor for the Calgary Branch for some time.

Stanley Chipman Webb, A.M.E.I.C.

Great regret will be felt at the announcement of the death of Stanley Chipman Webb, A.M.E.I.C., at Saint John, N.B. on February 17th, 1933.

Mr. Webb was born at Saint John, N.B. on November 23rd, 1882, and received his education at the schools in that city and at the University of New Brunswick.

President and general manager of the Webb Electric Company for many years, Mr. Webb was widely known in the electrical field. He interested himself particularly in the science of illumination, and took advanced courses in that branch at Nela Park, Cleveland. Among the larger electrical contracts successfully completed by Mr. Webb were the Saint John Harbour Commission sheds in West Saint John, the New Albert School and annex, the children's wing of the Saint John Tuberculosis hospital, the Ganong Memorial Hospital at St. Stephen, the King George School, the Old High School, and the Beaverbrook residence at the University of New Brunswick.

Mr. Webb became an Associate Member of The Institute on August 24th, 1920.

PERSONALS

W. P. Copp, M.E.I.C., was elected president of the Association of Professional Engineers of Nova Scotia at the annual meeting of the Association held at Halifax on January 19th. Professor Copp is professor of civil engineering at Dalhousie University, Halifax, N.S.

M. A. Prud'homme, A.M.E.I.C., has, it is announced, been appointed to the position of mechanical engineer of the Dominion Dump Car Company Limited, Montreal, the successors to the Hart-Otis Car Company Ltd. of which Mr. Prud'homme was chief draughtsman, since 1922. Mr. Prud'homme had been with the Hart-Otis Company since 1919.

R. B. Chandler, M.E.I.C. and W. H. Souba, M.E.I.C., have withdrawn from partnership in the firm of C. D. Howe and Company, Port Arthur, Ont. Mr. Chandler has opened an office in Port Arthur where he will carry on a private consulting engineering practice and Mr. Souba is now residing in Minneapolis, Minn.

Mr. Chandler has been associated with important engineering work, principally in the field of modern grain handling in Canada and abroad for the past twenty years. Graduating from the University of Toronto in 1912, he was assistant city engineer in Saskatoon, Sask. for about two years, following which he has been engaged continuously in the design and construction of modern grain terminals. In 1930, Mr. Chandler spent some time in the Argentine, reporting on a National bulk grain handling system for that country.

Mr. Souba graduated from the University of Minnesota in 1909, and following this was connected with Barnett and Record Company, Minneapolis, as mechanical draughtsman. From 1912 to 1914 he was mechanical draughtsman and designer on grain elevator work with Barnett-McQueen Co. Ltd., at Fort William, Ont., and in 1914-1915 was assistant engineer with the Board of Grain Commissioners for Canada, at Saskatoon, Sask., Calgary and Vancouver. In January 1916 Mr. Souba became assistant engineer to C. D. Howe, M.E.I.C., and in 1917 was made a partner in the firm of C. D. Howe and Company.

H. A. Crombie, A.M.E.I.C., who was recently appointed sales manager of Dominion Engineering Works, Limited, has grown up with the company, having joined the staff when the company was formed in 1920. Mr. Crombie was educated at Westmount Academy and McGill University, his university course being interrupted by service in France with the Canadian Engineers. He was invalided home in 1917, and resumed his studies, graduating with the degree of B.Sc. in 1918. Mr. Crombie then spent a year on the staff of the Canadian Allis Chalmers Ltd., in Toronto, and was also, for a short time in the service of the Canadian National Railways.

J. A. Heaman, M.E.I.C., is now office engineer of the Canadian National Railways at Montreal, Que. Mr. Heaman graduated from McGill University in 1902 with the degree of B.Sc., and following graduation joined the service of the Grand Trunk Railway as resident engineer on double track construction and grade reduction on the line from Whitby to Port Hope, Ont. Following this he was for a year assistant resident engineer at Toronto and from November 1903 until March 1905 acted as assistant engineer in charge of a location party on the Grand Trunk Pacific Railway. In 1905-1906 Mr. Heaman was engineer in charge of location surveys for the National Transcontinental Railway, and from May to October 1906 was division engineer in charge of construction of division on District F for the same railway. In 1906-1907 he was assistant district engineer of District F. and from 1907 to 1909 was assistant engineer on inspection of the National Transcontinental Railway for the Grand Trunk Pacific Railway. For the following two years Mr. Heaman was district engineer with the Grand Trunk Pacific Railway and in 1911-1912 was office engineer in charge of the office of the chief engineer. Following this Mr. Heaman was for several months division engineer in charge of the construction from Edmonton to Fort George, and in August 1912 was made assistant to the chief engineer of the Grand Trunk Pacific Railway at Winnipeg, Man. In 1923 Mr. Heaman became regional assistant to the chief engineer, Western Region of the Canadian National Railways at Winnipeg, and in 1924 went to Detroit, Mich., as chief engineer, Grand Trunk Railway system, later becoming chief engineer Grand Trunk Western Railroad Company, which position he has recently relinquished.

Annual Fees

Members are reminded that a deduction 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.

Students Admitted

At the meeting of Council held on February 24th, 1933, the following Students were admitted:

BROWN, Ralph Cuthbert Chisholm, (Queen's Univ.), 135 Alfred St., Kingston, Ont.

FINLAY, Ruskin Reid, (Univ. of Toronto), 62 Ann St., Toronto, Ont.

HEWITT, Robert, (Univ. of Toronto), 56 Roncesvalles Ave., Toronto, Ont.

HILLIER, Cecil H., (Queen's Univ.), 293 South Milton St., Sarnia, Ont.

NEWMAN, Phillip Marshall, (Queen's Univ.), Kingston, Ont.

POPE, Francis Robert, (McGill Univ.), 422 Metcalfe Ave., Westmount, Que.

PRICE, Robert W., (McGill Univ.), 3506 University St., Montreal, Que.

RAMSDALE, Donald O. D., (McGill Univ.), 51 Hallowell Ave., Westmount, Que.

THOMAS, George Henry, (McGill Univ.), 570 Claremount Ave., Westmount, Que.

WHITEHOUSE, Ralph John, (McGill Univ.), 772 Sherbrooke St. West, Montreal, Que.

Unemployment Conditions as at December 31st, 1932

E·I·C· UNEMPLOYMENT CHART-1932

	Branch	Members incl. Students	Unemployment Committee	Unemployed not incl. Students	Temp or Perm Employment	Funds Collected	Cases of Need	Remarks
1	Victoria	64	yes	7			1	
2	Vancouver	238	yes	26	6	$1248	7	Work thro A.P.E.
3	Calgary	105	yes	5				
4	Edmonton	77		6	8			
5	Lethbridge	38	yes	2	2			
6	Saskatchewan	125	yes	14	1			
7	Winnipeg	247	yes	8	1			Joint Comm with APE
8	Lakehead	35		3				
9	Sault Ste. Marie	97	yes	8	1		1	Numerous Removals
10	Border Cities	89	yes	5		$160	1	
11	London	56	yes	4	1			
12	Hamilton	151	yes	11	3			
13	Niagara	99	yes	6				
14	Toronto	558	yes	34	17	$1000	15	Well organized
15	Peterborough	85	yes	4				
16	Kingston	55		10				
17	Ottawa	408	yes	18	4			
18	Montreal	1206	yes	88	45	$1225	8	Technical Service Bureau also aided
19	St Maurice Val	43		1	2			
20	Quebec	115	yes	6	2			
21	Saguenay	33		1				
22	Moncton	76		1				
23	St. John	93	yes	6	6			
24	Halifax	223	yes	9	2			
25	Cape Breton	60		4				
	Totals	4176		287	101	$3633	33	

The above chart supplements the information contained in the report of The Institute's Committee on Unemployment (of which the chairman is D. C. Tennant, M.E.I.C.), appearing in the February, 1933, issue of The Journal. The chart illustrates the distribution of known unemployed as obtained from the recent survey.

Award of Medals and Prizes

Past-Presidents' Prize

The Past-Presidents' Prize of The Institute for the year 1931-1932 has been awarded to B. H. Steeves, A.M.E.I.C., the subject prescribed being "The Effect of the Development of the Electronic Valve upon Electrical Engineering and Industry." The second choice of the committee was the paper by E. Geoffrey Cullwick, Jr.E.I.C., and in view of its excellence it was awarded honourable mention.

Mr. Steeves graduated from McGill University in 1923 with the degree of B.Sc., and has been a member of the staff of the Northern Electric Company since that time. From 1923 to 1927 he was in the engineering inspection department, and in 1927 was appointed vacuum tube engineer, the position which he now holds.

B. H. Steeves, A.M.E.I.C.

W. B. Boggs

R. D. Parker

E. Geoffrey Cullwick, who is assistant professor of electrical engineering at the University of British Columbia, took his degree in engineering at Cambridge University with honours in 1925, and was a Scholar of Downing College. Professor Cullwick's paper on "Engineering Education" which was submitted for the Past-Presidents' Prize for the year 1930-1931, also received honourable mention.

J. H. Mowbray Jones, Jr.E.I.C.

E. Geoffrey Cullwick, Jr.E.I.C.

Leonard Medal Committee

On account of the excellence of two of the papers taken under consideration by the Leonard Medal Committee this year, it was decided to make two awards: a gold medal to Messrs. W. B. Boggs and J. N. Anderson for their paper on "The Anode Department of Noranda" and a silver medal to Mr. R. D. Parker for his paper on "Ventilation of the Frood Mine." Mr. R. J. Westwood, also a joint author of the paper by Messrs. Boggs and Anderson is not eligible for the medal, which can only be awarded to members of The Engineering Institute of Canada or the Canadian Institute of Mining and Metallurgy. Both of these papers appeared in the April, 1932, issue of the Bulletin of the Canadian Institute of Mining and Metallurgy.

Mr. W. B. Boggs is smelter superintendent at Noranda Mines, Noranda, Que., and Mr. J. N. Anderson is technical assistant to Mr. Boggs. This is the second time that Mr. Boggs has been the recipient of the Leonard Medal, having been awarded the silver medal for his paper on "The Noranda Smelter" for the prize year 1929-1930.

Mr. R. D. Parker, who receives the silver medal for the year 1931-1932, is superintendent of mines, International Nickel Company, Copper Cliff, Ont.

Students' and Juniors' Prizes

Only one award was made by the examiners in the various zones for the prizes for Students and Juniors of The Institute, that being the Martin Murphy Prize (Maritime Provinces) to J. H. Mowbray Jones, Jr.E.I.C., for his paper on "The History and Development of Fourdrinier Paper Making Machines."

Mr. Jones, who is a graduate of the University of Toronto of the year 1927, is resident engineer and assistant superintendent with the Mersey Paper Company at Liverpool, N.S.

No awards of the Gzowski Medal, the Plummer Medal or the Sir John Kennedy Medal were made for the year 1931-1932.

RECENT ADDITIONS TO THE LIBRARY

Proceedings, Transactions, etc.

Canadian Construction Association: Membership List, 1932.
The Royal Society of Canada: Fifty Years' Retrospect, 1882-1932.
The Mysore Engineers' Association: Silver Jubilee Souvenir Volume, 1932.
The Junior Institution of Engineers: Journal and Record of Transactions, Vol. 42, 1931-32.

Reports, etc.

Dept. of Mines, Mines Branch, Canada:
Investigations in Ore Dressing and Metallurgy, 1931.

Dept. of The Interior, Water Power and Hydrometric Bureau, Canada:
Water Power Resources of Canada, 1932.

Air Ministry, Aeronautical Research Committee, Great Britain:
Reports and Memoranda:
No. 1475: Arithmetical Solution of Problems in Steady Viscous Flow.
No. 1477: Slotted R.A.F. 34 Bristol Fighter.—Forces on Slat in Flight.
No. 1479: Wheels, Fairings and Mudguards.
No. 1480: Some Aspects of the Mutual Interference between Parts of Aircraft.
No. 1485: Radial Engine Tested at Reduced Mixture Strength and with Variable Ignition Timing.
No. 1488: Slipstream Effect on the Downwash and Velocity at the Tailplane.
No. 1489: Lift and Drag Measured in a Velocity Gradient.
No. 1490: Aerodynamic Characteristics of a Semi-Rigid Wing.
No. 1492: Porpoising Tests on a Model of a Flying Boat Hull.

Chamber of Commerce, New York State:
Survey of Adult Technical Education in the New York Industrial Area, 1932.

Technical Books, etc., Received

C.E.S.A. Canadian Electrical Code, Part 2: Essential Requirements and Minimum Standards Covering Electrical Equipment. Specification No. 2: Construction and Test of Electric Signs, 1933. *Presented by Canadian Engineering Standards Association.*

Canada's Railway Problem and Its Solution: An Address Delivered by E. W. Beatty before the Canadian Club, January 16, 1933. *Presented by the Canadian Club.*

BOOK REVIEW

Principles of Electricity

By Leigh Page and N. I. Adams. Van Nostrand, New York, 1933, cloth, 5½ x 8¾ in., 620 pp., figs., tables, $4.25.

Reviewed by Prof. A. F. Baird, M.E.I.C.*

Among the many books on electricity available to-day under a great variety of titles, it is pleasing to find one which really seeks to set forth in logical order the true fundamental principles of the subject. A large number of authors sincerely start out to do this but before they have done we find one particular phase greatly amplified and others sketched only in outline.

One of the usual methods adopted by writers to explain or make clear his point, and indeed sometimes as an expression of fundamental proof, is that of analogy. Mechanics particularly is called upon to make real and comprehensible the realm of electricity. These analogies are often incomplete and misleading and have been quite rightly avoided by the authors of this book. They use freely the legitimate tool of mathematics for explanation and definition. For an appreciation of several chapters, more than a casual acquaintance with the calculus is required.

From an engineer's standpoint, the book is perhaps a bit lacking in practical applications illustrative of deductions formulated. It is essentially a book for a student who has a curiosity to go to the bottom of things, but to one interested chiefly in the final result, the work should prove a valuable reference. The chapter on Coupled Circuits and Filters is especially good, and in view of their importance in modern networks is a proper addition and one not usually found in many books of the same nature.

**Professor of Electrical Engineering, University of New Brunswick, Fredericton, N.B.*

BULLETINS

Steels—Messrs. Thos. Firth and John Brown Limited, Sheffield, England, have issued a 60-page booklet describing the composition and use of the many steels of their manufacture. These include carbon, alloy, case hardening, nitriding, spring, stainless, heat-resisting, high speed, non-magnetic and magnet.

Lathes—A new 24-page booklet has been received from the Monarch Machine Tool Company, Sidney, Ohio, featuring the oval chuck, the centrode device and new developments in their machines.

Joints—"Ace" expansion and contracting and construction joints for highways are illustrated in a 4-page folder recently published by the American Concrete Expansion Joint Company of Chicago, Ill.

Concrete Pump—The Rex pumpcrete installation is described and illustrated in a 6-page folder which has been received from the Chain Belt Company, Milwaukee.

Speed Reducers—Two folders have been received from the Hamilton Gear and Machine Company, Toronto, Ont., containing descriptions of their small size worm gear speed reducer and welded steel bed plates adaptable to this equipment.

Switchgear—Recent installations and changes in electrical metalclad switchgear equipment are described in the November-December, 16-page bulletin issued by the Delta Star Electric Company of Chicago.

Steel Sheet Piling—The United States Steel Products Company, Montreal has issued a 32-page booklet containing information on the design and loading of steel sheet piling structures. Two methods are described, the data furnished being a summary of the work done by Dr. Herman Blum and Dr. Ing. H. Krey.

Optical Tools—An article on Optical Tools for Inspection and Testing, reprinted from *Machinery* is contained in an 8-page booklet published by Adam Hilger Limited, London, England. The catalogue numbers of the instruments referred to in the article are given.

Power Plant Equipment—A 132-page booklet has been received from Foster Wheeler Limited, St. Catharines, Ont., containing descriptions of and illustrating equipment manufactured by this firm, including, steam generators, water cooled furnaces, condensers, pumps, refinery equipment, marine equipment etc. This bulletin is entitled "Boilers" and is No. B-32-3.

Oberhasli Hydro-Electric Development

Another important step in the electrification of Switzerland has been accomplished by the construction of a large seasonal storage plant. Construction work on the first step of the Oberhasli hydro-electric development above Meiringen in the Bernese Oberland, Switzerland, has been completed recently and the Handeck Generating station was turned over to regular operation on October 1, 1932.

The entire development utilizes the precipitations as well as the melting water of a total area of 43 square miles, formed mostly by the glaciers of the Bernese Oberland. Since about 95 per cent of the total annual natural flow of water from this area takes place during the six summer months, it was essential to create storage basins. Nature offered very favourable conditions, so that it was possible to create two artificial lakes, the Grimsel lake (Grimselsee) and the Gelmer lake (Gelmersee), connected with each other by means of a tunnel, of a capacity of 3.5 billion and 450 million cubic feet respectively, corresponding to a total storage capacity of 130 million kilowatt hours.

The Grimsel lake is formed by two dams, the Seeuferegg dam and the Spitallamm dam which is the outstanding feature of the development.

The following are some of the dimensions of this latter dam, which at the present time is the largest in Europe:

Height above bottom of foundation......	375 feet
Radius..................................	295 "
Length..................................	850 "
Amount of concrete	12,000,000 cu. ft.

The water accumulated in the Grimsel lake is conducted through the horizontal tunnel mentioned above to the Gelmer lake and from there by means of a pressure line to the Handeck generating station. This pressure line consists of steel tubes 8 feet in diameter and the line is installed in a tunnel 3,700 feet long, thus covering a difference in altitude of 1,750 feet at a maximum inclination of 72 per cent.

The Handeck generating station is equipped with four vertical type units. Each unit is composed of a Pelton type turbine of 30,000 h.p. and a generator of 28,000 kv.a. operating at a speed of 500 revolutions per minute and delivering power at 11,000 volts.

The problem of delivering the power from the Handeck station to the load centre presented serious difficulties. On account of the large number of avalanches occurring in the neighbourhood of the generating station every winter, it was not considered safe to use high tension overhead lines, and it was finally decided that a reliable supply could only be obtained by means of underground cables. Thus a special cable tunnel of 3.1 miles has been built, connecting the generating station with the village of Guttannen. The power is stepped up at the generating station to 50,000 volts and is transmitted over four cable circuits to Guttannen and from there over overhead lines to the Innertkirchen transformer station. The cable tunnel has been built large enough to permit the passage of a small electric car which is the only means of communication between the generating station and the lower part of the valley during the winter season.

At Innertkirchen the power is stepped up to 150,000 volts and from there transmitted to the consumers in central Switzerland.

As a future extension to this development it is planned to collect the water at the turbine outlets of the Handeck generating station and to conduct it by means of a system of tunnels and pipe lines to another generating station which will be built near the present Innertkirchen transformer station. Thereby it will be possible to increase the annual production of the development from 230 million to approximately 540 million kilowatthours.

BRANCH NEWS

Calgary Branch

H. W. Tooker, A.M.E.I.C., Secretary-Treasurer.

On January 26th, about fifty members and friends met in the Board of Trade Rooms, Calgary.

The chairman, F. M. Steel, M.E.I.C., voiced the feelings of all present in expressing his sorrow at the sudden death of our old friend, ex-secretary and branch news editor, J. A. Spreckley, A.M.E.I.C. A letter of sympathy and a wreath was sent to his brother and sisters.

The Manufacture of Portland Cement

W. D. Armstrong, A.M.E.I.C., manager, Exshaw plant, Canada Cement Company, addressed those assembled on "The Manufacture of Portland Cement."

He sketched the history of the use of cement from its, probably accidental, discovery by early cave-dwellers, through the Egyptian and Roman civilizations, after which the art was lost for a time, to its rediscovery by Robert Smeaton in the latter part of the 18th Century.

Robert Smeaton found that limestones containing clay, when burned to lime, would not only harden better than mortars in the air, but would harden under water and this may well be taken as the beginning of the modern cement industry.

Another century of experiment and research, continued the speaker, passed before Ransome, an English engineer, developed the rotary kiln which is one of the chief factors in present day large production methods.

The cement industry today depends upon five factors:

1. The systematic application of chemistry to the discovery of different raw materials which have the necessary chemical constituents.
2. The development of machinery capable of the fine grinding necessary.
3. The development of the rotary kiln heated by means of powdered fuel.
4. The development of standard specifications which permit the use of widely varying materials while producing a reliable product.
5. Systematic study of the manufacture and use of concrete.

After elaborating these requirements and quoting quantities of materials and fuel used, size of machines and other operating data, Mr. Armstrong discussed the two methods—wet and dry—used in modern plants and their relative advantages. He stressed the necessity of accurate proportioning and uniformly fine grinding together with periodic sampling upon the quality of the finished product; the suitability of various grades of coal, also of oil and gas as fuels; furnace temperatures attained and resulting stack temperatures, utilization of the stack gases for preheating combustion air or for generating steam under waste heat boilers.

The chemical composition of cement, with the effect of the various constituents on strength, setting time and for special purposes such as resisting disintegration in alkali soils were then outlined by the speaker.

The industry has passed through three stages, stated the speaker; in the first place the material was ground wet, dried and sintered in vertical kilns, in the second it was ground wet and sintered in rotary kilns and in the third ground dry and fed dry to rotary kilns. Most modern mills still operate on the third method but there is a decided trend back towards the second and experiments are in progress which may lead to a return to the first. If they are successful the industry will have completed a cycle and will have returned to the original methods of one hundred years ago.

The lecture was followed by a very interesting series of motion pictures.

Among those taking part in the very lively discussion which ensued were Messrs. M. H. Marshall, M.E.I.C., R. S. Stockton, M.E.I.C., G. P. F. Boese, A.M.E.I.C., F. N. Rhodes, A.M.E.I.C., H. J. McLean, A.M.E.I.C., W. Anderson, A.M.E.I.C., and the chairman. A very hearty vote of thanks was accorded the speaker on a motion by Messrs. R. S. Stockton and J. Dow, M.E.I.C.

Hamilton Branch

J. R. Dunbar, A.M.E.I.C., Secretary-Treasurer.
G. Moes, A.M.E.I.C., Branch News Editor.

The Value of Photography to Engineering

The February meeting of the Hamilton Branch was held in the Royal Connaught hotel on the first of February. In the July 1932 issue of The Journal our Branch announced a new undertaking which arranged for several papers to be prepared by committees of the Branch. The first of these papers was delivered at this meeting and was entitled "The Value of Photography to Engineering" by the following committee under the direction of A. R. Hannaford, A.M.E.I.C., chairman-author.

C. H. Cunningham, B.A.Sc. — J. A. M. Galilee, Affil. E.I.C.
W. A. T. Gilmour, Jr.E.I.C. — T. S. Glover, A.M.E.I.C.
W. Hollingworth, M.E.I.C. — J. G. Morrow.
E. T. Stern, Reg. Prof. Engr. Ont.

The paper was delivered in the form of a symposium, each member of the committee reading the section which had been prepared by him although the material formed one continuous paper on the subject, as described by the title.

The chairman-author was introduced by the vice-chairman of the Branch, H. B. Stuart, A.M.E.I.C., who presided over the meeting owing to the illness of the chairman E. P. Muntz, M.E.I.C. In the introduction of the paper Mr. Hannaford traced the birth of photography from the projection of images known to Aristotle (322 B.C.) to the present time, showing its many applications to engineering.

The information continued beyond the use of the ordinary camera and pointed out that photography has become a "scientific implement" in the hands of the engineers and has so many uses that only a few of the major branches could be dealt with in the paper, these included, photographic surveying, aerial surveying, accoustical engineering, oscillographic and stroboscopic appliances, astronomical photography, photogrammetry, phototopography, also construction, industrial, electrical, metallurgical, chemical and advertising engineering.

The paper then proceeded to deal with some of these branches in detail as follows:—

Chairman-Author—Photographic and Aerial Surveying.

Mr. Hollingworth—Photography and Construction Work. This section was followed by a very interesting and spectacular moving picture film kindly loaned by the Canadian Industries Ltd., Explosives Division. Results of the use of explosives in various circumstances were shown. Of particular interest was the damming of the Saguenay river at Chute à Caron with a concrete obelisk. The value of the slow motion pictures in analyzing the progressive steps following the explosion of the dynamite was well illustrated by this film.

Mr. Gilmour —The Industrial Engineer and Photography.

Mr. Galilee —The Electrical Engineer and Photography.

Mr. Morrow —Photography in Ferrous Metallurgy.

Mr. Stern —The Contribution of the Art of Photography to Chemistry and Chemical Engineering.

Mr. Cunningham—Some recent advances in the perfecting of materials and equipment of a photographic nature applicable to the work of the Engineer.

Mr. Glover —Photography in Industrial Advertising.

The paper was illustrated by forty-four lantern slides, two moving picture films and a number of pictures projected by the Branch's projection machine.

The slides illustrated the paper, in a prearranged order, from the time of the "camera lucida" which gave a temporary picture of an object, to one observer only, to the time of the longest distance photograph ever made, being that of Mount Shasta, taken from the air and at a distance of 323 miles.

The films illustrated construction engineering and the value of photographic records. The pictures projected illustrated the use of micro-photography in the hands of the chemical engineer, showing the texture of silk, the action of aluminum paint and other substances.

The paper concluded with a brief summary by the chairman-author.

Following the symposium, J. J. MacKay, M.E.I.C., moved a hearty vote of thanks to the committee, which was carried unanimously.

The meeting was attended by a large number of local and out of town members and the manner in which the paper was received by them was demonstrated in a very striking and unusual manner. The reporters for the local papers, who came in to gather a few notes of the business meeting and the paper to be presented, were found to be present at the end of the meeting. When challenged for their lateness at our meeting, they informed a member that, having sat down for a few minutes rest, they became so interested that they had remained to the end.

This may be taken as a tribute to either the "paper" or to the hotel chairs.

Lethbridge Branch

E. A. Lawrence, S.E.I.C., Secretary-Treasurer.
R. B. McKenzie, S.E.I.C., Branch News Editor.

The regular dinner and meeting of the Lethbridge Branch took place Saturday, January 21st, in the Marquis hotel. A musical programme was enjoyed after which the speaker R. F. P. Bowman, Jr.E.I.C., was introduced by the chairman, Wm. Meldrum, A.M.E.I.C.

Maintenance of Railway Curves

In the maintenance of railway curves the two essentials are the elevation of the outer rail, and the alignment. Both of these may depart from the true value under traffic or weather conditions, and the restoring of them may be beyond the capacity of the section foreman.

The elevations used are determined from tables, but the selection of the proper elevation may be somewhat of a problem due to the varying speeds of trains. Incorrect elevation will show in the manner in which the rail wears and this indication is generally used in practice. The transition from the level to the elevation must extend out onto the straight track where simple curves are used, but on spirals they are generally made to coincide with the spiral. On compound and reversed curves, difficulties are found in the change of elevation required, but this is generally gotten over by the introduction of spirals between the curves. On very sharp curves it may be necessary to widen the track up to a half inch in order to allow for the stiffness of the locomotive.

The re-aligning of curves is somewhat difficult with the transit due to traffic on the road and obstructions, but the method of 'string lining' eliminates this trouble. This was invented by a C.P.R. section foreman and consists of stretching a string over two rail lengths (66 feet) and measuring the distance from the middle joint to the straight string, in tenths of an inch. These ordinates are measured for every joint on the curve and from them, the distance which each joint must be moved to perfectly align the curve, calculated. There are several methods of calculation, varying in ease and accuracy. Spirals can be introduced and maintained by this method.

This point closed Mr. Bowman's talk, and after an interested discussion, a vote of thanks was moved by N. H. Bradley, A.M.E.I.C., and the meeting closed with the National Anthem.

MANUFACTURE OF BEET SUGAR

At the regular meeting of the Lethbridge Branch of The Institute on Saturday, January 7th, 1933, Mr. F. H. Ballou, efficiency expert for the B.C. Sugar Refinery Co. Ltd. was the special speaker. A musical programme preceeded the speech and the speaker was introduced by G. N. Houston.

Mr. Ballou confined his remarks to a description of the plant and process of the Raymond sugar factory. He mentioned the manner in which the beets were collected and stored. When required they are carried from storage to the plant by a flume in which trash and mud are removed. At the plant the beets are carefully washed, hand-picked and weighed, then cut into thin strips called "cossettes' and carried to one of a battery of fourteen diffusion cells where sugar is extracted with hot water on the counter current principle.

The exhausted pulp is stored, ferments, and is sold as cattle food, while the sugar solution known as 'raw juice' is carried to first carbonation, where some of the non-sugars are removed. Here the juice is treated with saccharate milk from the Steffen house, and gassed with carbon dioxide. This produces a precipitate of calcium carbonate which includes a large portion of the impurities and is filtered off. A second application of carbon dioxide and filtering removes any excess lime and the colour is further improved by saturating the solution with sulphur dioxide. The product of this saturation, known as thin juice, and carrying about 11 per cent sugar, is then evaporated down to a 60 per cent sugar solution.

This syrup is re-sulphured and re-filtered, then sent to the pan floor where it is again boiled under vacuum until it reaches the supersaturation point. Sugar is crystallized out by 'shocking' with powdered sugar and the crystals allowed to grow to the required size. The mixture of sugar and mother liquor is then separated in centrifuges and the sugar washed with distilled water. The sugar then goes to air dryers after which it is ready for packing, while the liquor is re-boiled and recrystallized. The sugar from this step goes to the first pan and the liquor is further treated in the Steffen house.

Due to the concentration of non-sugars in the solution, or molasses as it is now known, it is impossible to remove the remaining sugar by crystallization, and use must be made of lime. Here the molasses is reduced to 6 per cent sugar content and powdered lime added. This lime goes into solution and combines with the sugar to form tri-calcium saccharate. This material precipitates, is filtered out, and on dilution becomes the saccharate milk used in the first carbonation.

Mr. Ballou also described the machines used in the various steps of the process and showed charts of the materials entering the plant each twenty-four hours. An interested discussion followed the talk and after a hearty vote of thanks to the speaker, the meeting closed with the singing of God Save the King.

London Branch

W. R. Smith, A.M.E.I.C., Secretary-Treasurer.
Jno. R. Rostron, A.M.E.I.C., Branch News Editor.

The Annual Dinner and Meeting was held on January 17th, 1933, at the Highland Golf Club, the speaker being Dr. Sherwood Fox, President of the University of Western Ontario, and his subject "The Engineer as a Citizen in Society."

An excellent dinner was provided by the caterers to the club and was thoroughly enjoyed by the fifty members, affiliates and guests present.

The menu and events of the evening were lucidly shown by a "graph," the work of the Secretary, blue prints of which were placed around the table.

Community singing, accompanied by Mr. Archie McCulloch at the piano, was indulged in at intervals throughout the evening.

The retiring chairman D. M. Bright, A.M.E.I.C., presided and welcomed those present, particularly two distinguished guests, Mayor Kilbourne and Warden Carmichael, and asked them for a few words; to which request they complied. He next called upon Major General C. J. Armstrong, M.E.I.C., a member of the Branch and who is shortly retiring from active military service.

The General, in the course of his remarks, expressed regret at the prospect of leaving the district through retirement from military activities, but as he had reached the age of sixty he thought that the time had arrived for him to take this step. However, he did not intend to relinquish engineering activities altogether but to carry on, possibly in consulting practice.

At the conclusion of the General's remarks the chairman introduced the speaker of the evening.

THE ENGINEER AS A CITIZEN IN SOCIETY

It might be thought an easy thing to frame a course of professional training and so it is, to choose the main divisions, but it is very far from easy to say just how much of each division is essential to complete instruction. An engineer is, after all, a human being and the human part of him must be trained as well as the other. An engineer who is all engineer does not know his public for whom he should practise his trade. Only morons and great geniuses can afford to be narrow specialists. An engineer may know his job, but does he know anything else?

The Technical Service Council organized in Toronto by a number of outstanding industrialists made the startling discovery that a great many young graduate engineers failed to be absorbed into business because of two great lacks:

(1) Lack of knowledge of financial procedure and business organization,
(2) Lack of command of good written and spoken English.

It is also noteworthy that of a canvass in America of 6,990 former graduates, 60 per cent indicated that the "cultural studies" in their college courses were of considerable (or greater) value to them in after life. Over half of these confined the cultural studies to commerce and business subjects and English.

If the engineer is so dependent upon society for the existence of his profession, he cannot escape the obligation of knowing thoroughly the society for which he works.

Broadly classified, the things upon which rest this knowledge of human society are (1) Language and Literature, (2) Social and Economic History of Man.

Human thought, the essential of all constructive activity, is more resisted in a plan of professional training than any other department. The freshman asks what bearing has literature on his profession and wants instructions of a routine nature which can be memorized with a minimum of thought. The result is a surplus of graduate engineers who are intellectually impotent to grapple with problems outside their routine and cannot express in clear language even the shred of thinking they are capable of. Language is an instrument of thought. Real thought requires words, and words are necessary to convey those thoughts to others. It is by our words we govern men.

The post graduate career of those who rely on pull, hunches, ragged thought and sloppy expression has at the best been brief. Therefore, every professional man must have in his training a considerable amount of language and literature. This applies to both English and foreign languages for the study of either develops the language sense.

As to history, this is a practical thing just as utilitarian as machinery. A sound interpretation of the accurate records of the economic and social facts of the past is necessary. To ignore this is to risk incorrect thinking and false conclusions.

This age may be summarily described by two designations: the machine age and the age of competition. In the former the machine must be put in its proper place, not scrapped, and into the gap thus created by the shift must go the practical recognition of the "more intrinsically valuable qualities" and not least among these is the mentality of the individual. The only hope of democracy lies in the encouragement of critical-mindedness. As to competition, interest in non-productive pursuits furnishes a relief from competitive life no less essential to its vigour than success itself.

E. V. Buchanan, M.E.I.C., in moving a vote of thanks to the speaker said it was embarrassing to an engineer to rise and speak after hearing such oratory as Dr. Fox had given.

Col. I. Leonard, M.E.I.C., seconded this vote of thanks which was unanimously carried.

The election of officers for the succeeding year then took place and resulted as follows:

Chairman	V. A. McKillop, A.M.E.I.C.
Vice-Chairman	H. B. R. Craig, M.E.I.C.
Executive	S. W. Archibald, A.M.E.I.C.
	J. Ferguson, A.M.E.I.C.
	W. C. Miller, M.E.I.C.
	H. A. McKay, A.M.E.I.C.
	A. O. Wolff, M.E.I.C.
Ex-officio-retiring Chairman	D. M. Bright, A.M.E.I.C.
Councillor	J. A. Vance, A.M.E.I.C.
Secretary-Treasurer	W. R. Smith, A.M.E.I.C.
News Editor	Jno. R. Rostron, A.M.E.I.C.

Mr. McKillop, newly elected chairman, said that he would be happy to serve: if he could do as well as the retiring chairman, Mr. Bright, had done he would be satisfied. He thought it would be a good thing to follow along some of the lines suggested by Dr. Fox. Something perhaps of non-competitive pursuit, which would make the proceeding interesting and he would suggest this to the Executive.

Moncton Branch

V. C. Blackett, A.M.E.I.C., Secretary-Treasurer.

DETECTING HIDDEN DEFECTS IN STEEL RAILS

A most interesting and instructive paper on "The Operation of the Sperry Car in Detecting Hidden Defects in Steel Rails" was read by H. B. Titus, A.M.E.I.C., on January 24th, before a combined meeting of Moncton Branch and the Engineering Society of Mount Allison, held in the Science building of the University, Sackville. D. H. Hayman, S.E.I.C., presided.

Mr. Titus described in detail the various processes in the manufacture of steel rails, from the casting of the steel ingot to the delivery of the finished product to the railway company. Of the various defects sometimes found in rails, by far the most dangerous is the transverse fissure, which rarely gives warning of its presence until failure of the rail occurs under traffic.

The Sperry car in detecting hidden defects in rails works on the principle that a defective section of rail offers greater resistance to an electric current than does a sound section. In operation the car moves slowly along the track while a current of 2,000 amperes is passed through each rail. Any defect in a rail is automatically recorded, after which further tests are made and, if necessary, the rail is reported for removal from the track.

At the conclusion of the address a hearty vote of thanks was tendered Mr. Titus by the presiding 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.

There was an attendance of 51 at the dinner meeting held in the General Brock hotel, Niagara Falls, on February 1st, to hear Mr. G. W. Lapp tell something of his impressions gained during a recent trip to Russia. Mr. Lapp viewed the situation from an engineering and economic standpoint.

Impressions of Russia

There are one hundred and eighty different kinds of people in Russia, said Mr. Lapp, and it was a remarkable achievement to bring them all together under one flag and one government. Formerly the government was autocratic, ruled by a Tsar, the aristocracy, the army and the church. The Soviets were developed from local institutions which were almost the only means whereby grievances could be brought to the attention of the Tsar.

With such a past, is it to be wondered at that the present government should be confused with a sudden access to power and responsibility?

One such precedent, or law, however, they have been quick to grasp. This is the law of progress by trial and error, or the experimental method, which is commonly used by many of our large industrialists. Suppose some condition exists, or arises, in either the social or economic field, which has to be rectified. The party deliberates, and various theoretical solutions are advanced, of which one is put into effect. If this theory does not work in practice, a second theory is tried, and so on until something is found which suits the actual conditions. The power of the Communist party is absolute and a fundamental change can be made almost over night.

The Russians are endowed with the faculty of great patience; they are also capable of vast enthusiasm and the building up of their new state is being attacked with such enthusiasm as to enlist all their energies.

Children are being trained to reverence the State above everything, and the new generation is being taught to work together and for each other.

At present the government by the Communist party is almost as autocratic as that under the former regime, but with the difference that it is self imposed and recognized to be for the ultimate good of the people as a whole.

An underlying fear of a return to the old conditions is constantly before them, and makes this autocratic method possible. The invasion under Kolchack with foreign legionaries assisting was one of the most powerful influences in stabilizing the government. In time this fear will wear away, but meanwhile the people will prevent any retrograde movement.

Engineers and technicians are given carte blanche to develop their ideas and to teach the younger generation. These too, as fast as they can develop a smattering of knowledge, are heaped with responsibilities, sometimes beyond their power, and held to the mark. If they fail they pay the penalty, and if they succeed they gain an overwhelming confidence.

At the present time the Russian plan calls for a concentration upon the "heavy industries," that is to say factories for the production of other machinery and capital. Some three-quarters of the available capital is being put into this work. Soon they hope to be independent of the rest of the world in this respect and keep this money at home.

Mr. Lapp remarked to a young Russian engineer that his country appeared to have leadership and control but lacked materials, whereas in other countries a reverse state of affairs exists. The rejoinder was to the effect that perhaps Russia would obtain the materials she wanted quicker than these other countries would succeed in perfecting their control.

Answering questions as to present day labour conditions and future policies, Mr. Lapp remarked that the standard of living was unquestionably low, but free education, medical, hospital and other services were computed to be worth about a quarter of the salary charges. Both men and women are forced to work for four days out of every five and for seven hours a day—lately reduced from nine hours. Their future policy would be hazardous to predict, but the impression he received was that they were striving primarily for an increased standard of living and then for an increase of leisure with little thought as to how the outside world fared. The Third Internationale did not carry very much weight and most of the rumours of funds being expended to foment trouble in other nations were unreliable. They have little capital to spare, and have very definite uses for every rouble.

Ottawa Branch

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

The last noon luncheon meeting of the Ottawa Branch for the 1932-1933 year was held at the Chateau Laurier on January 12th. Frank P. McKibben, B.Sc., of Black Gap, Pennsylvania, spoke upon the subject of "A Roman Bridge in an American City."

C. McL. Pitts, A.M.E.I.C., chairman, presided and other head table guests were Hon. R. J. Manion; Hon. H. A. Stewart; Hon. T. G. Murphy; W. H. Beck, United States Consul General; L. W. Meekins, United States Consul Attache; C. A. Magrath, M.E.I.C., Dr. Charles Camsell, M.E.I.C., G. J. Desbarats, M.E.I.C., Colonel A. E. Dubuc, M.E.I.C., F. H. Peters, M.E.I.C., K. M. Cameron, M.E.I.C., and Group Captain E. W. Stedman, M.E.I.C.

A Roman Bridge in an American City

Mr. McKibben's address referred to a newly constructed bridge over the Genesee river at Rochester on the Ridge road. The design of this bridge was evolved along old Roman lines after studying fourteen different types of structures.

It was desired to create something which would harmonize thoroughly with the beautiful surroundings of the location.

The bridge as finally built has a middle span of three hundred feet which, with approaches on either side, present a total length of somewhere in the neighbourhood of one thousand feet. The cost of the bridge itself was $2,550,000, an appropriation of three million dollars being allotted to the entire project.

The bridge was of concrete, faced with white granite blocks which were interlocked and thoroughly bonded with the former, the outward appearance thereby resembling closely the Roman type of structure.

Mr. McKibben stated that there are four distinct characteristics to the Roman arch. First, the arc of the circle is semicircular. Second, the spandrels are filled with solid walls whereas in the modern type of bridge they are generally left open. Third, there is the use of a wide pier in the dimension lengthwise of the structure, the Romans apparently not understanding the placing of foundations in soft material and so resorting to width here. Fourth, the ring stones in the arch ring are entirely separated from the stones in the spandrel walls. In modern bridges these stones are interlocked.

In the design as carried out, these four characteristics were followed.

By means of lantern slides, the speaker traced the various steps whereby the design was eventually arrived at, together with the course of the actual construction. At one end of the bridge there is a traffic circle where six streets converge around a point. This is a busy place, fifteen thousand automobiles in a twelve-hour day being the maximum amount of traffic actually counted.

At the conclusion of the address, upon responding to the vote of thanks which was heartily accorded to him by the local Branch, Mr. McKibben remarked that he enjoyed the opportunity for the interchange of technical knowledge with Canada, and could see no reason why there should not be further interchange, engineers all being interested in the same things.

Annual Meeting

The twenty-third annual meeting of the Ottawa Branch of The Engineering Institute of Canada was held at Standish Hall, Hull, on the evening of January 12th. About a hundred members were present, the retiring chairman, C. McL. Pitts, A.M.E.I.C., presiding.

In the absence of F. C. C. Lynch, A.M.E.I.C., secretary-treasurer, W. J. Peaker, A.M.E.I.C., acted as secretary throughout the meeting. After the notice of meeting was read, the chairman presented his address, in which the activities of the Branch for the past year were briefly reviewed. The general uncertainty of economic well-being had affected the Branch, creating a sub-normal atmosphere. Some had sustained severe losses to their incomes, some even their positions, and all had been under a tremendous added mental strain. A committee on employment had been appointed during the year, questionnaires had been sent out, and ways and means sought in co-operation with Headquarters of locating available employment for those—fortunately a surprisingly few—who were found to be actually out of employment.

There had been, however, a distinct feeling of uneasiness in the air as regards professional employment, even in the Civil Service, where economies had been instituted. The number of resignations and suspensions was quite large, there being a total decrease in the various grades, from all causes, of 53. The total membership for 1932 stood at 415.

During the year fifteen luncheon meetings and two evening meetings were held.

Ten special meetings during the year were held by the Managing Committee at which matters affecting the policy and work of The Institute were discussed.

At one of the evening meetings of the Branch, held on November 23rd, consideration was given to the interim report of The Institute Committee on Development as presented by its chairman, J. L. Busfield, M.E.I.C., of Montreal, as well as to a memorandum relating thereto presented by J. B. Challies, M.E.I.C. Mr. Challies took exception in his presentation to a number of the proposed changes and this brought forth considerable discussion on the part of local members. As a number of Branches had, after consideration, presented definite criticism and suggestions regarding the Report, and had invited an interchange of ideas before the 1933 Annual Meeting of The Institute, the Managing Committee approved and forwarded a letter to Council, a copy of which was sent to all Branches, outlining in general their reaction to the Report, expressing appreciation of the labours of The Institute Committee on Development, and requesting that further time be given for its study by the Branches and membership.

In accordance with a resolution passed at the last Annual Meeting, special prizes were awarded to pupils in both the Technical Schools of Ottawa and Hull.

Gratifying progress was made by the Aeronautical section and a grant of $20 was passed by the Managing Committee toward its expenses. This section with Professor J. H. Parkin, M.E.I.C., as chairman and Alan Ferrier, A.M.E.I.C., as secretary, held three meetings in the spring and three meetings in the fall.

During the year, The Institute, and particularly the Ottawa Branch, suffered severe loss in the passing of two of its most honoured and esteemed members, C. H. Keefer, M.E.I.C., who died April 12th, 1932, and L. E. Coté, M.E.I.C., who died September 26th, 1932.

Mention was also made of the kindly and gracious support and publicity received during the year from the three local newspapers, the Ottawa Citizen, the Ottawa Journal, and Le Droit.

Following the chairman's address, reports were presented from the secretary-treasurer and from regular committees with chairmen as follows: proceedings, by Dr. R. W. Boyle, M.E.I.C.; Membership, by R. F. Howard, M.E.I.C.; Rooms and Library, Branch By-Laws, and Reception, by G. J. Desbarats, M.E.I.C.; and Advertising, by W. S. Kidd, A.M.E.I.C. In addition J. H. Parkin, M.E.I.C., chairman of the Aeronautical section reported, and a report was read from a special committee, with O. S. Finnie, M.E.I.C., as chairman, formed to look into the question of a new site for a city hall for Ottawa.

The financial statement, according to the secretary-treasurer, showed that the assets of the Branch were $1,950.07, a gain of $34.24 over last year in spite of the fact that a total of $160 in equipment had been written off during the year. The cash balance (including two $500 Victory Bonds) was $1,899.27.

The election of officers for the year 1933 resulted as follows: Chairman, Group Captain E. W. Stedman, M.E.I.C., chief aeronautical engineer of the Department of National Defence; Secretary-Treasurer, F. C. C. Lynch, A.M.E.I.C., director of the National Development Bureau of the Department of the Interior who continues in office; new members of the Managing Committee to serve two years, W. F. M. Bryce, A.M.E.I.C., J. G. Macphail, M.E.I.C., and E. Viens, M.E.I.C. Other members of this committee who still have a year to serve are Dr. R. W. Boyle, M.E.I.C., and W. S. Kidd, A.M.E.I.C. Toward the end of the meeting Group Captain E. W. Stedman took over the chair and conveyed the thanks of the meeting to the retiring chairman, to the secretary-treasurer and the executive and also thanked the members for the honour accorded to him.

Following the business section, motion pictures were screened through the courtesy of B. E. Norrish, A.M.E.I.C., of the Associated Screen News, Ltd., of Montreal, who also sent an operator for the occasion. Music was supplied during the showing of the films by Leonard Tanner, F.R.A.M., F.R.C.O. At the close of the evening refreshments were served.

Mining Industry in the Yukon Territory

At the first noon luncheon of the 1933-34 year, held at the Chateau Laurier on January 26th, Hugh S. Bostock, M.Sc., Ph.D., spoke on the "Mining Industry in the Yukon Territory." Group Captain E. W. Stedman, M.E.I.C., the newly elected chairman of the Ottawa Branch, presided, head table guests including in addition: Hon. George Black, G. J. Desbarats, C.M.G., M.E.I.C., H. H. Rowatt, L. L. Bolton, M.E.I.C., Dr. Wm. Collins, B. F. Haanel, M.E.I.C., C. McL. Pitts, A.M.E.I.C., W. B. Timm, J. L. Turner, F. H. Peters, M.E.I.C., and O. S. Finnie, M.E.I.C.

Dr. Bostock, as a member of the Geological Survey of Canada, carried on field work for a number of years, mostly in the southern interior of British Columbia and more latterly in the Yukon Territory. At the commencement of his address he referred to mining, both placer and lode, as the chief industry of the Yukon Territory, surpassing other industries such as the fur-trade.

For many years placer mining held the lead. During the past decade or so, however, lode mining has been catching up and now surpasses the former in annual output. With placer mining the chief product is gold with a small amount of other metals such as silver, tungsten and native copper also produced. Placer gold was first mentioned by the Hudson's Bay Company fur-traders in 1847, though it was not until the 1880's that prospectors actually began to take gold out.

The discovery of the Klondike field in 1896 eclipsed all other placer localities; at one time the output rose to a maximum of over twenty-two million dollars per year. In 1926, a minimum production of slightly over one-half million was reached, although during the past few years the placer production has been gradually increasing and in 1931, it amounted to nine hundred thousand dollars. The history of the Klondike placer fields is thus one of large returns at first by crude methods, then as the deposits became depleted, the introduction of new methods for the extraction of the gold from the lower grade ore.

About 1906 some of the leading men in the Klondike began to consolidate their small holdings so that they could work them on a larger scale through the introduction of mechanical methods including the use of large dredges. These are the methods in use today. Practically the entire field is now under the control of the Yukon Consolidated Gold Corporation and its subsidiaries. Last summer this corporation employed an able engineer to examine their holdings and he estimated that there was a reserve for thirty years or more with dredging operations carried on at their present maximum capacity. Large reserves were also disclosed which could be treated by other methods.

Among the first impressions of the mining industry noted by Dr. Bostock, were the sizes of the dredges, some of them having a bucket capacity of 17 cubic feet, also the large areas of gravel, the huge amounts of equipment that had been junked, and the enormous areas of dredging and hydraulic tailings.

Before the dredges can be used the ground must be thawed out, an operation which in the old days was considered as impossible on a paying basis. Steam was utilized for this purpose but now it is effected by cold water thawing. In the latter method a number of pipes are forced into the ground to a depth varying from 10 to 50 feet according to the depth of the layer to be dredged, and water of normal temperature is allowed to run through them. Sometimes as many as fifteen hundred of these pipes, spaced at intervals of 50 feet or so, are placed around a dredge. In the ideal thawing plant, the gravel should be thawed out a year or so ahead so as to give it time to "mellow." That is, areas missed in the initial thawing would have a chance to thaw out during the course of time and also the consistency of the ground would be rendered more suitable for dredging. At the present time, during the normal summer seasons, the Yukon Consolidated Gold Corporation operate five dredges, three large ones in the Klondike valley and two small ones on the Indian river. The cost of operation for the large dredges is less than 10 cents per cubic yard and for the smaller dredges about 20 cents per cubic yard. With further development it is hoped that these costs will be cut even lower.

The lode mining is centered around the Mayo district. Silver occurs here in spectacularly rich veins, a considerable quantity having been produced in the past. Operations are still being carried on, a recent development of interest being the introduction of large ten-ton motor trucks to transport the ore from Keno Hill to Mayo Wharf. Transportation was formerly by the use of tractor trains, usually with seven trucks to a train and in winter this was a long, slow, and arduous undertaking, and in summer it was of course not feasible.

Toward the close of his address, Dr. Bostock devoted a few minutes in explanation of the methods by which the water works system in Dawson City is enabled to combat the extreme cold of winter and the frozen condition of the ground. Particular precautions are required to keep up the water supply and the pipe and sewer systems are entirely of wood, buried sometimes in boxes filled with sawdust. In the cold weather the water is heated to about 40 or 45 degrees before being sent out from the power plant and in the buildings a tap must be continually flowing. The water left over is returned to the power plant, at a temperature of about 32 or 33 degrees. The sewers are kept operating by means of the overflow from the water system. The water supply well, situated a hundred feet from the bank of the Klondike river near its junction with the Yukon, must be kept open in extreme winter weather by means of a steam jet introduced below its surface.

Peterborough Branch

W. F. Auld, Jr.E.I.C., Secretary
W. T. Fanjoy, Jr.E.I.C., Branch News Editor.

The Manufacture of Specialty Rubber Goods of Various Forms

Methods and processes involved in the manufacture of specialty rubber goods of various forms were described in an address by O. B. Crowell, chief chemist of the Viceroy Manufacturing Company, Limited, of Toronto to the Peterborough Branch at the regular meeting on January 26th at Paragon hall. Mr. Crowell built his address around many samples of crude, processed and finished goods of his firm's manufacture which he had brought with him for illustration.

His company, the speaker remarked, does not touch the field of rubber tires, rubber foot wear or mechanical rubber goods but manufactures a line of products ranging in nature from rubber erasers to storage battery cases.

Commencing with rubber heels, the speaker explained, crude rubber is compounded with carbon and other ingredients called for by the laboratory formulas. The mixture is extruded into a section approximating the shape of the finished heel. This section is sliced and the individual slices are placed in multi-cavity moulds from which the finished heel is turned out. In the moulding and curing process 165 tons pressure and a temperature of 350 degrees are required.

In making rubber bands a very careful selection of materials and constant checking is necessary. In process a mixture about 90 per cent pure rubber is formed into tubes by the extrusion process. After curing, the bands are sliced on machines which in the case of the smaller bands slice as many as 15,000 per minute. Rubber bands are made in seventy-two sizes from the smallest which will hardly slip over a man's little finger to the large package bands about 5 inches in diameter and ¾ inch wide.

The speaker declared that the manufacture of rubber erasers would also seem a simple matter but there is a lot more to it than would appear. The principal ingredient in the mixture for erasers besides rubber is pumice. Practically all the good mechanical qualities of rubber which are desirable in other articles such as tensile strength, set, elasticity etc., are deliberately avoided in erasers.

The process by which children's rubber bounce balls are made, was particularly interesting. The two uncemented halves of a ball are placed in the upper and lower parts of a mould. Gas pills of ammonium chloride and sodium chloride are placed in the bottom half with a small amount of water. The two halves are joined under pressure and subjected to heat during the process. As a result of the action of the gas pills and the water, nitrogen is formed and inflates the ball to a high degree of inflation. The ball is allowed to cool before it is taken out of the mould so as to avoid bursting.

Other articles of manufacture touched on by the speaker were tires for baby carriages etc. battery boxes, lace doilies, bath mats, flyswatters, rubber soles for shoes, refrigerator gaskets, printers mattes, garden hose etc.

Aluminum—Its Production and Utilization

The February 9th meeting of the Branch had as its speaker Mr. Paul S. White, B.A.Sc. of the Aluminum VI Company Limited, who presented in a graphic manner the story of aluminum, its production and utilization.

"Aluminum is really a product of the present age," Mr. White pointed out in the course of a brief outline of the history of the metal which in a few years, has come to be regarded as a necessity to modern civilization.

The present aluminum industry has grown from an initial commercial production of fifty pounds per day to a world production at the present time of 300,000 tons per year. The price of metal has decreased from $27.00 per pound in 1857 to $1 per pound in 1888 and to the neighborhood of 20 cents per pound at the present time.

Aluminum is secured commercially from aluminum ores, known under the general term of "bauxite" in which the aluminum is largely present as hydrated oxides. The richest bauxite deposits are located in Southern France, Arkansas, Dutch Guiana, Western Hungary and British Guiana.

Turning to the subject of production Mr. White described the operations of crushing and drying the bauxite, then the processes of extraction of the aluminum. While chemical methods used in some parts of the world extract the alumina in aqueous solution and might be said to aim primarily at the production of a pure aluminum salt solution by extracting the alumina from the ore and leaving most or all of the impurities insoluble, the dry process proceeds in the opposite direction by reducing the impurities to the metallic state and separating them from the molten pure alumina.

The electrolytic production of aluminum at Arvida was also described in some details. Broadly speaking, a cell for the electrolyte production of aluminum comprises a strong steel box provided with a carbon lining which acts as a cathode. The anodes are also made of a mixture of carbon, pitch and tar. The anodes hang from busbars over the cavity of the cells, dipping into the electrolyte.

In operation the cell contains a layer of molten aluminum at the bottom of the cell, varying in thickness from a fraction of an inch up to four or five inches. The molten cryolite (the solvent) remains on top unless the contents of the cell are violently agitated. During operation the electrolyte is kept in continuous agitation by the bubbles of gas given off at each anode and by the effect of the magnetic field produced.

During the operation of the cell, the alumina is used up in direct proportion to the production of the metal and is added from time to time in through the top of the crust.

The power required per pound of aluminum produced may vary from ten to twelve kilowatt hours. The anode consumption is from 0.6 to one pound of carbon per pound of aluminum produced so that the carbon or anode plant is almost as large as the aluminum plant itself.

When a sufficient amount of metal is accumulated at the bottom of the cell, it is removed by tapping and allowed to flow into a large ladle when it is skimmed and then repoured into ingot moulds. The aluminum as poured into these ingot moulds is thus in its final state for practically all commercial uses.

Quebec Branch

Jules Joyal, A.M.E.I.C., Secrétaire-Trésorier.

L'Or et son Rôle Économique

Tel fut le sujet très intéressant traité par un conférencier des plus compétents, M. J.-E. Grégoire, avocat, professeur d'Economie Politique à l'Université Laval, à un déjeuner-causerie de la Section de Québec, au Château Frontenac, le 16 janvier, 1933.

Comme ce déjeuner était le premier de la présente année, le président M. Hector Cimon, M.E.I.C., profita de cette occasion pour offrir ses meilleurs vœux à l'assistance, puis, en termes très élogieux, il présenta le conférencier.

"Précieux entre tous les métaux, recherché et convoité pour des raisons particulières", nous dit M. Grégoire, "l'or peut aussi être considéré au point de vue économique et c'est un point de vue intéressant, surtout à l'époque que nous traversons."

"L'or ou son équivalent apparut à plusieurs comme le seul refuge pour les débris de ce qu'ils avaient possédé et ce fut la course, la ruée vers l'or ou ce qu'il représente. Chacun voulut convertir ses valeurs en or mais la quantité existante était insuffisante pour satisfaire à la demande; la conséquence fut que la valeur de l'or monta, mais fatalement la valeur des autres marchandises ou titres baissa dans la même proportion. C'était la crise monétaire qui venait s'ajouter à la crise économique et l'aggraver."

"C'était la répétition en sens inverse de ce qui se passa au cours des années 1928-29, alors que tous faisaient confiance au 'papier' sous la forme de valeurs mobilières, d'autant plus remplies de promesses que dénuées de valeur. En résumé: au cours de 1928-29 ce fut une course au 'papier'; conséquemment, la valeur de celui-ci monta et la valeur de l'or baissa. Depuis octobre 1929 c'est le phénomène contraire qui se produit; le public abandonne le 'papier' et autres valeurs qui baissent pour l'or qui monte."

"L'or devenu rare et dispendieux est tenu responsable de tout ce mal; c'est ce qui explique qu'en certains milieux on fait actuellement le procès de l'or et de l'étalon-or."

"L'or, depuis des siècles, rend de précieux services à l'humanité et il nous continuera son indispensable et généreux concours à la condition que l'homme revienne à la saine raison et le considère, comme autrefois, non pas comme un dieu devant lequel il doit s'agenouiller, mais comme un métal, une marchandise comme toutes les autres, bien que la plus apte: 1—à servir de commune mesure aux autres valeurs; 2—à servir de marchandise intermédiaire dans les échanges ou de moyen de paiement; 3—à servir de base aux réserves qui garantissent la monnaie fiduciaire et supportent le commerce international."

M. J.-A. Duchastel, M.E.I.C., adressa quelques mots de remerciements au conférencier et exprima son désir de voir M. Grégoire invité plus souvent à nous donner des conférences de ce genre.

A la table d'honneur on remarquait, aux côtés du président, M. Cimon, et du conférencier, M. Grégoire: MM. A.-R. Décary, M.E.I.C., A.-B. Normandin, A.M.E.I.C., J.-A. Duchastel, A.-G. Sabourin, A.M.E.I.C., et Louis Beaudry, A.M.E.I.C.

Quelques journalistes assistaient à ce déjeuner-causerie.

Saskatchewan Branch

Stewart Young, A.M.E.I.C., Secretary-Treasurer.

The regular monthly meeting of the Branch, held in the Hotel Champlain, Regina, on Friday evening, January 20th, 1933, took the form of a Ladies' Night in that the wives and friends of the members were invited to attend. Included also in the guest list were Dr. H. R. Wolfe, J. B. Hiday, P. B. MacEwen, H. A. Reynolds and A. A. Catkin, members of the staff of General Motors at present in Regina, engaged in experimental work on winter driving of motor cars.

Immediately following the dinner several vocal numbers, rendered by Mrs. R. S. Patton and Mrs. W. G. Laird, accompanied by Mrs. W. J. Mars, were enthusiastically received.

The secretary drew the attention of the meeting to the annual meeting of The Institute in Ottawa on February 7th and 8th, when, on discussion, P. C. Perry, A.M.E.I.C., was appointed official delegate to the annual meeting with power in the event of his being unable to attend to appoint a substitute.

J. McD. Patton, A.M.E.I.C., reported for the Papers and Library Committee, stating that Dean C. J. MacKenzie, M.E.I.C., had consented to give an address on the new Saskatoon Bridge at the next meeting, which, in all probability, would be a meeting held jointly with the Association of Professional Engineers, on February 20th.

The secretary then presented a brief report of the activities of the Executive since the last meeting, intimating the action taken by the Council of The Institute with respect to the Report on Development, namely, that while the question would be discussed at the annual meeting at Ottawa, voting would be deferred for a period of one year.

The Chairman, J. D. Peters, A.M.E.I.C., then introduced the speaker of the evening, R. N. Blackburn, M.E.I.C., the subject of his address being "A Winter's Wanderings," illustrated by lantern slides.

After suitably introducing his subject, Mr. Blackburn took his audience on a motor trip by lantern slide from Regina, through the Dakotas, Nebraska, Kansas, Oklahoma, Texas, New Mexico, Mexico, Arizona, California, Oregon, Washington, Idaho and British Columbia, thence to Regina, stating that the views shown were obtained during the past year while on a motor trip.

The thanks of the meeting were conveyed by the chairman to Mr. Blackburn, also to Mrs. Blackburn who very ably assisted by operating the lantern.

The Canadian Ohio Brass Company Ltd., it is announced, has sold its manufacturing property on Portage road, Niagara Falls, Ont., and it is stated that the erection of a new modern factory with greatly improved facilities at Niagara Falls is contemplated, although plans have not progressed to a point where they are ready for announcement. Arrangements have been made for the company to occupy the present plant until such time as the new one is completed and ready for operation.

Preliminary Notice

of Applications for Admission and for Transfer

February 20th, 1933

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 April, 1933.

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 he considered as responsible charge.

An Associate Member shall be at least twenty-seven years of age, and shall have heen 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 hy 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 he considered as professional responsibility.

Every candidate who has not graduated from a school of engineering recognized hy the Council shall be required to pass an examination hefore a board of examiners appointed hy the Council. The candidate shall he examined on the theory and practice of engineering, with special reference to the hranch of engineering in which he has heen 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 he at least twenty-one years of age, and shall have been engaged in some hranch of engineering for at least four years. This period may he reduced to one year at the discretion of the Council if the candidate for election has graduated from a school of engineering recognized hy 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 hy the Council, or has not passed the examinations of the third year in such a course, shall he 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 he 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 he pursuing a course of instruction in a school of engineering recognized hy 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 he one who is not an engineer hy 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 memhers as reference does not necessarily mean that their applications are endorsed hy such memhers.

FOR ADMISSION

BERRY—EFFINGHAM DEANS, of 150 Aylmer Ave., Ottawa, Ont., Born at Shettleston, Glasgow, Scotland, April 5th, 1889; Educ., Certs. in elect'l. and mech'l. engrg., Royal Technical College, Glasgow, Scotland, 1911; 1904-09, mech. eng. ap'tice, D. Stewart & Co., Glasgow; 1909, engr., Hutson & Sons, Glasgow; 1909-13, designer, J. & G. Boyd Ltd.; Shettleston; 1913-15, dftsman., C.P.R., Winnipeg; 1915-17, engr. and designer, Blashill Mach. Co., Montreal; 1917-19, asst. chief dftsman., Canadian Aeroplanes Ltd., Toronto; 1920-21, engr., Riordon Pulp & Paper Co., Hawkesbury; 1922-25, production supt., Ottawa Car Mfg. Co., Ottawa; 1926-27, departmental engr., i/c wood room and digester house, Riordon Pulp Corpn., Temiskaming; 1927 to date, chief dftsman., E. B. Eddy Co. Ltd., Hull, Que.

References: W. S. Kidd, J. C. Day, J. L. Rannie, C. E. White, L. S. Dixon, H. Kennedy.

BRAINE—ARTHUR WENTWORTH, of 3800 Dewdney Ave., Regina, Sask., Born at Londonderry, N.S., Mar. 7th, 1909; Educ., B.Sc. (Forestry), Univ. of N.B., 1931; Summer work: 1928, timher cruising and surveying for Minas Basin Pulp & Paper Co.; 1929, rate of growth survey for Dom. Govt.; 1930, timher scaling on pulpwood. Not employed at present.

References: E. O. Turner. J. Stephens, T. G. Tyrer, R. H. Murray, H. A. Jones.

DAVY—ARTHUR CECIL MONTAGUE, Lieut.-Commander (E), R.C.N., of Ottawa, Ont., Born at Montreal, Que., Oct. 18th, 1902; Educ., 1917-20, Royal Naval College of Canada, Halifax. 1923-25, Royal Naval Engrg. College, Devonport, England, 1st Class as Lieut. (E), R.N., Aug. 1925; Memher, Inst. of Marine Engrs. (England). Assoc. Member, Inst. of Naval Architects (England); 1920-23, part-time training in engrg. and ship constrn., as midshipman and sub-lieut. (In the Fleet); 1925-26, watchkeeping officer, and 1926-27, senior watchkeeping officer, H.M.S. "Ramillies"; 1927-28, 2nd engr. officer, H.M.S. "Mackay"; 1928-31, chief engr., H.M.C.S. "Vancouver." At present, asst. director of naval engrg., Department of National Defence, Ottawa, Ont.

References: C. Camsell, F. P. Shearwood, B. F. Haanel, T. C. Phillips, A. N. Budden.

GRIFFITHS—GEORGE EWART, of Thorold, Ont., Born at Thorold Twp., Nov. 14th, 1890; Educ., B.A.Sc., Univ. of Toronto, 1915; 1915-16, inspections staff, war munitions, St. Catharines, Ont.; 1916, test dept., (transformers), Canadian Westinghouse Co., Hamilton, Ont.; 1916-19 military service, 2nd Army Troops, Can. Engrs., (Cadet Training); 1919 to date, asst. meter engr., H.E.P.C. of Ontario, Niagara Falls District.

References: H. M. King, P. E. Buss, R. W. Angus, C. G. Cline, G. C. Mountford.

HANSON—RALPH ELLIS, of Ottawa, Ont., Born at Falmouth, N.S., July 11th, 1905; Educ., B.Sc. (Mining), N.S. Tech. Coll., 1928. D.L.S. 1930; Summers 1925-28, articled pupil, topographical survey; 1929, junior asst. on surveying ship, 1930-31-32, chief asst. on surveying ship, and at present, hydrographer, Grade 1, Hydrographic Survey, Ottawa, Ont.

References: F. Anderson, H. W. Jones, C. A. Price, E. M. Dennis, O. M. Mechan, J. L. Foreman, M. A. MacKinnon, N. Wilson.

JOHRE—SAAVI GERMUNDSEN, of 153 Kent St., London, Ont., Born at Dalen, Telemarken, Norway, Jan. 27th, 1900; Educ., 1916-20, Norges Tekniske Skole, Porsgrund, Norway. Cert., June 1920; 1920-23, asst. engr. to National Industries, Norway; 1925-27, electrn., operating dept., and 1927 to date, asst. engr., Public Utilities Commission, London, Ont.

References: E. V. Buchanan, V. A. McKillop, J. R. Rostron, F. C. Ball, R. W. Garrett.

PIERCE—JOHN WESLEY, of Peterborough, Ont., Born at Cookshire, Que., July 14th, 1885; Educ., 1903-05, S.P.S., Univ. of Toronto (course interrupted by illness); 1904-05 (summers), chainman on Ontario Township surveys; 1906-09, ap'ticeship with H. J. Beatty, engr. and surveyor, Pembroke, Ont.; 1909-10, engaged with C. H. Fullerton, New Liskeard, in charge of survey contract—located road between Elk Lake and Gowganda, survey of mining claims local surveys etc.; 1911, asst. on survey, Dominion Lands System; 1912-18, member of firm, Beatty & Pierce, engrs. and surveyors, Pembroke, Ont., engaged each year on Dominion Govt. surveys and occasionnally on Ont. Govt. surveys, also local surveys, local town and municipal engrg., drainage, highway location etc.; 1919, entered continuous employ of the Surveyor General of Dominion Lands as surveyor in charge of party. Made permanent in 1921. 1919-20, in charge revision Edmonton, Peace Hills and Red Deer Sectional Sheets, both field work and office compilation. 1921-22; appointed surveyor in the field representing Dominion and Ontario Govts. on survey of Manitoba-Ontario boundary from Winnipeg river to 12th Base Line: 1923, acting provincial supervisor of New Brunswick for the Togog'l. Survey of Canada. 1924, first acting and later appointed supervisor for Ontario, which position was occupied to date of retirement from Civil Service of Canada in 1932. 1929-30, appointed surveyor in charge representing the Dominion, Ontario and Manitoba in the survey of the Manitoba-Ontario boundary between 12th Base Line and Island Lake; on retirement from Civil Service of Canada in April 1932, commenced a local practice in Peterhorough, which has included the retracement and restoration of the Manitoba-Ontario boundary from Winnipeg river to international boundary, performed under the direction of the Surveyor General of Canada and the Director of Surveys of Manitoba.

References: F. H. Peters, S. E. McColl, C. H. Attwood, C. H. Fullerton, J. L. Morris, G. H. Herriot.

ROSS—ALLAN CRAWFORD, of 35 Goulhurn Ave., Ottawa, Ont., Born at Ottawa, July 14th, 1886; Educ., B.Sc. (Elec.), McGill Univ., 1911; 1910-12, instr'man. on several surveys, Can. Nor. Ry., and C.P.R.; 1912-15, engr. and inspr., mech'l. dept., Nat. Transcon. Ry.; (acted as asst. elect'l. engr. and inspr., inspecting and reporting for acceptance on (1) nearly all hldg. structures at divisional points from Moncton to Winnipeg (2) all machy. and elect'l. equipment installed at the same divnl. points. Put into initial operation the steam, mech'l., elect'l. equipment, coaling plants, etc., at various plants from Moncton to Winnipeg; 1915-18, military service (Infantry); 1919 to date, President and Engineer, Ross, Meagher Limited (formerly Ross, Meagher Company), on constrn. of numerous bldg. works, including Ottawa Water Purification Plant, sub and superstructures, power house and service bldgs., Ottawa Civic Hospital, Medical Arts Bldg., etc.

References: C. Camsell, G. G. Gale, C. P. Edwards, K. M. Cameron, A. E. Dubuc, B. F. Haanel.

SHUTER—EDWIN, of 55 Worsley St., Barrie, Ont., Born at Birmingham, England, Sept. 7th, 1886; Educ., 1916-17, Royal Military College, Kingston; 1910-14, bldg. contractor, Toronto; 1914-16, and 1917-18, war service in France; 1919-24, bldg. contractor; 1924-27, road supt., acting engr., 1927-31, acting engr. in charge, and 1932 to date, town engr. in charge of all public works, Barrie, Ont.

References: J. M. Breen, C. K. S. MacDonnell, R. A. Crysler, G. Hemmerick, D. O. Robinson.

SIRRS—ROBERT RAYMOND, of 29 Butternut Terrace, Ottawa, Ont., Born in Bruce County, Ont., Aug. 2nd, 1898; Educ., B.A.Sc., Univ. of Toronto, 1924; 1 year research and graduate study under Westinghouse Electric at Pittsburgh and New

York; 1921 (summer), surveying, C.N.R.; 1922-23 (summers), design and erection, products of Toronto Wire Iron & Brass Works; 1925-26, consltg. engr., Compania Siderwyia de Valdivia, head office—Santiago, Chile—development of power, mine and smelter; 1927-28, chemist and plant supt., and 1929-31, president and gen. mgr., Canada Battery Co. Ltd., Toronto, Ont.; at present, consltg. engr., 227 Dalhousie St., Ottawa, Ont.

References: T. R. Loudon, C. M. Pitts, B. G. Ballard, H. G. Thompson, J. L. Foreman.

VILLENEUVE—PHILIPPE AURELE, of 111 Cote de la Montagne, Quebec, Que., Born at Calumet, Que., Aug. 26th, 1902; Educ., B.A., B.A.Sc., Ecole Polytechnique, Montreal, 1926; 1926-27, forest exploration, with R. E. Joron, A.M.E.I.C.; 1927-28, mtce. engr. and asst. to gen. supt., Quebec Pulp & Paper Corporation, Chicoutimi; 1928-32, consltg. engr., Caffiaux and Villeneuve, Chicoutimi; 1932 to date, Villeneuve & Caffiaux, consltg. engrs., Quebec. Since 1928 engaged mostly with municipal works, hydro-electric developments, reinforced concrete structures and lighting systems. Designed and supervised construction of an hydro-electric plant and concrete dam for town Jonquieres, also sewer line. Appointed engineers of Kenogami, Jonquieres, Roberval and many other municipalities.

References: T. M. Dechene, J. Joyal, G. E. LaMothe, A. B. Normandin, J. F. Grenon, C. H. Boisvert.

FOR TRANSFER FROM THE CLASS OF ASSOCIATE MEMBER TO THAT OF MEMBER

WYNNE-ROBERTS—LEWIS WYNNE, of Toronto, Ont., Born at Carnarvon, Wales, Nov. 14th, 1891; Educ., B.Sc. (Hons. Engrg.), Univ. of London, 1912; 1912 (Aug.-Oct.), analysing lignite coals, Regina; 1912-15, asst. engr., bridge constrn., Board of Highway Commnrs., Govt. of Sask.; 1916 (Jan.-Apr.); Ministry of Munitions, England; 1916-19, overseas with Royal Engrs., in India as instructor in mil. engrg.; in Mesopotamia with sapper field company; in Persia as field engr. on roads and bridges; 1920 (Jan.-May), engr. in charge of erection, Barrett plant; Ashbridge's Bay, Toronto; 1920-22, res. engr., bridge and highway constrn., Section London to Windsor, Dept. Public Highways, Ontario; 1922-23, asst. engr., Frank Barber & Associates, consltg. engrs., Toronto; 1923 to date, junior member, firm of Wynne-Roberts, Son & McLean, consltg. engrs., Toronto, designing and supervising constrn. of water supply systems, sewerage systems and sewage disposal plants, pavement constrn., etc., for municipalities. Numerous investigations and appraisals of engrg. nature. (*Jr. 1914, A.M. 1919.*)

References: W. A. McLean, C. H. Mitchell, C. R. Young, C. S. L. Hertzberg, T. R. Loudon.

FOR TRANSFER FROM THE CLASS OF JUNIOR

ELKINGTON—GERALD ERLAM, of Fernie, B.C., Born at Duncan, B.C., Jan. 7th, 1899, Educ., B.Sc. (Elec.), McGill Univ. 1923; Aug. 1916 to July 1917, at R.M.C., Kingston, obtained Commission; 1922 (Summer), on constrn., with Shawinigan Water & Power Co.; 1923-24, test course, and 1924-29, constrn. engr., Canadian General Electric Co. Ltd.; 1929-30, asst. to supt., and 1930 to date, operating engr., East Kootenay Power Co. Ltd. (This is the same position as supt.) (*St. 1919, Jr. 1928.*)

References: G. A. Gaherty, N. Marshall, R. S. Trowsdale, J. T. Watson, G. N. Thomas, G. R. Wright.

FRANKS—SELWYN THOMPSON, of Toronto, Ont., Born at Weston, Ont., Sept. 21st, 1899; Educ., B.A.Sc., Univ. of Toronto, 1924; 1917-19, R.A.F., Canada and abroad, with rank up to Flt. Commdr.; 1920 (summer), asst. to res. engr. on transmission line and railroad constrn. with Lang & Ross, Sault Ste Marie; 1921-22-23 (summers), instr'man. on location, supervision of constrn. and inspn. of highways with Dept. of Highways, Prov. of Sask.; 1924-27, research and development work on elect'l. power conductors, with Northern Electric Co. of Montreal; 1928, transferred to engrg. dept. of same co., on similar work, and 1928-29, asst. to wire and cable engr.; 1929 to date, asst. to elect'l. engr., Canadian & General Finance Co. Ltd., Toronto, working on wires and cables and misc. equipment. (*S. 1919, Jr. 1927.*)

References: A. W. K. Billings, H. L. Dowling, J. A. Langford, N. L. Morgan, A. M. Reid, R. A. Fairbairn.

SHANLY—JAMES, of Kenogami, Que., Born at Montreal, Jan. 5th, 1897; Educ., 1913-16, McGill Univ.; 1916-19, overseas, Lieut., Can. Engrs.; 1914-15 (summers), rodman and leveller, C.P.R., Dept. Natural Resources; 1920 to date, with Price Bros. & Co. Ltd., Kenogami Paper Mills, as follows: 1920-25, dftsman. and field engr. on constrn. and mtce. of plant and townsite; 1926-28, asst. to mech'l. supt.; 1929-30, supt., wood preparing plant; 1931 to date, asst. gen. supt. (*Jr. 1920.*)

References: G. E. LaMothe, G. F. Layne, C. N. Shanly, N. D. Paine, F. W. Bradshaw, N. F. McCaghey, W. G. Mitchell.

FOR TRANSFER FROM THE CLASS OF STUDENT

BENJAMIN—ARCHIE, of Outremont, Que., Born at Glace Bay, N.S., Sept. 22nd, 1905; Educ., B.Sc. (Elec.), McGill Univ., 1928; 1928 to date, with the Montreal Light Heat & Power Cons. as follows: 1928-29, operating and mtce., Cedars Power House; 1929 (3 mos.), operating, city substations; 1929-30, underground divn., distribution dept., and 1930 to date, distribution engrg. dept. (*S. 1926.*)

References: R. N. Coke, H. Milliken, L. A. Kenyon, S. Cunha, J. C. Antliff, L. L. O'Sullivan.

LEVERIN—HARALD LEICESTER, of Esquimalt, B.C., Born at Sault Ste Marie, Ont., Sept. 22nd, 1905; Educ., Grad. R.M.C., 1928. B.Sc., McGill Univ., 1930. School of Mil. Engrg., Chatham, England; 1923-24 (summers), shops, British American Nickle Co.; 1926 (summer), geol. survey; 1927 (summer), survey, Petewawa Camp; 1928-29, R.C.E. works, Halifax; 1930 (summer), works officer, R.C.E. Works, Quebec; 1931-32, asst. works officer, R.C.E. Works, Halifax; 1932 to date, works officer, R.C.E. Works, Esquimalt, B.C. (*S. 1930.*)

References: J. L. H. Bogart, W. S. Lawrence, G. R. Turner, E. L. M. Burns.

Standard Testing Machine for Grading Asbestos

One of the troubles of Canadian asbestos producers will be lessened as a result of efforts of the National Research Laboratories.

Specifications for a standard testing machine for use in the grading of milled asbestos fibre have been prepared by the Laboratories and have now been unanimously approved.

When the producers, after consultation among themselves, made a formal request for assistance to the National Research Council in 1930, they emphasized the importance of an investigation of the standardization of grading tests and in their recommendation that the National Research Laboratories undertake this, they were joined by the Committee on Uniform Classification and grading of Asbestos Mines Products which had been established by the province of Quebec.

Chemically, asbestos is almost identical with the rock in which it occurs; its value depends chiefly on its peculiar physical structure and properties. The case was still further complicated by the fact that fibres of different lengths vary greatly in value. The asbestos grading method in common use consisted in screening under controlled conditions on screens of standard dimensions. Because of factors which were not clearly understood the results varied.

A large number of tests were made in the National Research Laboratories on fifteen different machines and the results compared. To obtain dependable results a method of preparing uniformly mixed fibre batches was developed. Deviations in tests of the various machines were then established and an attempt made to determine the causes of these deviations. It was shown that a relationship existed between the deviations in test results and the mechanical characteristics of the testing machine; furthermore, the structure, material and condition of the screen cloth were found to have an important influence upon results. It was therefore decided to study the feasibility of a standard design of the testing machine proper as well as the standardization of the screen cloths. The recommendations made as a result of this work are those now accepted.

The meeting at which the recommendations were considered and accepted was attended by representatives of the following companies: Asbestos Corporation, Limited; Bell Asbestos Mines; Canadian Johns-Manville Company, Limited; Johnson's Company; Nicolet Asbestos Mines, Limited; Quebec Asbestos Corporation, as well as by representatives of the Federal Department of Mines, the Quebec Bureau of Mines and the National Research Laboratories.

Further studies on the grading and standardization of Canadian asbestos are being pursued.

The water power resources of Canada, as at present recorded, will permit a turbine installation of about 43,700,000 h.p. The total turbine installation is 7,045,260 h.p. Development up to the present, therefore, has utilized only a little more than 16 per cent of the recorded power. The above information is from the annual survey *Water Power Resources of Canada* issued by the Dominion Water Power and Hydrometric Bureau of the Department of the Interior.

Are Engineers Through at Forty?

Abridged from an article by Arthur Richards, M.Am.Soc. C.E., in *Civil Engineering*, New York, N.Y. for February 1933.

It has been claimed that after men reach the age of forty their services are not in great demand. But the 1930 census entirely disproves this claim, especially as regards the members of the engineering profession. In fact it can be readily proved that at the age of forty the engineer is really starting out on the most interesting and active period of his professional career.

The engineering profession is numerically larger in membership than several other professions, as the census shows the following distribution:

Architecture	24,057
Law	157,220
Medicine	221,300
Engineering	224,956

A number of charts were prepared including one showing the growth of the number of engineers in the United States between 1920 and 1930, indicating an increase of 66 per cent. This also shows the increase in the various branches of engineering, of which electrical is the greatest, with 113 per cent. During this time the total population of the United States increased only 16.1 per cent with the males gainfully employed, 15.2 per cent. This raises the query—is the profession overcrowded? A second figure gives the relative ages of males over twenty gainfully employed, and shows that in 1930, 50 per cent of the 35,031,771 males employed in the United States were twenty or more years of age, while 50 per cent of the 225,956 professional engineers were thirty-five and a half or more years old.

In a further figure it is shown that 50 per cent of the 12,322 chief engineers between 1911 and 1930 were forty-two or more years of age, and 50 per cent of the 1,085 chief engineers in the year 1930 were forty-five or more years old. The comparison indicates that during the past twenty years the ages of chief engineers have increased. It is interesting to note that the greatest number of engineers are aged forty; there are more engineers aged forty-four than thirty-four and there are as many aged fifty as there are aged thirty.

Mr. Richards considers that this data is worthy of consideration by members of the engineering profession and of passing on to the public. It is apparently a wise investment to employ engineers over forty in responsible positions because then the employer can be assured of securing the most productive and efficient years of the engineer's career in specialized knowledge and service.

It is reported that *Canadian Airways Limited* have been awarded a contract to move new milling equipment to the properties of the Central Patricia Gold Mines Ltd., Northern Ontario. Between 200 and 300 tons of freight are expected to be transported by airplane and winter road to the property. It is stated that this contract is the largest of its kind ever received by a Canadian airways company.

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 Wanted

MECHANICAL ENGINEER, Canadian, with technical training and executive experience in both Canadian and American industries, particularly plant layout, equipment, planning and production control methods, is open for employment with company desirous of improving manufacturing methods, lowering costs and preparing for business expansion. Apply to Box No. 35-W.

YOUNG ENGINEER, B.A., B.SC., A.M.E.I.C., R.P.E., Ont. Competent draughtsman and surveyor. Eight years experience including design, superintendence and layout of pulp and paper mills, hydro-electric projects and general construction. Limited experience in mechanical design and industrial plant maintenance. Apply to Box No. 150-W.

PURCHASING ENGINEER, graduate mechanical engineer, Canadian, married, 34 years of age, with 13 years' experience in the industrial field, including design, construction and operation, 8 years of which had to do with the development of specifications and ordering of equipment and materials for plant extensions and maintenance; one year engaged on sale of surplus construction equipment. Full details upon request. Apply to Box No. 161-W.

CIVIL ENGINEER, age 44, open for employment anywhere, experience covers about 20 years' active work, including 7 years on municipal engineering, 2 years as Town Manager, 3 years on railway construction, 3 years on the staff of a provincial highway department, 2 years as contractor's superintendent on pavement construction. Apply to Box No. 216-W.

REINFORCED CONCRETE ENGINEER, B.SC., P.E.Q., eight years experience in construction design of industrial buildings, office buildings, apartment houses, etc. Age 30. Married. Apply to Box No. 257-W.

MECHANICAL ENGINEER, B.SC., McGill 1919, A.M.E.I.C., P.E.Q., 12 years experience oil refinery and power plant design, factory maintenance, steam generation and distribution problems, heating and ventilation, etc. Available at once. Location immaterial. Apply to Box No. 265-W.

ELECTRICAL ENGINEER, B.SC., '28, Canadian. Age 25. Experience includes two summers with power company; thirteen months test course with C.G.E. Co.; telephone engineering, and the past thirty months with a large power company in operation and maintenance engineering. Location immaterial and available immediately. Sales or industrial engineering desirable. Apply to Box No. 266-W.

ELECTRICAL ENGINEER, B.SC., A.M.E.I.C., AM.A I.E.E., age 30, single. Eight years experience H.E. and steam power plants, substations, etc., shop layouts, steel and concrete design. Location immaterial. Available immediately. Apply to Box No. 435-W.

CIVIL ENGINEER, B.A.SC., A.M.E.I.C., JR.A.S.C.E., age 28, married. Experience: construction, design, cost estimating on hydro-electric and storage work, also railway. Desires work in engineering, industrial or commercial fields. Available at once. Apply to Box No. 447-W.

CIVIL ENGINEER, B.SC., A.M.E.I.C., with six years experience in paper mill and hydro-electric work, desires position in western Canada. Capable of handling reinforced concrete and steel design, paper mill equipment and piping layout, estimates, field surveys, or acting as resident engineer on construction. Now on west coast and available at once Apply to Box No. 482-W.

MECHANICAL ENGINEER, B.SC. Age 28, married. Four and a half years on industrial plant maintenance and construction, including shop production work and pulp and paper mill control. Also two and a half years on structural steel and reinforced concrete design. Located in Toronto. Available at once. Apply to Box No. 521-W.

Situations Wanted

CIVIL ENGINEER, Canadian, married, twenty-five years' technical and executive experience, specialized knowledge of industrial housing problems and the administration of industrial towns, also town planning and municipal engineering, desires new connection. Available on reasonable notice. Personal interview sought. Apply to Box No. 544-W.

ELECTRICAL ENGINEER, A.M.E.I.C., University graduate 1924. Experience includes one year test course and five years on design of induction motors with large manufacturer of electrical apparatus. Four summers as instrumentman on highway construction. Several years experience in accounting previous to attending university. Available at once. Apply to Box No. 564-W.

MECHANICAL ENGINEER, A.M.E.I.C., with twenty years experience on mechanical and structural design, desires connection. Available at once. Apply to Box No. 571-W.

MECHANICAL ENGINEER, B.A.SC., '30, desires position to gain experience, and which offers opportunity for advancement. Experience in pulp and paper mill and one year in mechanical department of large electrical company. Location immaterial. Available immediately Apply to Box No. 577-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.

MECHANICAL ENGINEER, Canadian, technically trained; eighteen years experience as foreman, superintendent and engineer in manufacturing, repair work of all kinds, maintenance and special machinery building. Location immaterial. Available at once. Apply to Box No. 601-W.

CHEMICAL ENGINEER, S.E.I.C., B.SC., University of Alberta, '30. Age 31. Single. Six seasons' practical laboratory experience, three as chief chemist and three as assistant chemist in chemical plant; one year's p.g. work in physical chemistry; three years' experience teaching. Desires position in any industry with chemical control. Available immediately. Apply to Box No. 609-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.

CIVIL ENGINEER, A.M.E.I.C., R.P.E., Ontario; three years construction engineer on industrial plants; fourteen years in charge of construction of hydraulic power developments, tower lines, sub-stations, etc.; four years as executive in charge of construction and development of harbours, including railways, docks, warehouses, hydraulic dredging, land reclamation, etc. Apply to Box No. 647-W.

MECHANICAL ENGINEER, A.M.E.I C., Canadian, technically trained; six years drawing office. Office experience, including general design and plant layout. Also two years general shop work, including machine, pattern and foundry experience, desires position with industrial firm in capacity of production engineer or estimator. Available on short notice. Apply to Box No. 676-W.

ELECTRICAL ENGINEER, B.SC., '29, JR.E.I.C. Age 26. Undergraduate experience in surveying and concrete foundations; also four months with Canadian General Electric Co. Thirty-three months in engineering office of a large electrical manufacturing company since graduation. Good experience in layouts, switching diagrams, specifications and pricing. Best of references. Available immediately. Apply to Box No. 693-W.

MECHANICAL ENGINEER, B.SC., '27, JR.E.I.C. Four years maintenance of high speed Diesel engines units, 200 to 1,300 h.p. Also maintenance of D.C. and A.C. electrical systems and machinery. Draughting experience. Westinghouse apprenticeship course. Practical mechanical and electrical engineer with a special study of high speed Diesel engine design, application and operation. Location in western or eastern Canada immaterial. Apply to Box No. 703-W.

COMBUSTION ENGINEER, R.P.E., Manitoba. A.M.E.I.C. Wide experience with all classes of fuels. Expert designer and draughtsman on modern steam power plants. Experienced in publicity work. Well known throughout the west. Location, Winnipeg or the west. Available at once. Apply to Box No. 713-W.

YOUNG ENGINEER, B.A.SC., (Univ. Toronto '27), JR.E.I.C. Four years practical experience, buildings, bridges, roadways, as inspector and instrumentman. Available at once. Present location, Montreal. Apply to Box No. 714-W.

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

MECHANICAL ENGINEER, age 41, married. Eleven years designing experience with project of outstanding magnitude. Machinery layouts, checking, estimating and inspecting. Twelve years previous engineering, including draughting, machine shop and two years chemical laboratory. Highest references. Apply to Box No. 723-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.

DESIGNING ENGINEER, M.SC. (McGill Univ.), D.L.S., A.M.E.I.C., P.E.Q. Experience in design and construction of water power plants, transmission lines, field investigations of storage, hydraulic calculations and reports. Also paper mill construction, railways, highways, and in design and construction of bridges and buildings. Available at once. Apply to Box No. 729-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.

CIVIL ENGINEER, M.SC., A.M.E.I.C., R.P.E. (Ont.), ten years experiènce 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.

ELECTRICAL AND RADIO ENGINEER, B.SC. '31, S.E.I.C. Age 25. Nine months experience on installation of power and lighting equipment. Eight months on extensive survey layouts. Two summers installing telephone equipment. Specialized in radio servicing and merchandising. Available at once. Location immaterial. Apply to Box No. 740-W.

CIVIL ENGINEER, graduate '29. Married. One year building construction, one year hydro-electric construction in South America, fourteen months resident engineer on road construction. Working knowledge of Spanish. Apply to Box No. 744-W.

SALES ENGINEER, B.SC., McGill, 1923, A.M.E.I.C. Age 33. Married. Extensive experience in building construction. Thoroughly familiar with steel building products; last five years in charge of structural and reinforcing steel sales for company in New York state. Available at once. Located in Canada. Apply to Box No. 749-W.

DESIGNING ENGINEER, graduate Univ. Toronto '26. Thoroughly experienced in the design of a broad range of structures, desires responsible position. Apply to Box No. 761-W.

Situations Wanted

MECHANICAL ENGINEER, graduate, '23, A.M.E.I.C., P.E.Q., age 32, married. (English and French.) Two years shop, foundry and draughting experience; one year mechanical supt. on construction; six years designing draughtsman in consulting engineers' offices (mechanical equipment of buildings, heating, sanitation, ventilation, power plant equipment, etc.). Present location Montreal. Available immediately. Montreal or Toronto preferred. Apply to Box No. 766-W.

CIVIL ENGINEER, S.E.I.C., B.Sc. Queen's Univ. '29. Age 25. Married. Three years experience as construction supt. and estimator for contracting firm. Experience includes general building, bridges, sewer work, concrete, boiler settings, sand blasting of bridges and spray painting. Available at once. Apply to Box No. 767-W.

WORKS ENGINEER, A.M.E.I.C. Twenty-four years experience, responsible for the design and building of extensions to mill buildings, specifying and installing of equipment and maintenance of plant of large manufacturing company. Good references. Will take position abroad. Apply to Box No. 768-W.

ELECTRICAL ENGINEER, B.Sc. (McGill Univ. '29), S.E.I.C. Married. Experience in pulp and paper mill mechanical maintenance, estimates and costs and machine shop practice. Desires position with industrial or manufacturing concern. Location immaterial. Available on short notice. References. Apply to Box No. 770-W.

ELECTRICAL ENGINEER, Queen's Univ. '24, Jr.E.I.C., age 32, married. Experience includes, student Test Course, Can. Gen. Elec. Co., four years dial system telephone engineering with large manufacturing company. Available at once. Apply to Box No. 772-W.

CIVIL ENGINEER, B.Sc., '25, Jr.E.I.C., P.E.Q., married. Desires position, preferably with construction firm. Experience includes railway, monument and mill building construction. Available immediately. Apply to Box No. 780-W.

DRAUGHTSMAN, experience in civil engineering, forestry engineering, land surveying and house construction. Good references. Apply to Box No. 781-W.

SALES REPRESENTATIVE. Electrical engineer with ten years experience in power field interested in representing established firm for electrical or mechanical product in Montreal territory. Excellent connections Apply to Box No. 795-W.

CIVIL ENGINEER, S.E.I.C., graduate '30, age 23, single. Experience includes mining surveys, assistant on highway location and construction, and assistant on large construction work. Steel and concrete layout and design. Apply to Box No. 809-W.

CIVIL ENGINEER, college graduate, age 27, single. Experience includes surveying, draughting concrete construction and design, street paving both asphalt and concrete. Available at once; will consider anything and go anywhere. Apply to Box No. 816-W.

CIVIL ENGINEER, B.E. (Sask. Univ. '32), S.E.I.C. Single. Experience in city street improvements; sewer and water extensions. Good draughtsman. References. Available at once. Location immaterial. Apply to Box No. 818-W.

CIVIL ENGINEER, S.E.I.C., B.Sc. (Queen's '32), age 21. Three summers surveying in northern Quebec. Interested in hydraulics and reinforced concrete. Available at once. Location immaterial. Apply to Box No. 822-W.

CIVIL ENGINEER, B.Sc., A.M.E.I.C., with fifteen years experience mostly in pulp and paper mill work, reinforced concrete and structural steel design, field surveys, layout of mechanical equipment, piping. Available at once. Apply to Box No. 825-W.

ELECTRICAL ENGINEER, S.E.I.C., grad. '29, age 24, married; experience includes one year Students Test Course, sixteen months in distribution transformer design and eight months as assistant foreman in charge of industrial control and switchgear tests. Location immaterial. Available at once. Apply to Box No. 828-W.

ALES ENGINEER, M.E.I.C., graduate civil engineer with twenty years experience in the structural, sales, and municipal engineering fields, and as manager of engineering sales office. Available at once. Apply to Box No. 830-W.

Situations Wanted

CIVIL ENGINEER, B.A.Sc., D.L.S., O.L.S., A.M.E.I.C., age 46, married. Twelve years experience in charge of legal field surveys. Owns own surveying equipment. Eight years on technical, administrative, and editorial office work. Experienced in writing. Desires position on survey work, assisting in or in charge of preparation of house organ, on staff of technical or semi-technical magazine, or on publicity, editorial or administrative office work. Available at once. Will consider any salary, and any location. Apply to Box No. 831-W.

AERONAUTICAL ENGINEER, B.Sc. (McGill), M.Sc. (Mass, Inst. Tech). Canadian. Age 26, recent graduate. Capable of aeroplane design and stress analysis. Apply to Box No. 838-W.

CIVIL ENGINEER, M.Sc., R.P.E. (Sask.). Age 27. Experience in location and drainage surveys, highways and paving, bridge design and construction city and municipal developments, power and telephone construction work. Available on short notice. Apply to Box No. 839-W.

CIVIL ENGINEER, S.E.I.C., B.Sc. '32 (Univ. of N.B.). Age 25, married. Two years experience in power line construction and maintenance; one year of highway construction; one summer surveying for power plant site, location and spur railway line construction. Available at once. Location immaterial. Apply to Box No. 840-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.

CIVIL ENGINEER, B.Sc. (Alta. '31), S.E.I.C., age 24. Experience, three summers on railroad maintenance, and seven months on highway location as instrumentman. Willing to do anything, anywhere, but would prefer connection with designing or construction firm on structural works. Available immediately. Apply to Box No. 846-W.

MECHANICAL ENGINEER, Jr.E.I.C., technical graduate, bilingual, age 30. Two years as designing heating draughtsman with one of the largest firms of its kind on this continent handling heating materials; three years designing draughtsman in consulting engineers' office, mechanical equipment of buildings, heating, ventilation, sanitation, power plant equipment, writing of specifications, etc. Present location Montreal. Available at once. Apply to Box No. 850-W.

BRIDGE AND STRUCTURAL ENGINEER, A.M.E.I.C., McGill. Twenty-five years' experience on bridge and structural staffs. Until recently employed. Familiar with all late designs, construction, and practices in all Canadian fabricating plants. Desirous of employment in any responsible position, sales, fabrication or construction. Apply to Box No. 851-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.

MECHANICAL ENGINEER, B.Sc. '32, S.E.I.C. Good draughtsman. Undergraduate experience:—One year moulding shop practice; two years pipe fitting and sheet metal work; one year draughting and tracing on paper mill layout; six months machine shop practice; and eight months fuel investigation and power heating plant testing. Desires position offering experience in steam power plants or heating and ventilating design. Will go anywhere. Apply to Box No. 858-W.

MECHANICAL ENGINEER, age 31, graduate Sheffield (England) 1921; apprenticeship with firm manufacturing steam turbine generators and auxiliaries and subsequent experience in design, erection, operation and inspection of same. Marine experience B.O.T. certificate thoroughly conversant with Canadian plants and equipment. Available on short notice. Any location. Box No. 860-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.

ENGINEER, McGill Sci. '21-'25, S.E.I.C., aerial mapping, stereoscopic contour work; lumber classification; highway, railway and transmission line locations; estimates; water storage investigations, etc. Five years ground surveys; three years aerial mapping. Bilingual. Available on short notice. Apply to Box No. 872-W.

Situations Wanted

CONSTRUCTION ENGINEER (Toronto Univ. of '07). Experience includes hydro-electric, municipal and railroad work. Available immediately. Location immaterial. Apply to Box No. 886-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.Sc., Montreal 1930, age 26, single, French and English, desires position technical or non-technical in engineering, industrial or commercial fields, sales or promotion work. Experience includes three years in municipal engineering on paving, sewage, waterworks, filter plant equipment, layout of buildings. etc. Available immediately. Apply to Box No. 891-W.

ELECTRICAL ENGINEER, grad. Univ. of N.B. '31. Experienced in surveying and draughting, requires position. Available at once. Will go anywhere. Apply to Box No. 893-W.

CIVIL ENGINEER, B.A.Sc., Jr.E.I.C., age 29, single. Experience includes two years in pulp mill as draughtsman and designer on additions, maintenance and plant layout. Three and a half years in the Toronto Buildings Department checking steel, reinforced concrete, and architectural plans. Available at once. Location immaterial. At present in Toronto. Apply to Box No. 899-W.

ENGINEER, Jr.E.I.C., specializing in reconnaissance and preliminary surveys in connection with hydro-electric and storage projects. Expert on location and construction of transmission lines, railways and highways. Capable of taking charge. Location immaterial. Apply to Box No. 901-W.

MECHANICAL ENGINEER, Canadian, age 25, B.Sc. (Queen's '32). Since graduation on supervision of large building construction. Undergraduate experience in electrical, plumbing and heating, and locomotive trades. Available at once. Apply to Box No. 903-W.

DESIGNING ENGINEER, A.M.E.I.C. Permanent and executive position preferred but not essential. Fifteen years experience in designing power plants, engine and fan rooms, kitchens and laundries. Thoroughly familiar with plumbing and ventilating work, pneumatic tubes, and refrigeration, also heating, electrical work, and specifications. Apply to Box No. 913-W.

INDUSTRIAL ENGINEER, B.Sc. in M.E., age 25, married, is open for a position of a permanent nature with an industrial concern. Experience includes three years in various divisions of a paper mill and two years in an electrical company. Apply to Box No. 917-W.

ENGINEER, B.Sc., A.M.E.I.C., R.P.E. (N.B.), age 35, married. Seven years' mining experience as sampler, assayer, surveyor, field work, and foreman in charge of underground development; two years as assistant engineer on highway construction and maintenance. Available on short notice. Apply to Box No. 932-W.

CIVIL ENGINEER, B.Sc., '25, McGill Univ., Jr.E.I.C., P.E.Q., age 32, married. Experience as rodman and instrumentman on track maintenance. Seven and one-half years with Canadian paper company, as assistant office engineer handling all classes of engineering problems in connection with woods operations, i.e., road buildings, piers, booms, timber bridges, depots, dams, etc. Apply to Box No. 933-W.

ELECTRICAL ENGINEER, Dipl. of Eng., B.Sc. (Dalhousie Univ.), S.B. and S.M. in E.E. (Mass. Inst. of Tech.), Canadian. Married. Seven and a half years' experience in design, construction and operation of hydro, steam and industrial plants. For past sixteen months field office electrical engineer on 510,000 H.P. hydro-electric project. Available at once. Apply to Box No. 936-W.

For Sale

TRANSIT, maker Cooke & Sons, inverting telescope, stadia diaphragm, full horizontal and vertical circles, vernier reading to minutes, compass, shifting head, gradienter, ordinary tripod, price $100.

LEVEL, maker Troughton & Sims, dumpy level, inverting telescope, ordinary tripod, price $25. Both instruments in Montreal. Apply to Box No. S-12.

Purchasers' Classified Directory

A Selected List of Equipment, Apparatus and Supplies

For Alphabetical List of Advertisers see page 22.

A

Acids:
Canadian Industries Limited.
Aerial Survey:
Canadian Airways Ltd.
Angles, Steel:
Bethlehem Steel Export Corp.
Canadian Tube & Steel Products Ltd.
U.S. Steel Products Co.
Ash Handling Equipment:
Babcock-Wilcox & Goldie-McCulloch Ltd.
Combustion Engineering Corp. Ltd.
Crude Oil Engine & Engineering Co. Ltd.
E. Long Ltd.

B

Ball Mills:
Dominion Engineering Works Limited.
Balls, Steel and Bronze:
Can. S.K.F. Co. Ltd.
Barking Drums:
Canadian Ingersoll-Rand Company, Limited.
Bars, Steel and Iron:
Bethlehem Steel Export Corp.
Canadian Tube & Steel Products Ltd.
U.S. Steel Products Co.
Bearings, Ball and Roller:
Can. S.K.F. Co. Ltd.
Billets, Blooms, Slabs:
Bethlehem Steel Export Corp.
Dominion Steel & Coal Corp.
U.S. Steel Products Co.
Bins:
Canada Cement Co. Ltd.
Blasting Materials:
Canadian Industries Limited.
Blowers, Centrifugal:
Can. Ingersoll-Rand Co. Ltd.
Blue Print Machinery:
Montreal Blue Print Co.
Boilers:
Babcock-Wilcox & Goldie-McCulloch Ltd.
Combustion Engineering Corp. Ltd.
Foster Wheeler Limited.
Wm. Hamilton Ltd.
E. Leonard & Sons Ltd.
Vulcan Iron Wks. Ltd.
Boilers, Electric:
Can. General Electric Co. Ltd.
Dominion Engineering Works Limited.
Northern Electric Co. Ltd.
Boilers, Portable:
E. Leonard & Sons Ltd.
Bolt Cutters:
The Jno. Bertram & Sons Co. Ltd.
Bolts and Nuts:
Canadian Tube & Steel Products Ltd.
Bolts, Galvanized:
N. Slater Co. Ltd.
Boring Mills:
The Jno. Bertram & Sons Co. Ltd.
Boxes, Cable Junction:
Northern Electric Co. Ltd.
Braces, Cross Arm, Steel, Plain or Galvanized:
Northern Electric Co. Ltd.
Brackets, Ball Bearing:
Can. S.K.F. Co. Ltd.
Brakes, Air:
Can. General Elec. Co. Ltd.
Brakes, Magnetic Clutch:
Northern Electric Co. Ltd.
Brick, Acid Proof:
National Sewer Pipe Co. Ltd.
Bridge-Meggers:
Northern Electric Co. Ltd.
Bridges:
Canada Cement Co. Ltd.
Dominion Bridge Co. Ltd.
Bucket Elevators:
Jeffrey Mfg. Co. Ltd.
Building Papers:
The Barrett Co. Ltd.
Buildings, Steel:
Dominion Bridge Co. Ltd.

C

Cables, Copper and Galvanized:
Northern Electric Co. Ltd.
Cables, Electric, Bare and Insulated:
Can. Westinghouse Co. Ltd.
Can. General Electric Co. Ltd.
Northern Electric Co. Ltd.
U.S. Steel Products Co.
Caissons, Barges:
Dominion Bridge Co. Ltd.
Cameras:
Associated Screen News Ltd.
Capacitors:
Can. Westinghouse Co. Ltd.
Cars, Dump:
E. Long Ltd.
Castings, Brass:
The Superheater Co. Ltd.
Castings, Iron:
Babcock-Wilcox & Goldie-McCulloch Ltd.
Dominion Engineering Works.
Wm. Hamilton Ltd.
E. Leonard & Sons Ltd.
E. Long Ltd.
The Superheater Co. Ltd.
Vulcan Iron Wks. Ltd.
Castings, Steel:
Vulcan Iron Wks. Ltd.
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Canada Cement Co. Ltd.
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The Hamilton Gear & Machine Co. Ltd.
Jeffrey Mfg. Co. Ltd.
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Hamilton Bridge Co. Ltd.
U.S. Steel Products Co.
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Northern Electric Co. Ltd.
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National Sewer Pipe Co. Ltd.
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Can. S.K.F. Co. Ltd.
Clutches, Magnetic
Northern Electric Co. Ltd.
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Combustion Engineering Corp. Ltd.
E. Long Ltd.
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Bailey Meter Co. Ltd.
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Babcock-Wilcox & Goldie-McCulloch Ltd.
Canadian Ingersoll-Rand Company, Limited.
Foster Wheeler Co.
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Canada Cement Co. Ltd.
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Canadian Ingersoll-Rand Company, Limited.
Foster Wheeler Limited.
Smart-Turner Machine Co. Ltd.
Condensers, Synchronous and Static:
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Can. Westinghouse Co. Ltd.
Harland Eng. Co. of Can. Ltd.
Northern Electric Co. Ltd.
Conduit:
Can. General Elec. Co. Ltd.
Can. Westinghouse Co. Ltd.
Northern Electric Co. Ltd.
Conduit, Underground Fibre, and Underfloor Duct:
Northern Electric Co. Ltd.
Conduit Fittings:
Northern Electric Co. Ltd.
Conduits, Wood Pressure Creosoted:
Canadian Wood Pipe & Tanks Ltd.
Construction Hardware, Electrical:
N. Slater Co. Ltd.
Controllers, Electric:
Can. General Elec. Co. Ltd.
Can. Westinghouse Co. Ltd.
Northern Electric Co. Ltd.
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Pratt & Whitney, Co. of Canada Ltd.
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Canadian Tube & Steel Products Ltd.
Dart Union Co. Ltd.
Dresser Mfg. Co. Ltd.
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Dresser Mfg. Co. Ltd.
The Hamilton Gear & Machine Co. Ltd.
Smart-Turner Machine Co. Ltd.
Cranes, Hand and Power:
Dominion Bridge Co.
Smart-Turner Machine Co., Ltd.
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Dominion Hoist & Shovel Co. Ltd.
Shovel, Cranes, Gasoline Crawler, Pillar:
Dominion Hoist & Shovel Co. Ltd.
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Canada Creosoting Co. Ltd.
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B. J. Coghlin Co. Ltd.
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D

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Dynamite:
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E

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Canadian Ingersoll-Rand Company, Limited.
Crude Oil Engine & Engineering Co. Ltd.
Harland Eng. Co. of Can. Ltd
Engines, Gas and Oil:
Canadian Ingersoll-Rand Company, Limited.
Engines, Steam:
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Crude Oil Engine & Engineering Co. Ltd.
Harland Eng. Co. of Can. Ltd.
E Leonard & Sons Ltd.
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Foster Wheeler Limited.
Expansion Joints:
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Foster Wheeler Limited.
Explosives:
Canadian Industries Limited.

F

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The Superheater Co. Ltd.
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U.S. Steel Products Co.
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Forgings:
Bethlehem Steel Export Corp.
N. Slater Co. Ltd.
Foundations:
Canada Cement Co. Ltd.

G

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N. Slater Co. Ltd.
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H

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Purchasers' Classified Directory

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I

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J

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L

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M

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Neptune Meter Co. Ltd.
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Northern Electric Co. Ltd.
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R

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Riveted Pipe:
Dominion Bridge Co. Ltd.
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Canadian Tube & Steel Products Ltd.
Road Oils and Preservatives:
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Roads:
Canada Cement Co. Ltd.
Rods:
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Canadian Tube & Steel Products Ltd.
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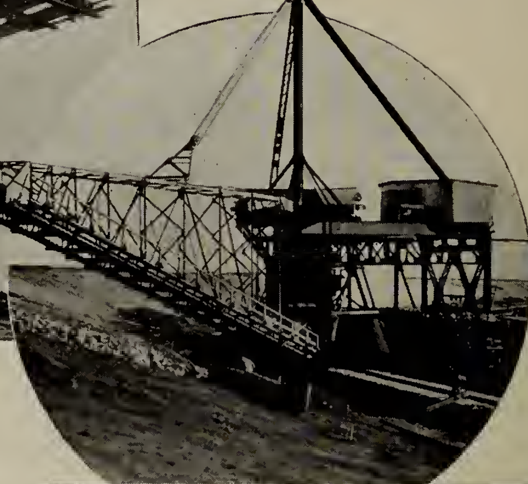

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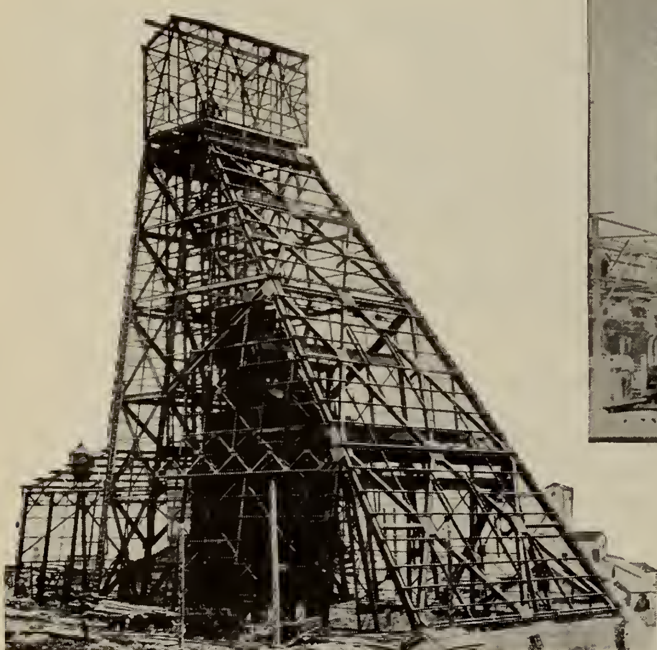

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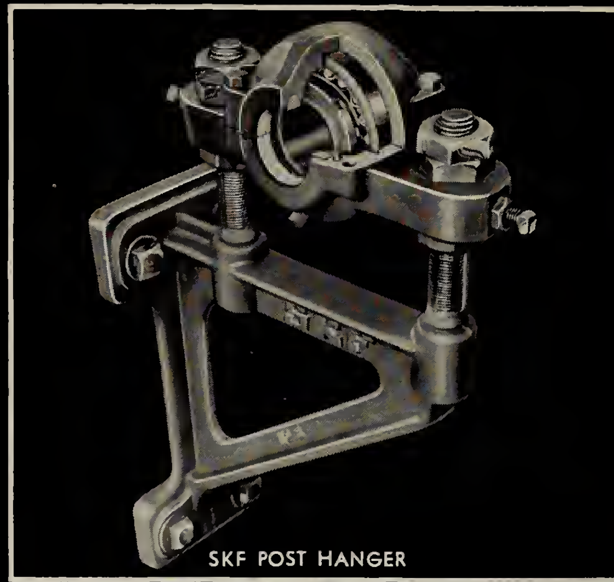

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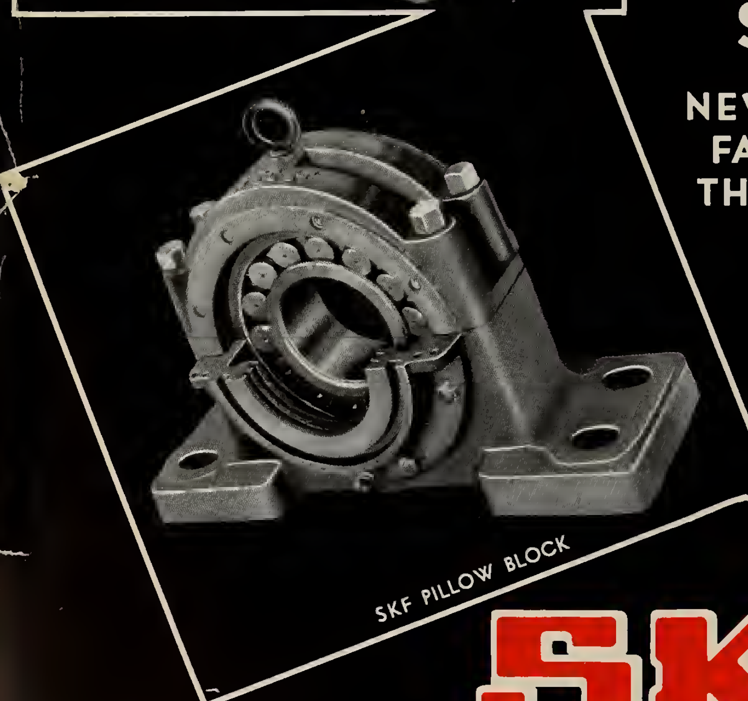

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The Development of the Hudson Bay Project

D. W. McLachlan, B.Sc., M.E.I.C.,

Engineer-in-Charge, Hudson Bay Railway Terminus, Department of Railways and Canals, Ottawa, Ont.

Paper presented at the General Professional Meeting of The Engineering Institute of Canada, Ottawa, Ont., February 8th, 1933

SUMMARY.—The author first discusses the development work carried out at Port Nelson from 1913 to 1917, and then describes the preliminary investigations at Churchill and the actual construction operations which followed there. Particulars are given of the docks, elevator and power house, water supply arrangements and dredging plant, and the paper also contains data regarding air, water, and soil temperatures, and observations as to ice formation as affecting the length of the open season at Port Churchill.

In this paper an effort will be made to present facts with regard to the Hudson Bay route which may be of interest to members of The Engineering Institute of Canada.

As is well known, the improvement of Port Nelson had proceeded about one quarter of its way to completion when the government of the day decided to move the terminal from Port Nelson to Churchill. The problem of developing terminal facilities at Port Nelson was of more scientific interest than that of developing a terminal at Churchill, and it would seem some mention of the projects that had been prepared for that purpose should be made at this time.

Conditions at Port Nelson

Port Nelson is the estuary of the Nelson river. This river drains about half a million square miles of the interior of Canada and has its source in Lake Winnipeg and other lakes which regulate its flow in a manner somewhat similar to the way the Great Lakes regulate the St. Lawrence. At Port Nelson the shoal water begins about twenty miles seaward from the site of the partly built works, and the head of the tide is about twelve miles inland from these works. In the centre of the estuary there is an axial channel, the outer seven miles shallow, the centre seven miles deep, and the inner seven miles shallow again. At the outer end of the deep section, velocities at ebb tide rise to 8½ miles per hour. This estuary opens directly into Hudson Bay, presenting a fetch for waves of 800 miles.

In this estuary the tides rise and fall in a most uniform and regular manner gradually decreasing in amplitude from 20 feet at spring tides at the outer bar to zero at Seal Island, 32 miles inland. It is regularly conical in form and its clearly defined axial channel is in accordance with the well known natural laws which operate in estuaries of uniform materials. The high tide takes about one hour and fifteen minutes to run from the outer bar to Seal Island. The estuarial area west of the works fills on the flood tide in about three and a half hours. Water levels change rapidly with the incoming tide, and a rise of 6.5 feet in one hour is normal for spring tides. This rise is twice as fast as at Churchill, (Figs. 2 and 3) and is due to the funnel shape of the estuary. The flood tide velocity in an estuary of this kind is difficult to control. It differs from the ebb velocity in that it is intense along the shore, while moderate in the axial channel.

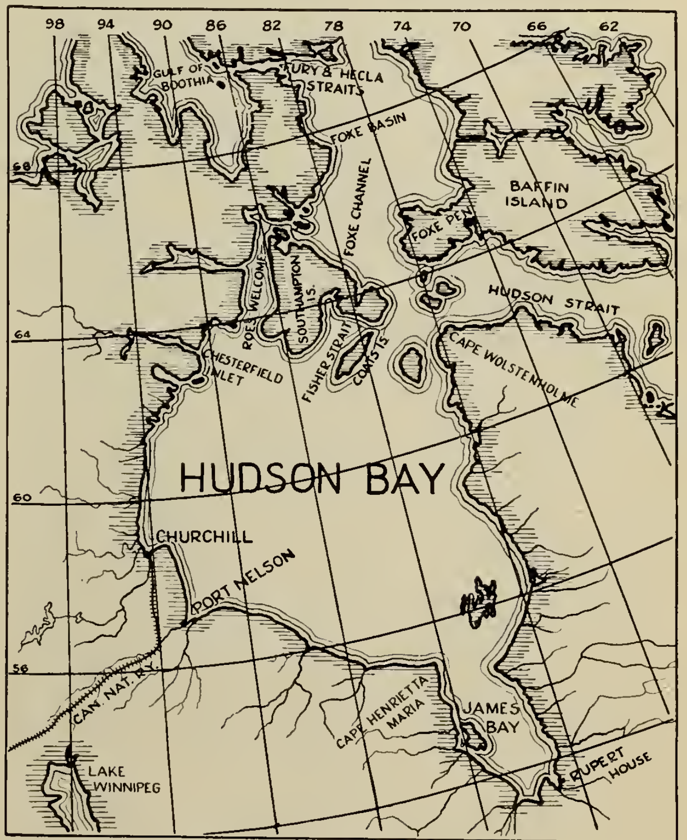

Fig. 1—Hudson Bay and Strait.

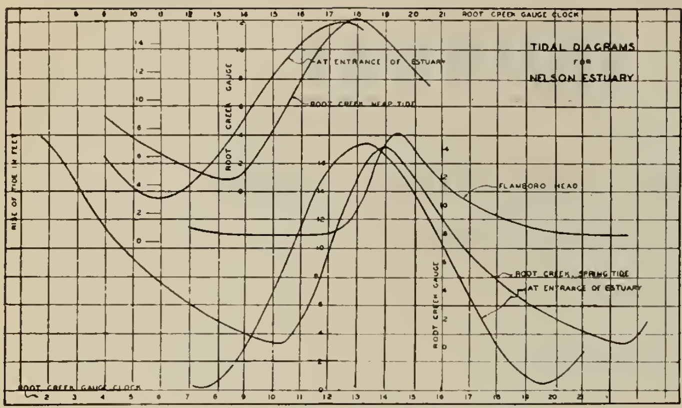

Fig. 2—Tidal Diagrams for Nelson Estuary.

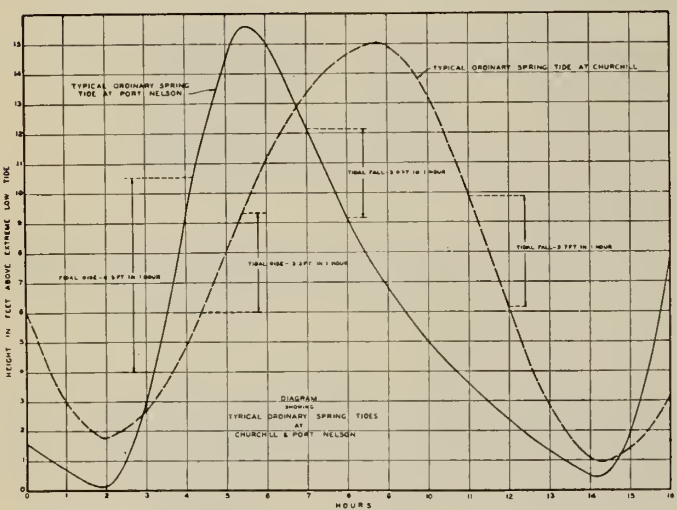

Fig. 3—Spring Tides at Churchill and Port Nelson.

In the early plans which were proposed for the improvement of Port Nelson, the eroding power of the flood tide was not appreciated. This is shown by the plans put forward by Mr. John Armstrong, H. T. Hazen, M.E.I.C., and the late W. A. Bowden, M.E.I.C., former chief engineer of the Department of Railways and Canals, before the work at Port Nelson was started.

The writer was sent to Port Nelson in 1913 and after long and continuous study of this problem proposed a bridge and island project. This was approved, and had reached an advanced stage of completion by the time the work was closed down in 1917. (Fig. 4.)

In 1924 a great storm occurred in the Hudson Bay area, which caused a rise of tide at Port Nelson four feet greater than anything that had been formerly observed, and 8½ feet higher than ordinary spring tides. This storm tore adrift a large amount of the plant laid up at Port Nelson and gave the estuarial development a bad black eye. In 1926 the government of the day asked Mr. Frederick Palmer, now Sir Frederick Palmer, a consulting engineer of London, England, to report upon the relative merits of continuing the work at Port Nelson, or moving to Churchill.

On Mr. Palmer's arrival the writer prepared a plan of what he thought would be a proper scheme for completing the work at Port Nelson. It shows a bridge, two-thirds of a mile long, already built; an island, partly constructed, which could be extended upstream as required, and protecting breakwaters about one and a half miles seaward. (Fig. 6.)

Mr. Palmer, after an inspection of the ground, proposed continuing the use of the bridge and island as built but laid down a somewhat different arrangement of breakwaters. Mr. Palmer accepted some annual silting of the turning basin as a feature of his project. The writer's project proceeded on the theory that the waves could be checked a mile and a half away and any deposit of silt which the breakwater would cause would be placed on the north side of the channel and out of the way of the channel to be excavated.

In this connection, it might be pointed out that the shoal areas, which flank the axial channel on both sides of the 20 miles of estuary on the seaward side of the works, normally reduce and break up the deep waves of Hudson Bay and make the wave action in the upper parts of the estuary of Port Nelson, such as you would have in a lake perhaps 15 or 20 miles in length. It may also be interesting to note that the bridge piers which were built between 1915 and 1917, caused very little silting on either side of them. The island, as constructed, caused a deposit on its upstream side, and the solid breakwater, which was built at Root Creek, caused a large deposit on both its up and down stream sides. These deposits extended out from shore for a width somewhat greater than the length of that breakwater.

At Port Nelson, one of the most difficult questions to settle was the size and weight of piers necessary to resist ice action in connection with the construction of the bridge which was to be built. These piers of timber crib construction were made 40 feet by 62 feet and were filled with gravel and stone from the river bed 12 miles above and with ordinary earth excavated on shore. They were protected by rip rap and gravel, deposited by dump scows, and were successful in resisting ice pressures which have since occurred.

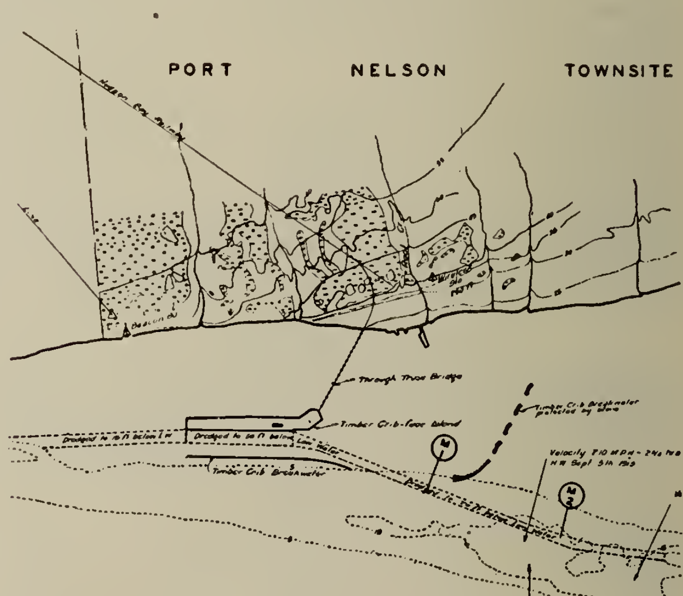

Fig. 4—McLachlan Proposal for Port Nelson Development.

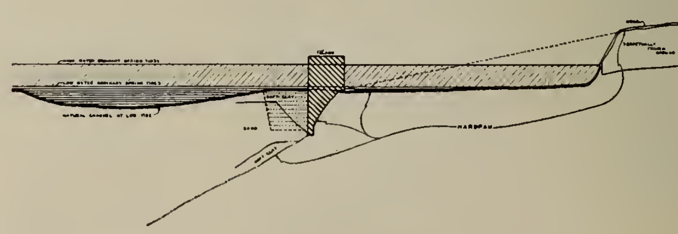

Fig. 5—Nature of Material on Site, Port Nelson.

Conditions at Churchill

At Churchill there is a basin at the mouth of the Churchill river. (Fig. 7.) This basin fills and empties with the tide, which has a daily range slightly less than at Nelson. The outlet of this basin is protected from the waves of the sea and modified in shape by two high rocky peninsulas which overlap one another in a very fortunate way. These natural breakwaters, or jetties, cut off the deep sea waves of Hudson Bay and direct the tidal currents where they assist in harbour development, rather than in obstructing it. A part of the tidal basin is scoured to a depth sufficient to float ships and deep water channels can easily be made to connect the above basin to docks along the east shore in protected waters. In entering Churchill, there is not much excuse for a ship going aground

Fig. 6—Port Nelson, Man.

and the cost of operating and maintaining the port will always be moderate whether the traffic be large or small.

At Churchill there are no wide tidal flats or flood tide currents to deal with, though strangely enough the area which fills and empties with the tide upstream from the works is, in the case of Churchill, not very different from Port Nelson. About 240,000 acre feet of sea water enter the harbour basin at Churchill each spring tide. This is 5 to 10 times the flow of the Churchill river. The water in the harbour is therefore brackish, and the velocity at Merry Rock is sometimes 5 knots per hour. On this account large ships should not enter the port during the greater part of the ebb tide.

Preliminary Investigations at Churchill

Shortly after the government decided to obtain the report from Mr. Palmer, an investigation of rock conditions in Churchill harbour by boring methods was ordered, and the railway forces were asked to survey the country between the end of steel, at the Limestone river, and Churchill, a distance of 160 miles.

In the early months of 1927, arrangements were made to transport men and materials to Churchill, for boring purposes. In March and April twelve men and eight tons of boring material and supplies were flown by aeroplane from Cache Lake, south of Kettle Rapids, to Churchill. The distance was about two hundred miles as the crow flies. During May and June three test pits and twenty-two borings were put down along the east peninsula.

In the succeeding summer, additional men were sent to Port Nelson. A tug which had lain on the beach for ten years was reconditioned and in August an official party consisting of the Minister of Railways, and Mr. Palmer, along with a number of officials, were transported by canoe, gasoline boat, and tug from the Limestone river, via the Nelson river, and Hudson Bay to Churchill.

On the termination of this inspection, Mr. Palmer submitted his report in which he recommended the abandonment of Port Nelson and the establishment of the terminal at Churchill. Mr. Palmer estimated the selection of Churchill would save about $1,000,000 per year in annual charges. The writer did not check with Mr. Palmer on the amount of the saving shown but did agree that the move could be justified on other grounds.

The writer's estimate (Tables I and II) of the cost of completing the work at Port Nelson, and the cost of an equal development at Churchill, shows very little difference in capital costs, but we have a harbour at Churchill which can be entered and departed from during a large range of the tide, while at Port Nelson entry and departure must be confined to an hour at high tide.

At Churchill it was possible to locate the dock about one and a half miles from the deep water of the Bay, the approach being through a well defined channel, while at Nelson the dock was located about twenty miles from the deep water of the Bay and the approach, over this twenty miles, is through a restricted channel.

The government decided to act on Mr. Palmer's recommendation and immediately the shifting of plant and materials from Port Nelson to Churchill began.

Annual Progress of Work

Starting in August, 1927, additional men with food and supplies were sent down the Nelson river to Port Nelson. The dipper dredge *Kennequhair* which had been purchased for the Hudson Bay Railway in 1917, but which had not been delivered to Port Nelson, was fitted for the long tow from Halifax to Churchill. The Canadian government merchant ship *Raider* was loaded with a variety of materials and dispatched to Churchill. However, bad weather and other things interfered and the work accomplished at the end of 1927 was quite small. The dredge *Kennequhair* was sunk during a storm off the Labrador coast. A number of scows met misfortune in storms between Port Nelson and Churchill, and the organization at Churchill was not able to fully unload the *Raider* during the period

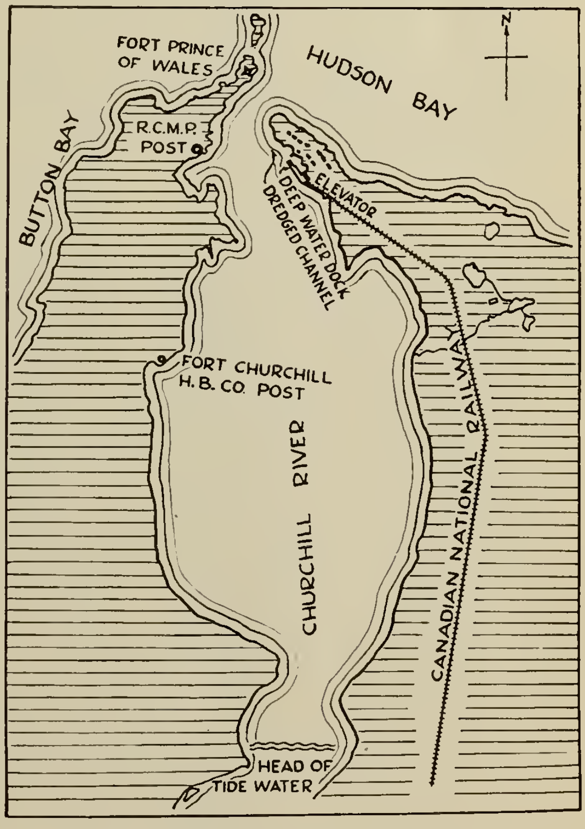

Fig. 7—Churchill Harbour and Vicinity.

TABLE I SHOWING ESTIMATED COST OF ACCOMMODATING 10 SHIPS AT PORT NELSON

Description	Quantity and Rate	First and Capitalized Cost of Work	Cost of Work required every 30 yrs.
Transportation and losses in connection with establishment		$ 423,000	
Temporary wharves	24,400 cu. yds. @ 12.00	293,000	
Timber cribwork	148,050 " " @ 11.00	1,629,000	$1,629,000
Narrow gauge railway tracks	7.5 miles	150,000	
Temporary buildings, incl. wireless station	980,000 cu. ft. @ 0.35	343,000	
Temporary dry dock		100,000	
Clearing and draining		20,000	
Piling grounds filled		40,000	
Large stone filling	11,000 cu. yds. @ 4.00	44,000	44,000
Gravel and stone filling for cribs	100,000 " " @ 2.00	200,000	200,000
Earth filling from borrow	201,000 " " @ 1.00	201,000	100,000
Dredging	260,000 " " @ 0.60	156,000	
Steel bridge to island		490,000	
Water works		61,000	
Plant $1,274,000 less $624,000 charged to Churchill		650,000	
Purchase of ships		473,000	
Surveys and borings		66,000	
Engineering and management		300,000	
TOTAL SPENT TO 1926		5,639,000	1,973,000
Cost to complete as at end of 1926:			
Entrance channel	1,570,000 cu. yds. @ 1.20	1,884,000	
4,400 ft. along dock	2,790,000 " " @ 0.90	2,511,000	
5,400 ft. above dock	1,200,000 " " @ 0.90	1,080,000	
Dock 4,000 ft. @ 82 cu. yds. /ft. =	328,000 " " @ 10.00	3,280,000	1,093,000
Rear wall 3,000 ft. @ 25 " " " =	75,000 " " @ 10.00	750,000	750,000
Anchorage 3,300 ft. @ 8 " " " =	26,400 " " @ 10.00	264,000	264,000
Filling of island above + 8 to 22	1,000,000 " " @ 0.60	600,000	
2,500,000 bushel Elevator with conveyor and power plant		4,200,000	
3-Beacon cribs	23,100 cu. yds. @ 12.00	277,000	-
3-Sheds	@ $152,000	456,000	
Loss of investment in dredging plant after 5½ years use		2,158,000	
Timber crib breakwater		2,684,000	2,440,000
Rock protection	140,000 cu. yds. @ 4.00	560,000	
		20,704,000	
Engineering and management = 5% of all but elevator		825,000	
Railway yards and terminal buildings		400,000	
Railway from mile 356 to Nelson	68 miles @ $31,000.	2,108,000	
		24,037,000	4,547,000
Present worth of cribwork to be rebuilt every 30 years	48% of $1,973,000	947,000	
" " " " " " "	30% " 4,547,000	1,364,000	
Maintenance of service boats and aids to navigation as per Palmer report	$166,265 capt. @ 5%	3,325,000	
		29,673,000	

which she was able to remain there. The *Raider* afterwards met misfortune in the unsheltered harbour of Port Burwell on her way back to Halifax. One hopper barge which was secured from the Department of Marine was delivered safely at Port Nelson, and a dump scow secured from the Department of Public Works was safely towed from Halifax to Port Burwell, and a few buildings were erected.

During the winter of 1927-28, contracts were let for two large dipper dredges with hulls so moulded that they could be towed in any weather. Contracts were also let during the winter for one large dump scow and an additional hopper barge; four large 100-h.p. tractors and twenty-four sleighs were purchased. The gaps left for culverts in the grade of the Hudson Bay Railway between Mile 356 and Port Nelson were bridged with timber and about 400 tons of food, gasolene, and equipment, were hauled by tractors from the end of steel to Port Nelson. In March and April about 800 tons of timber and other material were hauled from Port Nelson to Churchill. In the latter case, the tractors did not follow any beaten road but made their way along the coast between the rough ice and the almost indefinable shore. The tractors travelled as a caravan and continued in motion day and night.

A small force of men was maintained at Churchill during the winter of 1927-28, gathering such supplies of timber as were available within seven or eight miles of the proposed works.

In July and August, 1928, two reconditioned lighters and the motor schooner *Neophyte,* used during the former year, succeeded in making four trips each from Port Nelson to Churchill. The voyages during July were possible, because, during this particular year, the wind drove the ice 15 to 20 miles off the shore, kept it there, and allowed passage of the small boats between the ice and shore from Port Nelson to Churchill.

With the timber delivered by tractor during the winter, and the material delivered by lighter in July, a wharf was completed and ready for the handling of materials when the first ship arrived in August.

In August and September, four ship loads of material were sent to the work. One consisted of timber from British Columbia, one of coal, and the other two of a variety of materials. During this year, in all, 800 tons of material were delivered by tractor; 2,500 tons by lighter; and 16,500 tons by ocean ships; from Halifax, Sydney, and Vancouver. The two dipper dredges, *Churchill No. 1,* and

Fig. 8—Churchill Harbour and Peninsula.

Churchill No. 2, were completed at Montreal, and were towed by tugs to Gaspe first, and from this port via one of the harbours on the Labrador coast, and Wakeham Bay to Churchill. On each voyage the tug doing the towing was coaled at an intermediate point on the Labrador coast, or in Hudson straits. During 1928 also, a hopper barge built at Collingwood was sent under her own steam to Churchill and the dump scow left the previous year at Port Burwell, was towed to the work.

Thus, at the end of the construction season, practically all the plant required for the construction of the port was assembled, and an establishment, consisting of bunk houses, store houses, offices, shops, narrow gauge railway tracks, and a wireless station, was completed.

At the end of October, 1928, the end of steel of the Hudson Bay Railway, and, in fact, the end of the grading also, was still about seventy miles away.

Throughout the winter of 1928-29, the Canadian National Railway forces laid steel on the natural ground between Mile 445 and Churchill, Mile 511, and while the ice and snow continued to hold their track in position they placed steam shovels and rolling stock at two borrow pits:

Table II Showing Estimated Cost of Accommodating 10 Ships at Churchill

Description	First and Capitalized Cost of Work	Cost of Work required every 30 yrs.
Establishment, less value of buildings and temporary wharves	$ 423,000	
Temporary wharves ... 7,100 cu. yds. @ 12.00	85,000	
Narrow gauge railway tracks ... 6.53 miles	54,000	
Temporary buildings ... 790,000 cu. ft. @ 0.35	276,000	
Marine railway	243,000	
Clearing and draining	18,000	
Grading piling grounds	55,000	
Stone filling ... 429,000 cu. yds. @ 0.735	316,000	
Earth filling ... 1,225,000 " " @ 0.565	692,000	
Dredging for 4,000 ft. of dock ... 2,000,000 " " @ 0.90	1,800,000	
Losses on investment in dredging plant—50% Cost.—4 yrs.	719,000	
Ice surveys and patrol	45,000	
Ship losses—Kennequhair, Raider, etc	173,000	
Plant from Port Nelson, less Kennequhair	524,000	
Plant, other than dredging and from Port Nelson. (No overhead)	407,000	
Surveys and borings	46,000	
Water supply works	530,000	
Dock ... 4,000 ft. @ 82 cu yds. /ft. = 328,000 cu. yds. @ 9.00	2,952,000	$ 984,000
Rear wall ... 3,600 ft. @ 18 " " " = 64,800 " " @ 9.00	583,000	583,000
Approach bulkhead ... 8,830 " " @ 9.00	80,000	
Ends of dock ... 10,000 " " @ 9.00	90,000	90,000
2,500,000 bushel elevator with conveyor and power plant	4,200,000	
3-Sheds ... @ 152,000 =	456,000	
Buoy and pilot vessel "Eagle"	81,000	
	14,848,000	
Engineering and management = 5% of all but elevator	532,000	
Railway yards and terminal buildings	400,000	
Hudson Bay Railway from mile 356 to Churchill = 155 miles	8,303,000	
	24,083,000	1,657,000
Present worth of cribwork to be rebuilt every 30 years ... 30% of $1,657,000	497,000	
Operating cost of 87 extra miles of railway handling 15,000,000 bushels per year @ 40c. per 100 ton miles equiv. to 1½ ships per day ... $158,100 capt. @ 5%	3,162,000	
Maintenance of 1 pilot vessel ... 50,000 capt. @ 5%	1,000,000	
	28,742,000	

Table III Showing Cost of Development to Date and Estimated Cost to Complete Initial Development at Churchill, Man.

Establishment less value of buildings and temporary wharves	$ 422,926
Temporary wharves, 7,100 cu. yds. @ $12	85,000
Stores from Nelson, $170,000, cancels stores on hand	0,000
Narrow gauge railway track, 6.53 miles	53,979
Temporary buildings, 790,000 cu. ft.	275,405
Floating plant from Port Nelson	163,343
Ship losses, Kennequhair and Raider	173,000
Ice Surveys and patrol	45,000
Filling Provincial Townsite, 32,900 cu. yds	18,250
Grading and filling piling ground, 53,200 cu. yds	55,700
Gravel—C. N. Ry., 851,638 @ 56½	479,829
Stone and gravel filling—outside of cribs, 429,000 cu. yds. @ $0.735	315,773
Dredging Channels and Docks, 1,706,500 cu. yds. @ $0.894	1,522,200
Cribwork, including filling, 197,270 cu. yds. @ $9.00	1,775,006
Marine Railway........$ 179,970+63,500 cu. yds. @ $1.00	243,470
2,500,000 bus. elevator building, including cement	1,044,234
Elevator equipment	1,328,000
Power house building and intake	247,684
Power equipment up to 3,600 Kw	569,590
Conveyor Galleries with equipment	767,671
Consulting Engineer's fees	198,902
Cost of test shipment	43,919
1 Shed, 300 x 173 x 20	152,179
Depreciation of dredging plant taken pro tem. of 100%	1,438,924
100% of plant other than dredging	604,900
Buoy and pilot. Vessel Ocean Eagle	84,191
Surveys and borings. Vessel Ocean Eagle, (no overhead)	32,384
Expropriation of land	50,981
Water supply works, (incomplete)	485,142
Mooring posts	15,314
Engineering, management, and sundries	680,000
Cost of present development to date	$13,372,896
Estimated additional cost to complete	427,104
Estimated cost of completed initial development	$13,800,000
Less probable recovery on plant ($743,729)	$13,056,271
Less value placed on Port Nelson plant, ($625,000)	$12,431,271

Note:—This estimate does not include any extension to Freight Shed Accommodation now at Churchill, or for provision of Coal Handling Bridge.

one near Churchill, and one about forty-five miles south. In that way they were able to prosecute the grading of the railway during the next season, from three points instead of one, thereby shortening the period required to construct the railway by at least one year.

In April, 1929, 140 tons of additional material were hauled from Port Nelson to Churchill by tractor, over the ice as in 1928. During the winter of 1928-29, an additional tug, now called the *Graham Bell*, was built at Levis, for use in connection with the dredging operations and, being of small bunker capacity, had to be towed by the tug *Ocean Eagle* from Gaspe to Churchill.

In 1929 the bay ice held close to the west shore until a late date. Not until August 6th did it move out sufficiently to permit the tug *George W. Yates* to move from Port Nelson to Churchill or to permit the tugs *Ocean Eagle* and *Graham Bell* to make their way along the westerly fringe of the ice to Churchill harbour.

Before the arrival of the above craft and *Yates* from Port Nelson, there were no tugs at Churchill but dredging started by use of the two hopper barges then on the job.

The first work required to be done consisted in the excavation of the area between the 15-foot contour in the harbour and the site of the proposed docks, to a depth of 17 feet. This was necessary because the dredges required a depth of 15 feet in which to work before they could begin to dredge the crib seats required for the dock walls themselves. The accomplishment of this task required all the season of 1929. Dredging began on July 10th, and ended on October 20th. During this period 470,000 cubic yards were removed.

While dredging was being prosecuted as above described, the approach and rear wall of the main dock was constructed. This consisted of a series of timber cribs which were filled with gravel and stone secured from a borrow pit within the townsite.

In the summer of 1929 additional plant was hauled from Port Nelson to Churchill; camp facilities extended; storage areas filled; a narrow gauge railway track to Lake Rosabelle built; a new steel dump scow erected; two derrick scows built; and everything prepared for the work of crib building and sinking which was to be prosecuted in succeeding years.

In 1929 the railway forces completed the ballasting of their railway track from Mile 445 to Churchill, and regular service between Churchill and points south became established on September 14th. In October, B.C. fir and other supplies began arriving on standard gauge railway equipment, and the isolation of the port came to an end.

Fig. 9—General Plan, Churchill Docks and Vicinity.

The work done in 1930 was as follows:

(1) Dredging began on June 26th, and ended on October 18th. Four hundred and eighty thousand cubic yards of material were excavated along or in front of the site of the deep water dock.

(2) Eight hundred and seventy-three linear feet of deep water crib dock were completed in place. Work began on the first deep water crib on June 23rd, and the last crib was sunk in place on September 22nd. The season's work was laid out so the cribs sunk could be back filled and protected from the arch action of ice before the advent of winter.

Fig. 10—Dock and Elevator from Churchill Harbour.

(3) The filling of dockage and other areas began about the end of May and continued until the last of October when in all 135,000 yards of material were delivered by narrow gauge equipment of the Department, and 400,000 yards by standard gauge equipment operated by the Canadian National Railway forces. The fine gravel which was delivered by the Canadian National Railways was used to fill the interior spaces where there is no wash, while that drawn from the Departmental borrow pit was used in cribwork and where there is exposure.

(4) The excavation of a reservoir for a water supply, and the construction of the pipe line for carrying the water to the works at Churchill were begun in June and July.

(5) In May a contract was awarded for the construction of a 2,500,000 bushel grain elevator to be completed on September 15th, 1931. Later a contract was let for a power house building. An advance party representing the contractor arrived at Churchill on June 2nd, and immediately the erection of camps and buildings for men began. Pile driving operations began on July 3rd. Some concrete was poured when work stopped on account of cold weather on November 3rd.

(6) In September, contracts for boiler room equipment and for generator room apparatus were awarded.

During 1931 the following work was done:

(1) An additional 982 linear feet of deep water cribwork was placed. This completed the 1855 feet of dock as planned.

(2) The two dredges removed 575,000 cubic yards of material. They started work on June 18th, and ceased operations on October 16th.

(3) The narrow gauge equipment in use on land delivered 99,000 cubic yards of gravel and 5,100 cubic yards of blasted rock, the bulk of which was used for crib filling and protection to embankments.

(4) The standard gauge equipment operated by the Canadian National Railways delivered 499,728 cubic yards of fine gravel from their borrow pit seven miles away.

(5) Forty-three thousand cubic yards were excavated in the Grassy Slough reservoir, bringing the total quantity removed to 103,000 cubic yards and the storage capacity to 17,000,000 gallons.

(6) In connection with the water supply project two 60,000-gallon water tanks were erected, and 2,500 feet of pipe line were covered with protecting moss.

(7) In March a contract for the construction of the conveyor galleries system was awarded.

(8) Work was prosecuted by the several contractors on the elevator, power house, and galleries with vigour.

On September 15th, the 2,500,000 bushel elevator was completed with equipment. The power house was ready to deliver power for a test shipment and 325 linear feet of conveyor gallery along the dock was in commission. The elevator started to receive grain on September 7th, and the loading of two ships, the *Pennyworth*, and the *Farnworth*, was completed on the 20th of that month.

In 1932 activities at Churchill were curtailed, partly because the project was largely completed, and partly because funds were not sufficient to do all the remaining work in one season.

The work was as follows:

(1) One dredge with attending tugs and scows was put in commission. This dredge started work on June 23rd, and ceased operations on October 12th. In that period it removed 242,000 cubic yards.

(2) A Crandall marine railway of 1200 tons capacity was constructed. Work on this railway started on June 28th, and was completed on October 20th.

(3) An additional 30,000 cubic yards of moss was placed in and around the pipe line which carries the water required for the port from the Grassy Slough reservoir to the docks at Churchill. The placing of moss started on June 10th, and ceased on October 7th, frost conditions governing these dates.

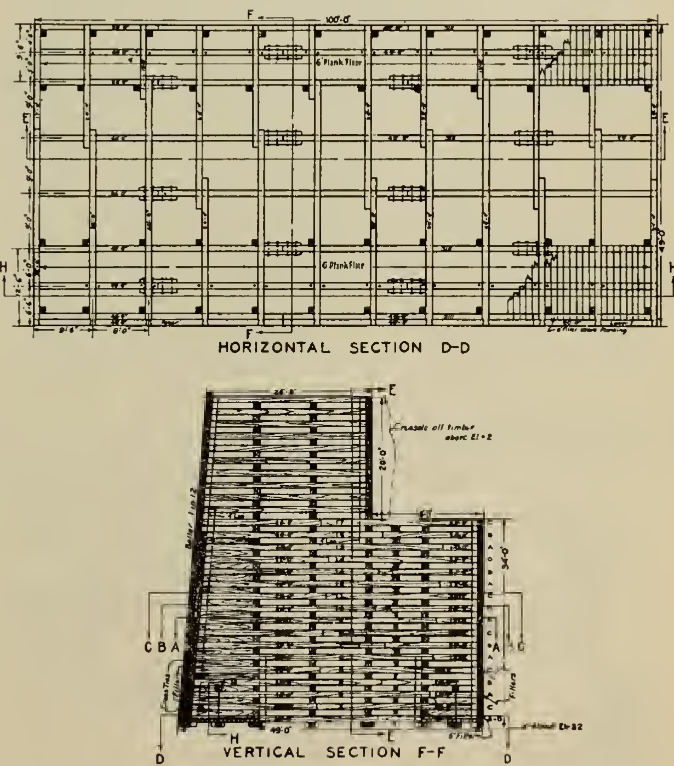

Fig. 11—Deep Water Crib for Permanent Dock, Churchill.

(4) On May 10th, a contract was let for the erection of a steel shed 173 feet wide and 303 feet long. Departmental forces put in the foundation for this structure, which was completed and ready for use on August 15th.

(5) The contractor completed the grain conveyor gallery along the dock face, and had it ready for use on August 10th.

During the progress of the work the maximum number of men employed directly by the Department were: 175 in 1927, 389 in 1928, 528 in 1929, 658 in 1930, 650 in 1931, and 395 in 1932. In addition to these, the Canadian National Railway forces numbered about 400 from 1929 to 1931, and at the height of activity on the elevator construction principal contractor, and other contractors employed about eight hundred men.

Work Required to Complete Initial Development

At Churchill there still remains to be done one season's dredging with one dredge; one season's work in connection with the covering of the water supply pipe; and a small amount of work connected with water supply intake; extension of elevator tracks; and some further sheathing of the face of the deep water dock.

Costs

The expenditure to date chargeable to Churchill, amounts to about $13,372,896, (Table III), and the cost on completion of the development now under way will be about $13,800,000. If the dredging plant towed to the work can be sold for half its original first cost, this figure will be reduced to about $13,100,000. Of this amount $625,000 is incurred through taking over plant formerly charged to the works at Port Nelson. The net cost may be taken at about $12,500,000.

In 1926, the writer estimated the cost of development at Churchill for accommodation of ten ships with an entrance channel 300 feet wide at $13,000,000. The actual cost of the completed initial development will be about $13,100,000 but will provide accommodation for only four ships at the dock and about three at anchor. The entrance channel, however, will be 500 feet wide, and a much more costly elevator is provided than originally contemplated.

Description of Works at Churchill

The design of the harbour works at Churchill involved no special difficulty. Nature at this point had provided a natural basin at the outlet of the Churchill river, the high east and west peninsula provided protection against waves, and good materials for construction were available close at hand. Convenient and accessible docks were easily placed along the east side of the natural basin. (Fig. 9.)

Timber from British Columbia was a cheap material with which to build timber crib dock walls, and this was chosen. In these cribs timber was used liberally, and filling was carefully selected. The cribs when partly built were easily sunk with the assistance of the tide. They were founded on the gravel and boulders which underlie the harbour. They were filled with material, part of which was obtained from dredging and part from a borrow pit on land. These cribs have great shearing strength and even this shearing strength was increased by depositing very coarse material in a wedge shaped section behind the crib when sunk. No fear need ever be entertained as regards their slipping or as regards any serious settlement. (Fig. 11.)

The position of solid rock, about 30 feet below low water along the harbour side of the east peninsula, determined the line of the deep water dock. This line when set, determined the best position for the elevator, and other harbour works. The determination of the dock alignment required about sixty-five borings before it could be finally

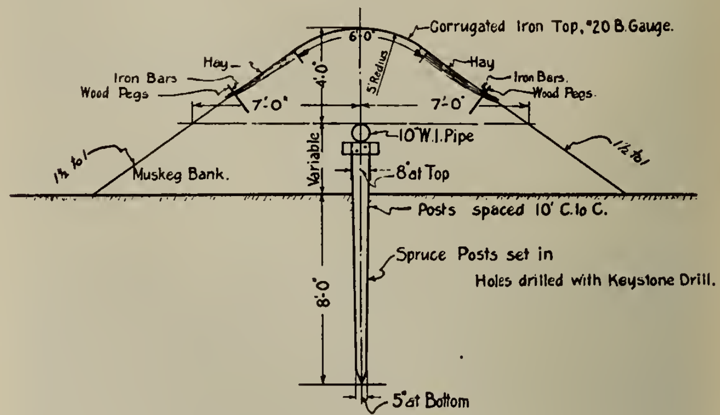

Fig. 13—Water Supply Pipe.

settled. These were nearly all made in the middle of April, and May, when the ice held solid over the harbour and the weather was mild enough to permit churn drills to operate.

The deep water cribs were started on sills which were laid just outside the temporary wharf built in 1928. This crib building site was served by three stiff leg derricks, and a framing yard. After the cribs were built to about the 10th course, they were moved out to deep water and raised to the 17th course. After this, again they were moved out to pile clusters in the harbour where they were built up to the 37th course. After the seats were dredged and then refilled so as to give a smooth area, the cribs were sunk in place by use of a dipper dredge, and two derrick scows. The latter placed ten-ton blocks as soon as the cribs came satisfactorily to rest. The spuds of the dredge held the crib in line while it was going down to position.

The cribs when placed were filled with coarse gravel brought from shore and with stoney material cast into the cribs by use of one dredge. The bulk of the cribs were placed in sections 154 feet long. Creosoted timber was used on the face of the crib and in the cross ties from elevation + 2, to + 23. In the 1855 feet length of deep water dock, 9,750,000 feet of timber was placed. In the whole pier as built there are about 12,100,000 feet of timber, 500 tons of drift bolts, and 315 tons of screw bolts and washers.

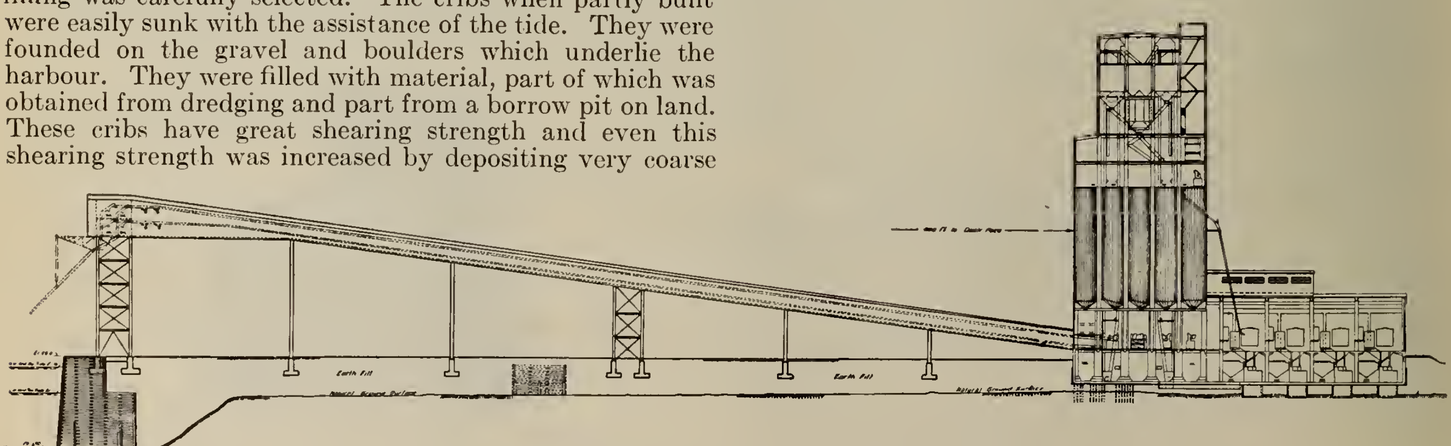

Fig. 12—Wharf, Conveyor Gallery, Workhouse and Track Shed.

The dredging at Churchill which is now almost complete consisted of about 2,000,000 yards of very coarse sand, gravel, and boulders. In some cases boulder beds were almost continuous and there was almost an absence of clay in the whole area excavated. In a few cases small ledges of solid rock were excavated without blasting.

Dredging Plant

The dredging plant at Churchill consists of two dipper dredges, two hopper barges, three dump scows, and two tugs. The dredges are equipped with Bucyrus Erie machinery. They were specially designed for the long sea tow from Montreal to Churchill, and have a ship shaped bow, and were towed with the boom lashed in place where it acted like a rudder.

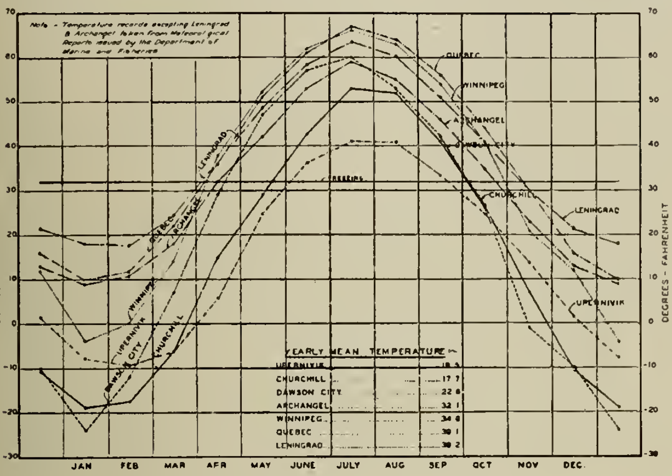

Fig. 14—Yearly Mean Air Temperatures.

On the voyage each dredge broke away from its tug on more than one occasion but in these cases the dredge headed up against the wind and rode out the storms like a duck. The dredges are of the A frame type. The hulls are 135 feet by 44 feet, steel throughout, modern in all respects, and are equipped with 35-ton steel spuds. These dredges are equipped with 16-inch by 18-inch double cylinder main engines, and 5 and 8 yard buckets. The spuds are raised and the boom is swung by separate engines.

Grain Elevator

The grain elevator at Churchill was designed by C. D. Howe & Company of Port Arthur. It has a storage of 2,500,000 bushels, and is equipped with four receiving legs, four shipping legs, eight cleaning legs, two screening legs, and two drier legs.

The track shed is equipped with four Dominion Howe car dumpers each capable of easily handling six cars per hour. The workhouse is well equipped with cleaning machinery. The conveyor gallery along the dock is 1,460 feet long and is equipped with twenty-three loading spouts. In this gallery there are four 36-inch belts, each capable of carrying 15,000 bushels per hour.

The elevator power house is built close to the elevator work house and is equipped with two 1,500 and one 600 kilowatt generators each driven by Parsons steam turbines operating under 250 pounds of superheated steam. There is a space in the powerhouse for one additional 1,500-kilowatt machine. The turbines are condensing, each of the larger using about 2,000 gallons of water per minute. This water is delivered from a pumping station and intake built in one of the deep water cribs. The powerhouse is also equipped with three Babcock-Wilcox & Goldie-McCullough boilers, two of which are able to supply steam at the rate of about 25,000 pounds per hour and the remaining one at 15,000 pounds per hour. The boilers are equipped with chain grate stokers, and screenings from the elevator are burnt without difficulty.

Water Supply

The provision of a water supply for the locomotives, ships, and camp in general is quite a difficult matter. The peninsula on which the works are built, consists of a narrow area of land jutting out into Hudson Bay. In this area there are no creeks of any size and such as there are freeze solid on the advent of winter. The ground underneath the blanket of moss covered country is perpetually frozen to great depths. However, the shipping season at Churchill will always be short. The climate is adverse, and it is not likely a large population at this point will ever have to be accommodated, at least in winter.

The plan which has been adopted and is now nearly complete consists of the provision of a reservoir excavated in the earth with a capacity of about 17,000,000 gallons, located at Grassy Slough, about three and a half miles from the dock. At this reservoir, a pumping station and tank have been provided. From this station a 10-inch wrought iron pipe is carried across the country to another tank located within the townsite of Churchill, and again an 8-inch pipe leads from this point to the railway water tank and also to the elevator and dock. This reservoir and pipe line may become a part of a scheme to obtain water from the Churchill river if such should ever be required.

The pipe line as laid out and now nearly complete, is held true to grade by a series of piles driven 6 to 8 feet into the perpetually frozen ground. (Fig. 13.) It is covered with moss in a way that should prevent it from freezing if a steady supply of water is required throughout the winter. It is given such slopes and grades as will enable it to be drained quickly if a steady supply is not required, and the communities' needs can be met by the use of stored ice as at present. The pipe line being covered with moss, as shown in the diagram, will in winter acquire the general temperature of the perpetually frozen soil beneath which is about 24 degrees or 25 degrees F. As a consequence, before the pipe line can be placed in commission at the beginning of the summer season, if previously drained for the winter, it will have to be warmed up by use of a brine or solution of some kind because fresh water if introduced would immediately solidify in the pipe line.

The tank and pumps at the several stations are laid out with a view to moving this briny liquid backwards and forwards until the pipe has been heated sufficiently to carry fresh water. The reservoir has been excavated to a depth of about twenty feet. This will prevent freezing to the bottom in winter. The reservoir now intercepts the drainage of about two and a half square miles, and this

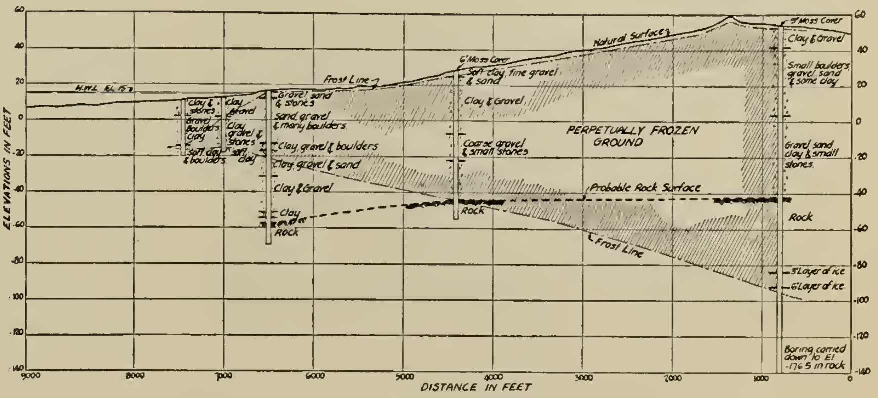

Fig. 15—Nature of Ground on Site at Churchill.

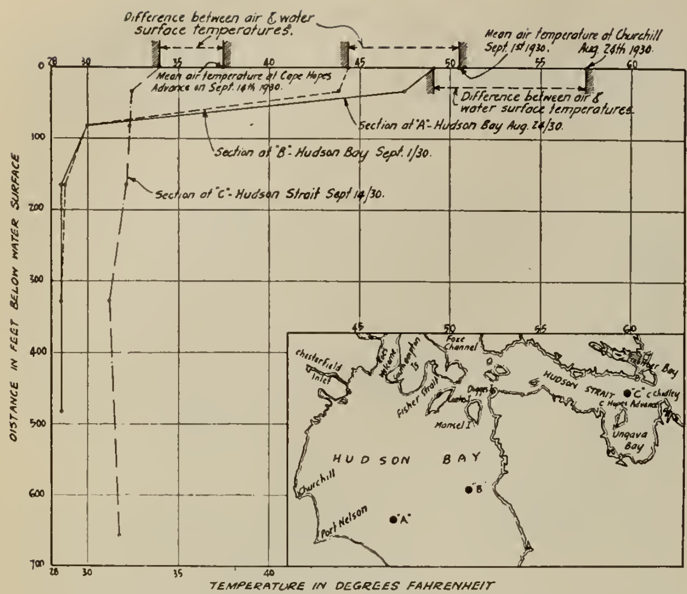

Fig. 16—Water Temperatures Hudson Bay and Strait.

intercepted area can be increased to 10 square miles without great expense. The capacity of the pipe line is about 250,000 gallons per day.

Temperature Data

Outside and beyond the development at Port Nelson and Churchill there are a number of scientific facts which may be of interest to engineers.

The mean annual temperature of the air at Churchill is about 17.7 degrees above zero on the Fahrenheit scale. (Fig. 14.) The air at Churchill is about one degree warmer than at Upernivik, in Greenland, about 14.4 degrees colder than at Archangel, and about 10 degrees colder than at Nikolaievsk, the Russian port on the North Pacific. In Russia a perpetually frozen blanket is usually found where the mean annual air temperature is a few degrees below the freezing point of fresh water. At Churchill the mean air temperature is about 14 degrees below the freezing point of fresh water, and the perpetually frozen blanket under the usual moss covering is about 140 feet thick. The slope of the frozen blanket is modified under lake surfaces, and disappears under the flowing water of the Churchill river. (Fig. 15.) The temperature of this perpetually frozen blanket is about 25 degrees F. This frozen blanket is 30 feet deep at Port Nelson. It is believed to disappear about 180 miles south of Churchill.

In the still basin of Hudson Bay the effect of cold average air temperatures is also felt. Below the effects of wave action, the whole volume of Hudson Bay water has an average temperature of about 29 degrees F.

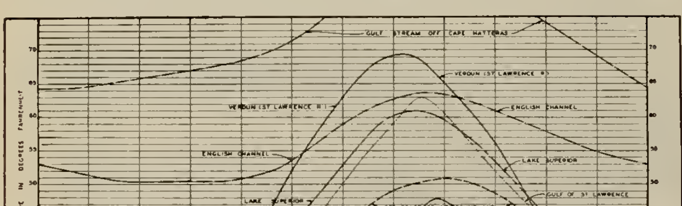

Fig. 17—Water Temperatures.

As the season changes the surface temperature of Hudson Bay changes with it. (Figs. 16, 17, 19 and 20.) The heat derived from the hot air of June and July goes to melt the ice which has accumulated on the surface of the bay in winter. By the first of August the northerly half of the bay is usually free of ice and from that time on the temperature of the water surface of the bay rises rapidly. It reaches its maximum about August 25th, when a mean temperature of about 48 degrees is reached. This warm blanket of water, however, is only about 50 feet thick. Below this depth, the decrease in water temperature is rapid, and the great mass of water in Hudson Bay remains close to the freezing point of salt water throughout the year.

Through Hudson straits different conditions maintain. The currents which are generated by the tides stir up the water in that section and the temperature is approximately uniform from top to bottom.

In connection with the Hudson Bay project there are two types of currents which might be mentioned. The tidal impulse enters Hudson Bay at the north east corner and swings around the bay in a somewhat circular manner. The tidal impulse takes about seven hours to cross the bay and reaches Churchill two hours in advance of Port Nelson. This tidal current has very little effect on ice conditions except in the mouths of harbours and estuaries.

An arctic current of much greater importance sweeps through Fury and Hecla straits, and southward through Foxe basin. This current enters Hudson Bay through Evans and Fisher straits, and also along Coates Island.

Fig. 18—Ice on Shore of Churchill Harbour twenty hours after First Appearance, October 19th, 1930.

There is also a current, in Hudson straits, which sweeps in on the north side and out on the south side. This current carries Greenland icebergs as far west as Charles Island, and then carries them out to the Atlantic again.

The temperature of the water entering Hudson Bay from Foxe channel is never very much above the freezing point of salt water. The water entering Hudson Bay from Davis straits is also cold at all times of the year. Figs. 17, 19 and 20 show the temperature of the surface water flowing into Hudson straits from Foxe channel; of that flowing out of Hudson Bay at Wolstenholme; and of that at Cape Smith in Hudson Bay just south of where it is affected by the Foxe channel currents.

The prevailing wind at the westerly end of Hudson straits during September, October, and November, is very strongly from the north. This brings down quantities of taryn ice from the shores of Foxe basin. At one time it was thought this ice was carried across the mouth of the straits to the vicinity of Cape Wolstenholme, and that it blocked the channel for a dangerously long period of time. Recent investigations tend to show that this does not ordinarily occur as the effect of the wind seems to be more than

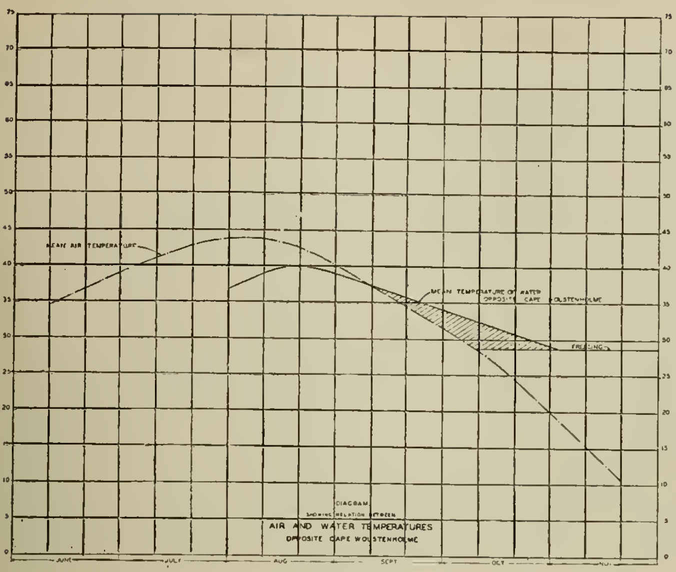

Fig. 19

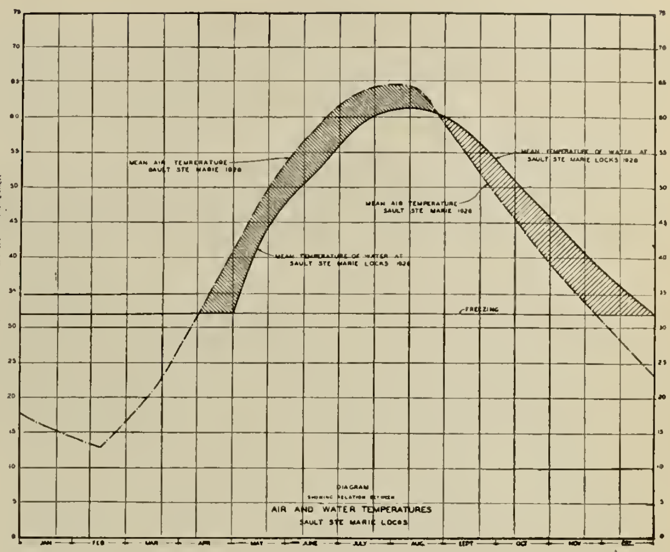

Fig. 22

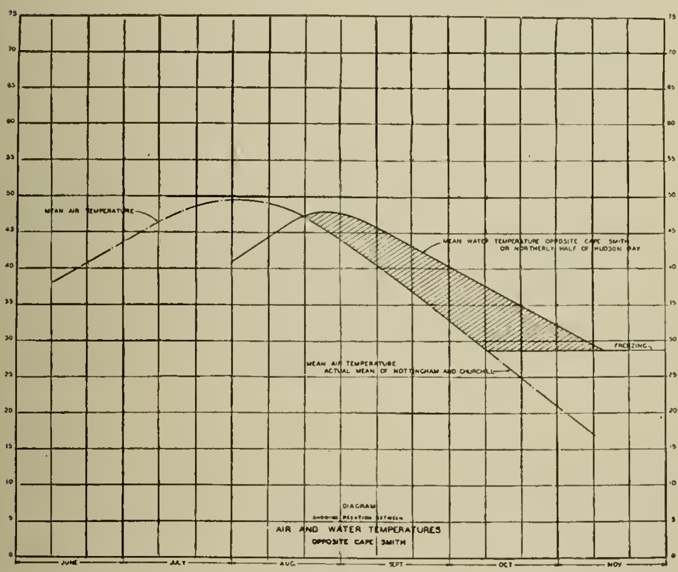

Fig. 20

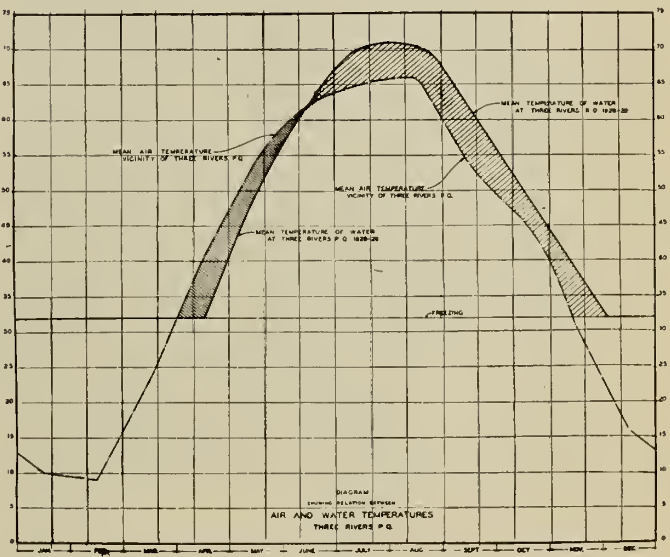

Fig. 23

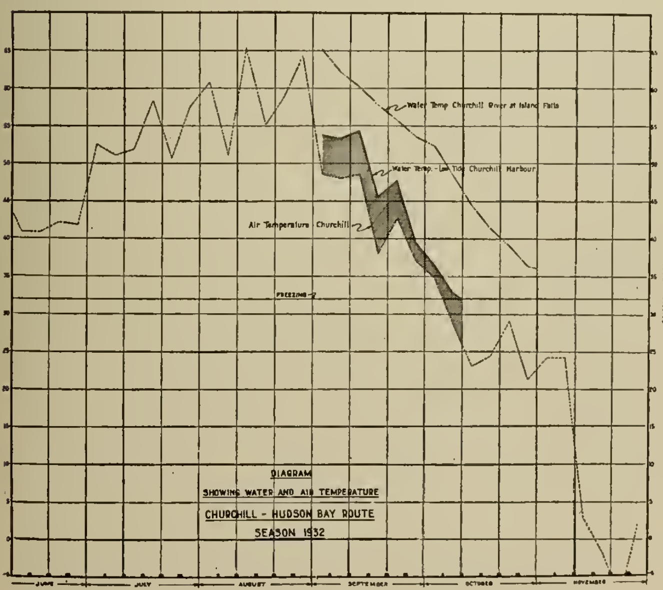

Fig. 21

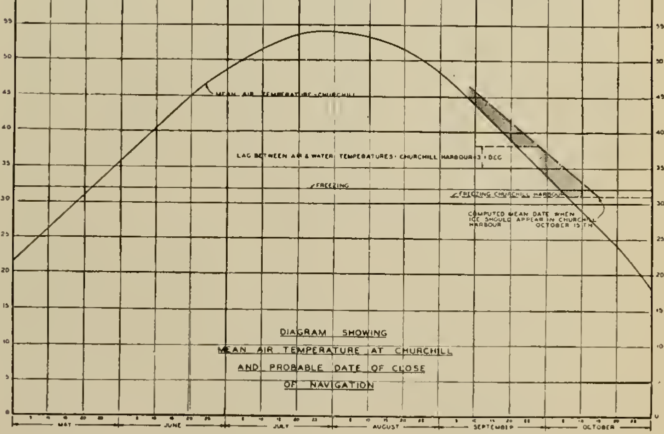

Fig. 24

counterbalanced by the carrying power of water currents which set into Hudson Bay through Evans straits along the south side of Coates Island. Between the mainland of Quebec and Mansell Island there is an outward current, and relatively warm water is found along the south west border of Hudson straits in midsummer.

At the beginning of the year, ships entering Hudson Bay are in danger of being delayed by ice about half way through the straits and near the west coast of Hudson Bay. Whether the last appearance at these points be late in July or early in August depends upon conditions which we are yet unable to determine. Apparently about half of the heat of summer is consumed in melting the ice formed during the former winter. Usually the northerly parts of Hudson Bay become clear of ice in July. Northerly winds drive the ice south as it melts away. The last ice on the surface of Hudson Bay is found just north of Cape Henrietta Maria where it usually remains until about the first of September.

Figs. 19, 20 and 21 show the mean temperature of air and water surface at a number of points on the Hudson Bay route. They show when ice may be expected. As soon as the ice disappears from the water surface of Hudson Bay in late July its surface heats up rapidly. About August 25th, the surface of the bay becomes heated to about 48 degrees F. From then on until November 10th, the water surface of Hudson Bay cools rapidly, as mean air temperatures are much colder than the water. Towards the end of the navigation season this difference is about 10 degrees.

The behaviour of air and water temperatures at other points on the main water transportation routes of Canada are shown on Figs. 22 and 23. One of these is at Sault Ste. Marie, at the outlet of Lake Superior, another at Three Rivers, Que., the controlling point on the navigation route out of Montreal. These diagrams show the manner in which water temperatures lag behind mean air temperatures. They show how it is navigation continues from Lake Superior to Lake Huron until the middle of December, even though the air temperature causes the formation of ice on shallow water surfaces much before that date. They also show how it is navigation continues to Montreal until about the first of December, even though the mean air temperature reaches the freezing point two weeks before that date.

Churchill is unfortunately placed in regard to this matter. The Churchill river has a width of about two miles for a length of 25 miles above Churchill harbour. Over this area there is a depth of only two or three feet of water. This expanse, being shallow, cools very quickly when air temperatures fall and the lag of water surface temperature as compared with air temperature is only about 3.1 degrees at Churchill (Fig. 24), in comparison with about 10 degrees found at critical points in Great Lakes—St. Lawrence routes. As Churchill harbour rapidly fills with slush ice after the temperature of the water reaches the freezing point, navigation at Churchill must on the average terminate on or about the 16th day of October. In mild years this date will be later. In specially cold years it will be earlier. At Port Nelson the lag between air and water is greater than at Churchill, and the date of closing of navigation would have been later. This, however, is balanced by a later opening due to the southerly drift of the bay ice in August.

The Hudson Bay railway has been built by the Canadian National Railways, acting as agents for the Department of Railways and Canals. The district engineer in charge for the railway is Major J. G. McLachlan, A.M.E.I.C.

The following work at Churchill was carried out under contract:—

Elevator, including track shed, workhouse, storage annex, office building, power house building, with pump house, and total conveyor gallery system—Carter-Halls-Aldinger Co. Ltd., Winnipeg, Man.

Boiler room equipment and apparatus—Babcock-Wilcox and Goldie-McCulloch Co. Ltd., Galt, Ont.

Generator room equipment and apparatus—C. A. Parsons & Co. Ltd., Toronto, Ont. (Switchboard, exciters, etc. supplied and installed by the Canadian Westinghouse Co. Ltd., Hamilton, Ont.)

Freight shed—Carter-Halls-Aldinger Co. Ltd.

The elevator plant was designed and erected under the supervision of C. D. Howe & Co. Ltd., Port Arthur, Ont.

The harbour work was carried on by Departmental forces.

The construction of the Churchill terminus is under the jurisdiction of the Department of Railways and Canals, of which the Hon. R. J. Manion, M.C., M.D., is Minister, V. I. Smart, Deputy Minister, Colonel A. E. Dubuc, D.S.O., M.E.I.C., chief engineer, D. W. McLachlan, M.E.I.C., engineer-in-charge, and George Kydd, A.M.E.I.C., resident engineer.

The Trend of Modern Electric Power Distribution

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Paper presented before the Montreal Branch of The Engineering Institute of Canada, December 15th, 1932.

SUMMARY.—The author points out that a large proportion of the total expenditure of electrical supply companies is chargeable to the distribution system, and believes that a thorough study of distribution problems is of great importance. He discusses the economic principles governing the layout of primary distribution systems of the radial type and passes to the advantages and disadvantages of primary network systems. The consideration of secondary distribution systems follows.

For at least ten years remarks have been frequently made that the distribution system has been neglected, that it involves considerable investment and that something will soon have to be done to improve the situation. As a result, at the present time, the distribution system is receiving more consideration than ever before. Now is the opportune time to take advantage of the engineering organizations' lack of work on major system expansions and direct their effort to the field of distribution system economics.

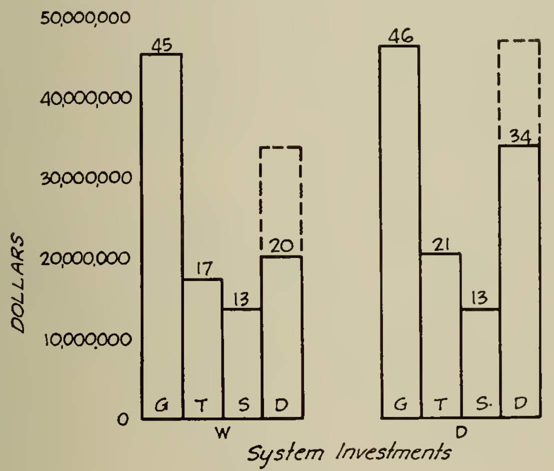


Fig. 1

It is not difficult to show that the distribution system represents a substantial part of total system investment. The various investments in two large systems are shown in Fig. 1. These systems are not representative of the industry in general because they are located in a territory where considerable energy is sold in bulk. The load is also scattered over a number of communities thereby requiring a substantial transmission investment. Even so, it is apparent from the figures that the distribution investment is next to generation in importance. The dotted line over distribution shows the superposition of the substation investments, most of which are for distribution purposes and are properly shown as a part of the distribution system itself.

Another way of showing the importance of distribution system investment is by considering the yearly expenditures of the industry published from time to time by the *Electrical World.* A few of these years have been selected and tabulated in Fig. 2. A glance will show that investment in distribution increases rapidly until it becomes the outstanding item. It is readily seen that generation and transmission have been rigidly curtailed during the period of depression but apparently little can be done in curtailing distribution expenditures. The figures for 1932 are budget figures. That this relation will hold for 1933 is already becoming evident. The fact is that expenditures still have to be made, in spite of the depression, and practically all of these expenditures are to be made on distribution systems.

Finally, these distribution expenditures are not insignificant and therefore warrant the best engineering talent available to reduce their value to a minimum and assure that what is spent is spent for facilities and improvements that will obtain best results. The rising cost per kilovolt-ampere of load distributed and per kilowatt-hour sold is a decided contrast to the lowering of rates. This relation cannot go on much longer without putting the utilities in a very embarrassing position financially.

Problems pertaining to electrical distribution are principally economic in their nature, there being a very few technical problems involved. The economic principles to be applied to distribution system studies are simple but their application to existing conditions is complex. This complexity is due principally to the nature of the distribution system. A little consideration will show that the distribution system is a conspicuous contrast to generating stations and transmission systems because of the large number of small kv.-a. units involved and scattered over a large area. This makes it very difficult to obtain accurate and reliable data and also to prevent waste. The nature of the distribution system also requires its problems to be treated with average conditions for it is impossible to take each particular locality up in detail. It is also difficult to show results concretely. It is probably these facts that have prevented executives from being more sympathetic and more liberal in allowing expenditures for proper analysis. Nevertheless, it is still possible to show results and remove any question about the wisdom of the attention and expenditures involved.

Before anyone can approach the economic problems of distribution intelligently, he first needs to know the facts as they are. Many studies have been based on data

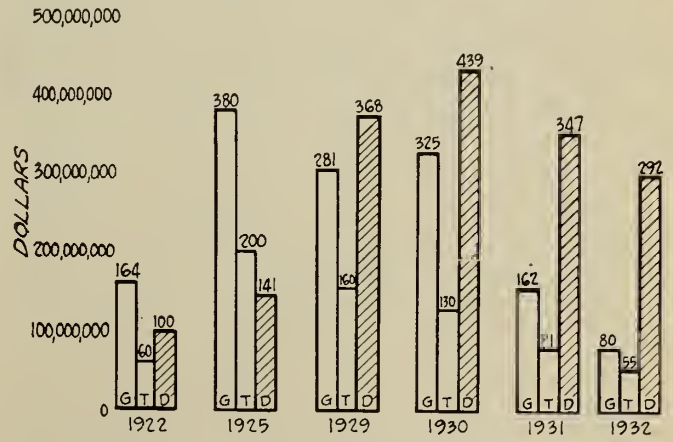


Fig. 2—Yearly Expenditures in Generation, Transmission and Distribution*.

that are not accurate or reliable because they are a product of so-called intelligent guesswork. Some believe that a more liberal use of instruments such as demand or recording types should be made. The obtaining of reliable data is, however, only the starting point, and efforts will be almost useless unless those having good judgment are put in charge of the work. The evaluation of average figures and the

*From Electrical World.

weight to be given to certain factors have a very important bearing upon the result.

It has been common practice for engineers to consider a distribution system as a completed thing similar to a generating station, but, as a matter of fact, a distribution system never stays the same, because the load varies from time to time and from place to place. For this reason a simple cost comparison giving investment figures only is

Fig. 3

not sufficient, nor are the conventional annual charges derived from the investment figures sufficient. It is necessary to consider how expenditures are made from year to year, and in comparing systems, it is important to consider the difference in carrying charges over a period of time. This idea is illustrated in Fig. 3 where the investment on a particular type of radial system is compared with that in a particular type of network system. It will be observed that sometimes the investment in one or the other is greater and therefore it is difficult on the basis of investment to decide which system will be the most economical. The lower curves showing the carrying charges really give the answer, because in this particular case the network is consistently lower than the radial. The reason for this is due to the higher initial investment shown for the radial system. It means that its depreciation, interest charges, taxes and other costs are greater for the earlier years and are sufficient to make up for the later years when the network will have a higher investment. The importance of carrying charges has been appreciated for a number of years and will be discussed later. Distribution systems are continually being changed or added to and therefore it is essential that regular, careful and continued study be made.

Another mistake which has been made in years past in comparing system costs is to assume that substations and circuits will be fully loaded and to figure the cost per kv.-a. on the basis of the firm rating of the station or circuits. Observation will show, however, that substations or distribution circuits are seldom fully loaded and that the real basis of cost comparison should be the cost per kv.-a. of the actual load carried.

In the analysis of distribution systems, it is convenient to distinguish three areas, namely industrial, residential and commercial, for the nature of their loads frequently requires three different distribution systems. This, however, is not always true but, many times, has proved to be the case.

It is instructive in this connection to observe that during this depression, the domestic load has shown marked stability and in spite of curtailments in all directions, it has increased appreciably. The domestic load requires the bulk of the distribution system. A study of the figures for the industry show that the domestic load has been and is less than the total kilowatt-hours lost and unaccounted for in the system. Thus, it appears that a load less than the total system losses brings in the largest revenue. According to appliance load-figures published in the *Electrical World* some time ago, the figures 2,000,000,000 kilowatt-hours were given for 1926 and 6,000,000,000 kilowatt-hours for 1931. In five years the appliance load trebled. Three-quarters of this increase is estimated to be the result of three appliances, namely ranges, water-heaters and refrigerators. It is by no means certain that these three devices have been applied anywhere near the point of saturation. It is therefore very reasonable to expect that these devices alone will still contribute very substantial increases in domestic load in the future. This would require further distribution system expenditures and will of course bring in increased revenue to permit the additional expenditures. This does not even consider the development of other appliances to be used in the home that will consume energy. These considerations lead to the conclusion that the developments of distribution systems are by no means completed and that substantial expenditures will be necessary in the future because of increased load.

One of the subjects of general discussion at the present moment is the question of expenditures for a high order of service continuity. A great deal of money has been spent on schemes of distribution as well as transmission to render additional improvements of service over more simple methods of distribution. It is a well known fact that beyond a certain point heavy expenditures are necessary to obtain slight advantages of improved service. The wisdom of such expenditures is being questioned at the present time by a number of engineers and systems are being analyzed to determine just how many and when interruptions occur to the consumers. Analysis made by one company showed for a one year period that 85 per cent of all interruptions in a certain section occurred at times other than the normal lighting period. It is believed that future expenditures for

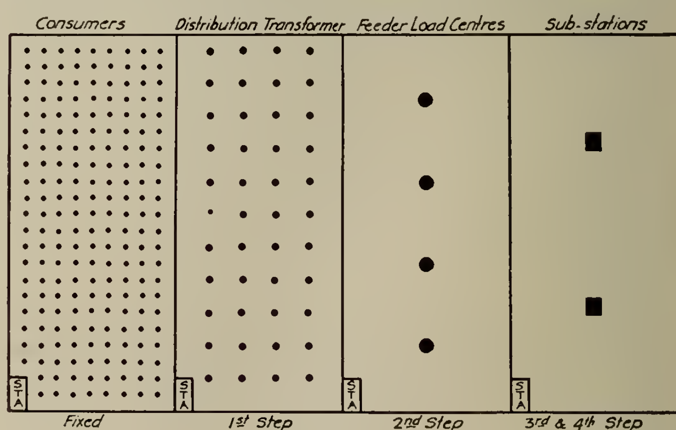


Fig. 4

improved service will be justified upon the basis of past operating experience and not upon theoretical considerations as to what might happen. In other words, experience has shown in numerous cases that certain expected events either do not happen or happen very seldom or happen at times other than normal lighting periods, so that expenditures to prevent interruption due to them are either not warranted or are questionable.

Economic analysis of systems has generally been viewed from the station to the consumer. It is believed that the reverse order is more logical and is illustrated in Fig. 4. Each rectangle represents the same area. The location of the generating station is practically fixed, while the consumer's location and voltage is rigidly fixed. The first step is to determine how many consumers should be connected to a distribution transformer. This determines the transformer size and spacing and the secondary copper size, thereby settling the secondary system design. The second step is very similar, the distribution transformers are used as units to determine the number to be connected to a feeder load centre. Thirdly, feeder load centres are taken as units to determine the number to be connected to a substation. Thus, the second and third steps settle the primary distribution system design. Fourth and last, substations are taken as units to determine how many should be connected to a generating station or primary source of power from a larger hydro-electric system. This fourth step settles the metropolitan transmission system design.

The foregoing considerations are sufficient to show that distribution system economics are very important and not as simple as might be supposed. Further discussion will take up more specific points regarding present practice and ideas under consideration that will improve the economic situation.

Primary Distribution Systems

Practically all distribution systems for residential and industrial areas are designed upon the radial principle, with distribution substations supplying a number of radial feeders that cover the surrounding territory. In well developed territory the practice has been to install substations of relatively large size, anywhere from 5,000 kv.-a. to 30,000 kv.-a. firm capacity and even larger in a few cases. This type of distribution has been accepted for years with some variations.

Some engineers have believed, however, that the large unit rating of substations usually involved was not the best economic solution. They knew from experience that it was often difficult to obtain appropriate locations for these substations. If the future development of the load was known with reasonable accuracy, there would be difficulty in obtaining just the right location. A compromise location would entail a higher cost for distribution feeders, for they would have to be longer in order to pick up the estimated load. Even if the substation was located where it seemed to be appropriate, the uncertainties of future load development in many cases required the building of additional substations in the territory, because the load would not develop within a reasonable distance of the substation as originally assumed and therefore cause the same difficulty of longer feeders or else the building of a new substation to permit shorter feeders even though sufficient substation capacity was already available. Another disappointment was that load would not always develop as fast as expected. All of these factors caused an excessive investment for the load carried over a long period of time.

Attempts were made, therefore, to build the substations in smaller units located at many different points. Other schemes have been to design substations on the section or block principle, adding each section or block as the load developed. This has been one of the principal means of reducing substations and feeder costs. Another method used has been to build the substations along more simple lines omitting spare busses and in some cases even the high-tension bus connecting the transmission feeders directly to the transformers which were paralleled on the low-tension bus, this low-tension bus with an auxiliary transfer bus for regulators being the only bus in the station. Substantial cost reductions have been made by this method.

Another attempt at cost reduction has been by using higher kv.-a. rating of distribution circuits. For a great many years distribution circuits were of the order of 150 amperes and 200 amperes. The 200-ampere circuit with 4/0 copper for the main feeder to the load area predominated. The 4-kv. circuit positions in the substations have a very pronounced effect upon the substation cost and therefore, if the circuits could be made of a larger rating, their number and cost would be reduced appreciably. In the same way pole or duct congestion would be avoided by the smaller number of circuits and further reduce the circuit cost. These methods were very effective and efficient when applied in areas of high load density. The result has been that a number of substations have been developed with feeder circuits of 300 and even 400 amperes. It is believed that these higher circuit ratings have been applied without sufficient investigation into the distribution circuits themselves. If the load is not of a high density, then a 300-ampere circuit might be too long. A 300-ampere circuit may never be loaded to its full rating because the voltage drop from the substation to the load centre would be too high for the regulators provided. This would further aggravate the difficulty, causing the building of additional substations to pick up these long circuits for no other reason than to correct voltage conditions. The building of this new substation shortens up the long feeders but at the same time underloads the existing substations. Some day the load might grow to a density to permit the loading up of the circuit to a maximum of 300 amperes without voltage regulation difficulty. The economics of this practice, however, are very questionable when the carrying charges over a period of years are considered.

These factors which have been discussed are believed to be the principal ones that are forcing the trend in substation practice towards smaller kilovolt-ampere ratings with short feeders. At the same time the substations themselves are simplified by the use of 3-phase transformers, using two, three or more banks connected to as many transmission feeders and omitting the high-tension bus. The smaller unit also permits a greater degree of standardization.

Almost any company could accumulate a set of figures similar to those shown in Fig. 5. The letters A, B, etc. refer to certain specific substations on one particular system. This system is representative of best engineering

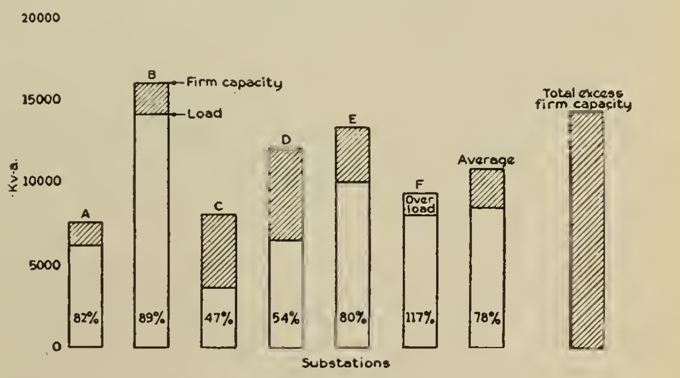


Fig. 5—Distribution Substations.

design of the conventional radial system. The top of the column is the kilovolt-ampere firm capacity rating of the substation as determined by the operating companies themselves. The white portion of the column indicates the peak load carried on the substation so far. The shaded portion of the column indicates the excess firm capacity that is available to carry load. It will be observed that this loading varies over a wide range with one particular substation carrying an overload. Of course, overloading is as undesirable as underloading and the desire to prevent overloading is one of the reasons that explains the prevalence of underloading. One column shows the average loading for all six substations which is 78 per cent of firm capacity.

It is well to state again the incorrectness of comparing systems on the basis of the cost per kilovolt-ampere of the firm capacity or assuming that the substations will eventually carry full rating. These figures show that it is an exception for a substation to carry full rating. To bring out the significance of the excess capacity on which money has been spent, the last column shows that the total excess firm capacity is enough to carry the load of the largest substation. The problem before engineers, therefore, is to cut down as much of this reserve or excess capacity as possible. The most successful attempts are in the direction of smaller units spaced closer together, of more simple design and of reasonable standardization. The significance of such conditions can be determined by any one for his own particular system. The larger the system, the more significant they are.

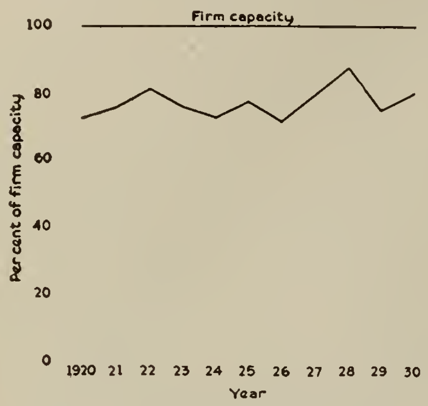


Fig. 6—Yearly Substation Load.

Fig. 6 shows another way of looking at substation loading. The previous figures gave the loads at a particular time. This gives the loads on a particular substation from time to time and shows that the substation is never permitted to carry its rated firm capacity. It is, of course, appreciated that the installed capacity is greater than the firm capacity. The curve indicates clearly that the load hardly gets above 80 per cent when it is reduced by building another substation or cutting over feeder loads from one substation to another. The use of smaller substation ratings, particularly those of a simple standardized design, will permit a much closer loading than here indicated. The smaller the unit, the less guesswork involved to take care of future uncertainties, because the quickness of installation permits a longer delay to observe load growth before expenditures are made.

It is a habit of engineers not familiar with distribution facts to forget the importance of the distribution feeder costs. In Fig. 7 a similar story to Fig. 5 is given except that the columns now represent the feeders out of the corresponding substations. For instance, B has a total feeder rating of 20,500 kv.-a. The total peak load obtained by the summation of the individual feeders is little over 15,000 kv.-a. The average loading of the feeders is 84 per cent. and it is believed that this is much higher than that generally found. The total rating of the circuits out of the substation will always exceed the firm capacity of the substation when it is fully developed. The reason for this is that the peak load on the individual circuits does not occur at the same time. This diversity between feeders is shown in Fig. 8 for the corresponding substations. The full height of the column indicates the sum of the peak loads out of that particular substation, while the white portion of the column indicates the peak load of the substation itself, which is the resultant of individual feeder peaks. The figures in the columns show the ratio of the sum of the feeder peaks to the substation peak. The average diversity factor for all substations is shown to be 1.21. That means that on the average the feeder circuits must have a kilovolt-ampere rating at least 21 per cent higher that the substation firm capacity. In practice it will really be higher than this, because it is not always possible to load each feeder fully, so that it can easily happen that the feeder kv.-a. will exceed the substation firm capacity by 50 per cent after all circuits have been added. Good engineering design, however, can keep this figure close to 25 per cent.

It is therefore of first importance to have some appreciation of the cost involved in the distribution circuits from the substation to the load area supplied by a feeder. In Fig. 9 is shown by the height of the column the average cost per feeder out of each substation. For example, the total cost of all the feeders out of substation B was determined. This figure was divided by the number of feeders out of the station, giving over $12,000 as the average cost per circuit. If this substation had twelve feeders, it means that there would be an investment in copper and poles and conduit of approximately $150,000. The shaded portion of the column indicates the cost per 1,000 feet, and shows at a glance which substations have a substantial part of their circuit length in underground conduits. It also gives some

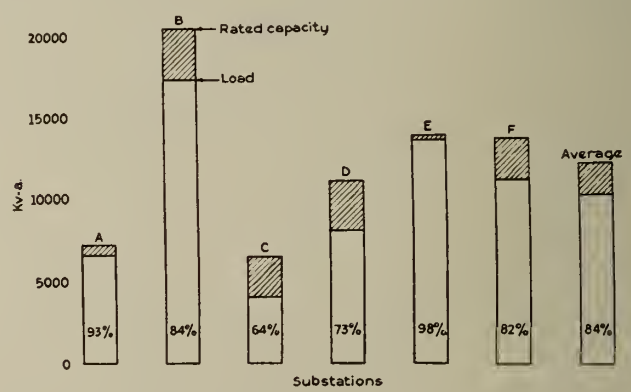


Fig. 7—Distribution Feeders.

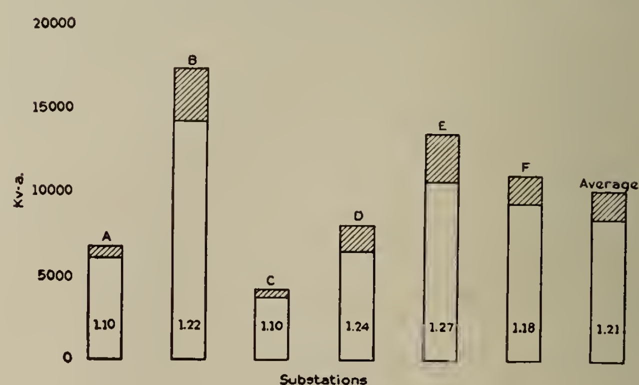


Fig. 8—Feeder Diversity.

idea as to the relative area supplied by the substation. The feeders out of substation C are short and principally of overhead construction while those out of E are much longer with a substantial amount of underground construction. In most cases it is to be expected that each circuit represents an investment of around $12,000. To make these figures of more significance, they are converted into costs per kilovolt-ampere in Fig. 10. Column 2 indicates the cost per kilovolt-ampere of all the feeder circuits out of the corresponding substation as determined by the actual peak load of the substation. It will be observed that the average cost per kilovolt-ampere of load carried is over $10.00 with a maximum cost of $15.80 per kv.-a. This is sufficient to warn anyone against the practice of comparing distribution systems by considering the difference in cost of substations alone. It is also very

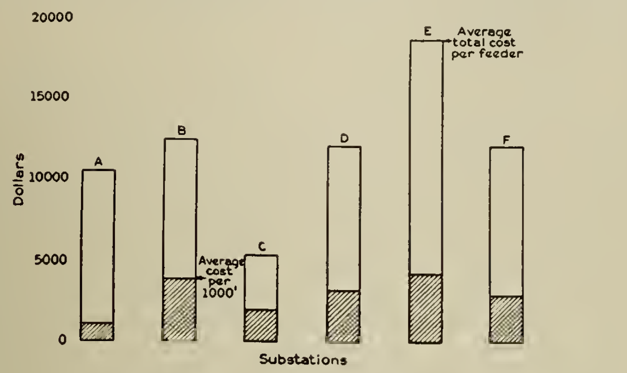


Fig. 9—Feeder Costs Per Circuit.

effective in preventing the location of substations just to secure a lower real-estate investment. A 10,000-kv.-a. substation might be located on a piece of property costing $10,000 less than the preferred location, but it is easy to see that much more than $10,000 might be spent in the distribution feeders. This factor again is in favour of the small substation, because, as shown by substation C, the feeder cost becomes negligible and permits of more latitude in the location of a station although it does increase the number of locations to be obtained. It is probably better to have more latitude together with more locations than to be so rigidly curtailed with fewer locations. Column 1 in Fig. 10 indicates the cost per kv.-a. of the circuits based upon the firm capacity of the substation. In column 3, the complete length indicates the cost per kilovolt-ampere based on the sum of the circuit ratings, while the white portion of column 3 gives the cost per kilovolt-ampere of the sum of the actual loads carried. These other columns are added merely to show that the really significant cost is the cost per kilovolt-ampere of substation load actually carried and that any other figures may be misleading.

A number of feeders on a particular system were analyzed to determine the voltage regulation at the actual peak load carried. The results are shown in Fig. 11. The first observation is that a wide difference exists in the regulation for individual phases of particular circuits. The second is that the total regulation of just the feeder from the substation to the load area often exceeds the boosting range of the regulator. Thus, if the substation bus voltage was held constant throughout the day, then some feeders would not have ample range of regulating facilities. This condition could be improved if the substation voltage at light load times could be made higher so that the bucking side of the regulators would be effective. If such an arrangement can be made, it is possible to operate with the voltage drops indicated and compensate for the drops in the feeders. Even if this is done, there is very little margin left to make up for variations that naturally occur in the supply voltage to the substation from time to time. This leaves practically nothing in this case for over-compensation to correct for a distribution transformer drop and secondary drop.

Another observation to be made is that all of these circuits except the first one are rated 300 amperes, the first one being rated 150 amperes. Even at the present time they are not fully loaded, so that before they can be loaded to their full rating, they will have to be shortened up by the introduction of new facilities and that usually means a new substation, even before existing substations are fully loaded. It is believed that these conditions are very common in practice, for the reason that they cannot be detected with the conventional testing methods used. The conventional testing method is to locate at some point a recording instrument and observe the voltage recorded and adjust the regulators accordingly. A further check is made by spot tests on secondaries. It is the opinion of some that this method is not sufficient because in addition to the guess required for the proper location of the instruments, a guess has to be made as to the proper time to make the spot test. Considering the investment made in regulators and in the complete feeder circuit itself, approximating $100 to $150 per kv.-a. of load carried, it is probably sound to make use of recording instruments at several points on the feeder. A small investment in recording ammeters and voltmeters will give accurate data that will permit a reduction in expenditures and a more efficient use of the expenditures made. It would be a simple matter for any company to determine to what extent such conditions exist on their system.

The matter of system losses is a very important one in the distribution system, for it is here that the greatest losses occur. In Fig. 12 the white portion of the columns show the losses of eleven circuits under the peak loads actually carried. These losses are based on balanced loads and would be higher for unbalanced loads. For the eleven circuits the total is now 970 kw. or 4½ per cent. based on the summation of the peak loads carried. These circuits are rated 300 amperes and the shaded portion shows the

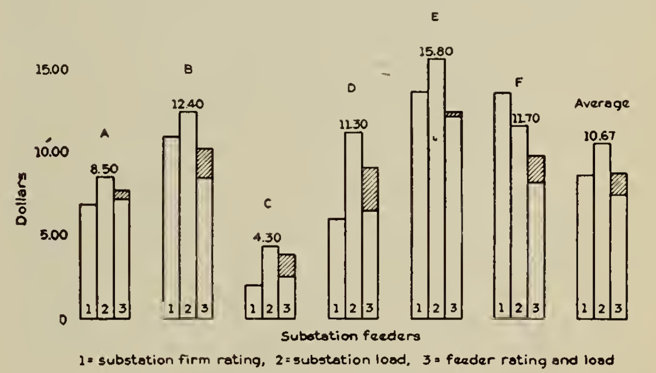


Fig. 10—Feeder Costs Per Kv.-a.

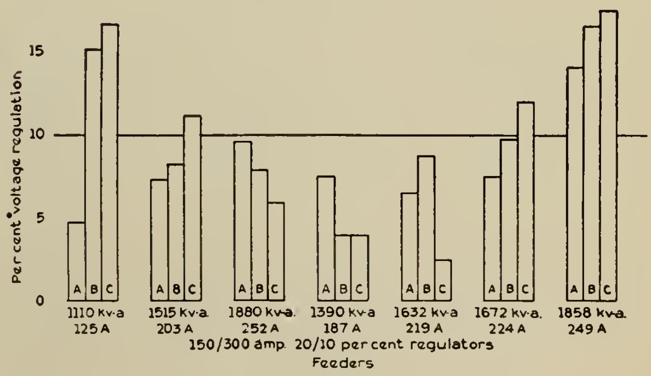


Fig. 11—Feeder Voltage Regulation (Balanced Loads).

additional kilowatt loss at peak load to carry their rating with their present lengths. The loss at peak load is practically doubled and becomes about 8 per cent. These circuits are not all supplied from the same substation, but if they were supplied, say from a 20,000 kv.-a. substation, the peak load loss would have the effect of reducing the actual rating of the substation about 8 per cent. This again introduces another factor to be considered when trying to save substation feeder costs when using high ampere rated circuits.

Primary Network Systems

The primary network system was developed as a substitute for the conventional radial system with large substations and a number of long radial feeders at some such voltage as 4,000 volts, 3-phase, 4-wire. The idea is to form a 4,000-volt grid over the area and reinforce this grid

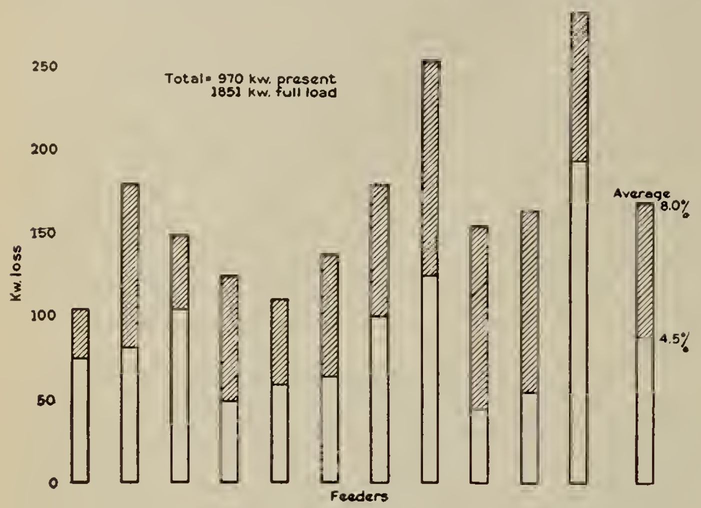


Fig. 12—Feeder Losses.

from time to time and place to place by means of small standardized unit substations which in turn are supplied from a transmission feeder at 11,000 volts or higher. These substations being of around 1,500/2,000 kv.-a. rating (corresponding to that of a distribution feeder circuit) permit taking up load growth at small increments so that the system may be built up step by step when and where the load occurs. The large substation is replaced by smaller ones of a size that can be located if necessary in a vault under the street or sidewalk surface. Real estate difficulties, therefore, do not prevent the location of suitable facilities. The small increment feature of the primary network gives it a decided advantage over the larger radial substations.

Fig. 3 has already been referred to as showing the economic advantage of a distribution system made up of small units even though the investment may be higher. Figs. 13 and 14 show other comparisons where the investment is more in favour of the primary network. The simplicity of the primary network unit permits a very high degree of standardization in the field of substation equipment. Its small rating furthermore permits it to be assembled at the factory and shipped complete ready for installation. This makes it portable, which may be an advantage where the territory changes and requires some rearrangement of location.

The small unit rating of the primary network substations means that the 4-kv. feeders are completely eliminated from the distribution system and therefore whatever waste was due to these feeders is completely avoided. This is offset somewhat, however, by the substitution of higher voltage laterals to supply these small substations. Because of this higher voltage and the small kilovolt-ampere capacity involved, the voltage drop is negligible. They can therefore be depended upon to carry the rated load of the unit, for the distances involved will practically never be long enough to give sufficient voltage drop to be important.

This substitution of the higher voltage laterals for 4-kv. feeders is very advantageous from the point of view of using these same laterals to supply industrial loads and small low-voltage a-c. networks direct without the use of an intermediate voltage. Power for such networks or industrial customers can be transformed directly from transmission to utilization voltage.

The small kv.-a. rating also permits the primary network to make use of existing facilities at substantial savings in cases where excess capacity in transmission lines is available. It is very common practice to find high-voltage tie lines and industrial feeders with margins around 2,000 kv.-a. The adoption of this system practically substitutes a higher transmission voltage as a distribution voltage.

One of the difficulties in justifying the primary network is the fact that it makes use of more switchgear than the conventional radial system. This difficulty will ultimately disappear when quantity production reaches a point that will permit substantial price reductions. Even the present cost of the primary network units seldom prevents the proof of its economy as compared to a radial system at the same voltage. The nature of the network system is such that it is necessary to provide for the loss of a number of network units in the event of a transmission feeder failure. The load that was carried by this faulty feeder is then distributed over the remaining ones in service. Inasmuch as the network transformers are equal to conventional substation transformers from the point of view

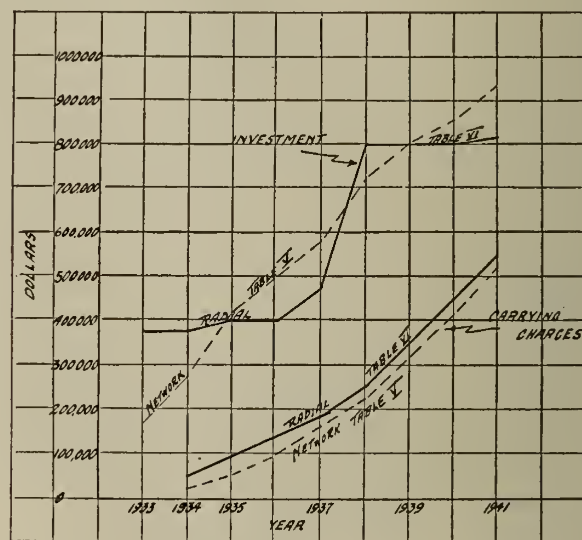


Fig. 13

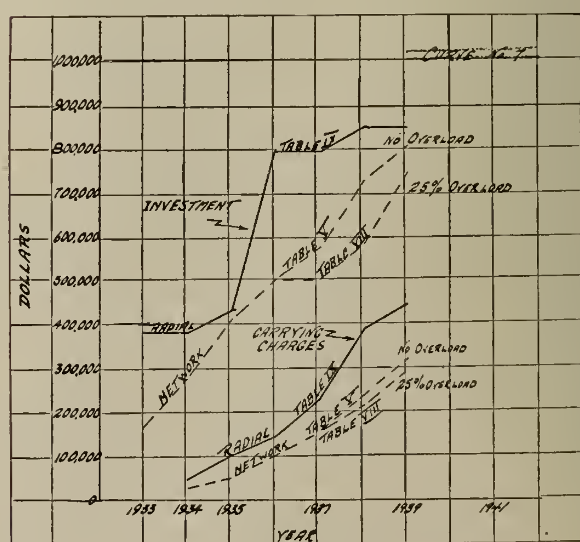


Fig. 14

of heating, it is reasonable to permit overloading under emergency conditions just as is now common practice with substation transformers. The provision of such emergency rating on the network transformers reduces the number of units required and therefore makes the primary network distinctly more favourable as compared with the radial system. The effect of this emergency rating is shown in Figs. 15 and 16. In Fig. 15 the network system investment

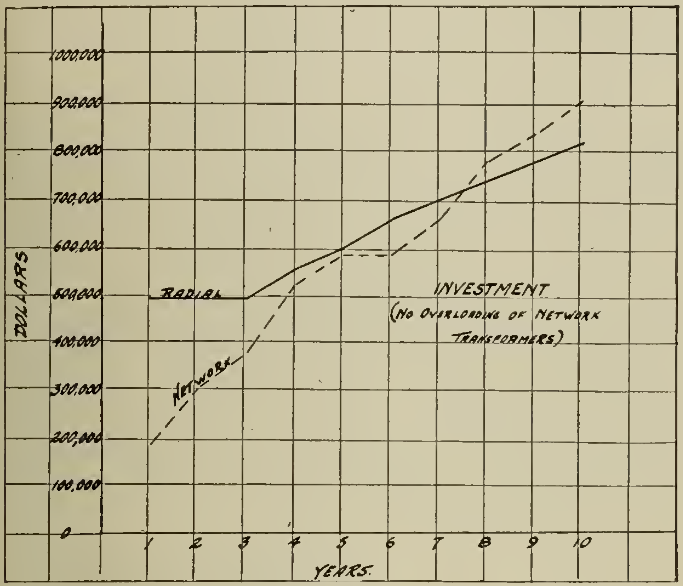


Fig. 15

exceeds that of the radial system after eight years. If, however, an emergency rating of 25 per cent overload is considered acceptable, the investment of the network is always below that of the radial system for this particular case as shown in Fig. 16. The effect of the overload rating is also shown in Fig. 14.

It is interesting to study Fig. 15 from the point of view of a progressive expenditure of investment. The curve for the primary network does not take into consideration the possibility of a cost reduction in the future because of standardization and production. The cost of the radial system assumes that the complete rating of the firm capacity of the station will be carried. Information already submitted shows that this seldom if ever happens, so that by the time the eighth year is reached, additional expenditures will be made on the radial system basis for a new substation and new feeders. Another point of view is that eight years is a long time ahead to guess load developments and therefore it is much safer to choose a system with lower initial expenditures, for it is possible that the load may not develop in the territory, and that the radial system facilities will not be fully utilized. Figs. 15 and 16 are merely investment curves. In both cases the network system proves to be more economical when the carrying charges are considered.

An outstanding advantage of the primary network is its uniformity of voltage regulation. The spacings of the small units are such that at the lightest load densities the voltage drop in the mains is the maximum and is less than 2 per cent. This means that as the load develops and new units are added the distance becomes shorter and the voltage drop decreases accordingly. Each primary network unit is provided with transformers having equipment for changing taps under load. Compensation can be provided to give a rising voltage characteristic to the network so that as it approaches full load the full load voltage of the network is about 2 or 3 per cent higher than the no load voltage and this holds for practically all of the area within the grid. Of course, it does not hold for any long radial taps extending beyond the network territory, and these have to be treated as special cases. The primary network system has inherently lower losses than the radial system due to the elimination of the 4-kv. feeders. This was shown in Fig. 12 to be a substantial item. It is believed that the future will witness a considerable number of primary network system installations*, such as those already installed in Boston, Pittsfield, Oklahoma City, Pittsburgh, Medford, Mass., and Altoona, Pa.

Higher Voltage Radial Systems

It has been the desire of distribution engineers for many years to take advantage of the savings resulting from the use of higher voltage. Practical difficulties, however, have prevented a very extensive development along these lines. Some of these difficulties are joint use of poles with telephone companies, clearances from trees, buildings, etc. If higher voltage distribution circuits could be used as a substitute for the intermediate voltage circuits, then the conventional radial substation with its distribution feeders and the economic difficulties therein would be eliminated almost entirely.

Difficulties would still be experienced with the location of switching centres if it is desired to use high voltage circuits of load ratings corresponding to 4-kv. circuits such as 2,000 kv.-a. If such switching centres are not provided when using such small circuits, pole congestion would develop or else expensive underground construction would be necessary. It is by no means certain that the economy of the higher voltage system can be proved on this basis, because of the relatively higher cost for 13-kv. distribution transformers over the 4-kv. distribution transformers together with the accessories such as lightning arresters.

It does seem certain, however, that if the larger ratings of 5,000 or 6,000 kv.-a. for 13,000-volt circuits are accepted, substantial economy will be obtained. There would be some sacrifice in reliability because each circuit

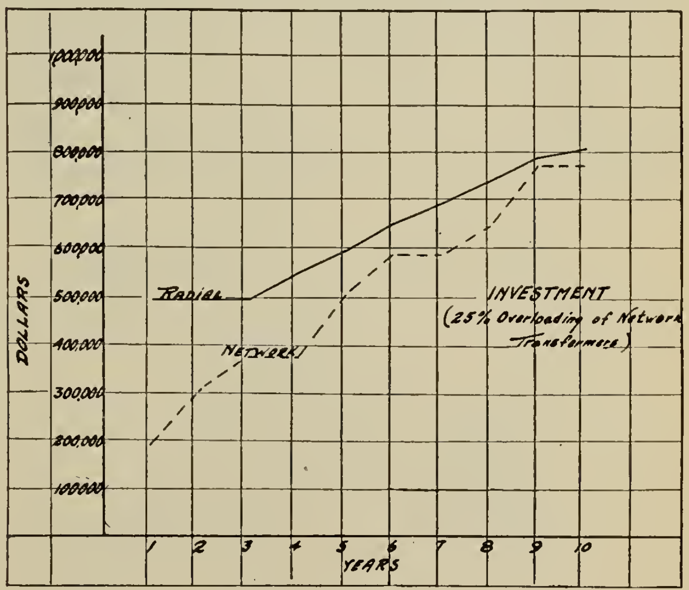


Fig. 16

would cover a larger territory for a given density, which would undoubtedly mean a larger number of interruptions per circuit and each interruption in turn would mean a larger number of customers affected. This assumes that the higher voltage would not cause more interruptions as well. Some engineers contend that there should be no

*The General Electric Review for June 1932 covers the story of the primary network system completely.

more interruptions due to the higher voltage alone if the lines are properly constructed and maintained. Past experience should be studied to determine whether the claim for reduced reliability of the higher voltage 5,000 kv.-a. circuit is justified.

The use of higher voltage distribution circuits for the distances involved would practically eliminate regulation difficulties in the primary circuit. The distances for the load carried are so short for most cases that it would be very easy to obtain good regulation.

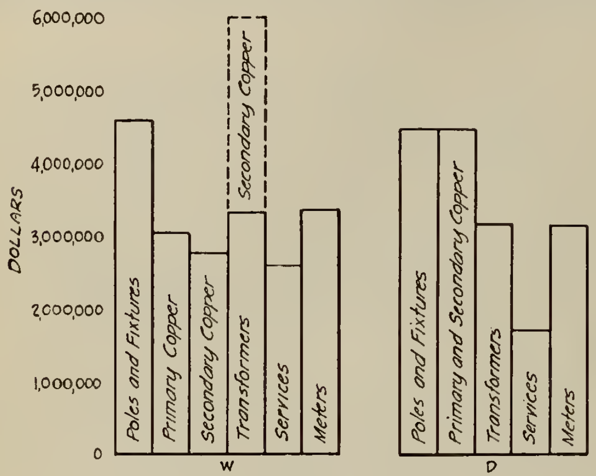


Fig. 17—Distribution System Cost.

The foregoing discussion pertains entirely to higher voltage radial circuits. It is believed that in practice more is to be gained by considering a higher voltage distribution system such as 13-kv. as the principal distribution system and that, according to the loads and circumstances, they will supply industrial loads, primary networks and low-voltage secondary networks and feed radially whatever territories seem desirable. Thus, if it is desirable to eliminate interruptions to consumers due to the high-voltage feeder failures, the primary network could be used in those cases. If the load is dense enough the secondary low-voltage network overhead or underground could be used in those particular localities. Large industrial customers would be supplied from two or more of the same 13,000-volt distribution circuits. Thus, 13,000-volts or higher would be the principal distribution voltage and network or radial systems supplied from these circuits according to the circumstances.

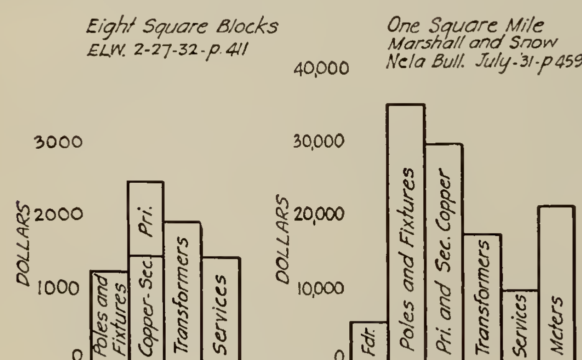


Fig. 18

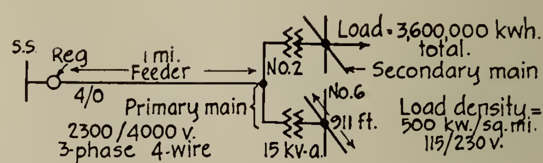
Rural Lines

The primary distribution systems for rural territories continue to be an important problem before the distribution engineer. Substantial economies have already been made by the use of longer spans and higher distribution voltages. Studies are being continued to increase the spans and also to save money on the customers' installations. There has recently been developed an auto-transformer with tap-changing-under-load equipment for use on 13,000-volt circuits. This will help improve voltage regulation in many rural communities where it has not been possible to justify the expense of the modern induction voltage regulator. After all, however, it is apparent that the real economic solution for the rural load is an increased use by the consumer. In order to put the rural load on a paying basis, it will be necessary to show the farmer how he can use more electricity to his economic advantage.

Secondary Distribution

The secondary system, consisting of the distribution transformers and secondary wire, as discussed previously, is really the first in the series of steps from the consumer to the generating station. This problem has not received the concentrated attention that it deserves and is the subject of considerable discussion at the present time.

One way of showing the importance of secondary system design is to apply diversity factors beginning at the generating station and proceeding to the consumer. For instance, 100,000 kv.-a. of generating capacity will require approximately 110,000 kv.-a. in substations, 132,000 kv.-a. in distribution feeders and almost 200,000 kv.-a. in distribution transformers. Thus, it is seen that the kv.-a. capacity of distribution transformers for domestic load is at least twice the total kv.-a. capacity of the generators necessary to supply that particular load. Further, a study of load factors will reveal that the distribution transformer load factor is half the load factor of the generators, bringing out very forcibly that there is twice as much kv.-a. capacity which is used half as much. If the average size of these



Voltage Regulation 0.8 Power-factor

Substation to feeder point		4.6%
Feeder point to transformer		1.0%
Distribution transformer		3.0%
Secondary mains		3.0%
Total		11.6%
Losses		
Primary feeder (2250 hr.)	74,000 kwh.	2.06%
Transformer — Core loss (8760 hr.)	92,500 kwh.	4.09%
Transformer — Copper loss (1500 hr.)	54,500 kwh.	
Secondary mains	78,000 kwh.	2.16%
Total		8.31%

Fig. 19

TABLE I

Cost

Copper Pri. feeder	7 tons @ $400	$ 2,800
Pri. mains	40 tons @ 400	16,000
Sec. mains	30 tons @ 400	12,000
Total	77 tons	$30,800
Transformers	138, 15 kv.-a. @ $131.00	$18,131
Cutouts	276, " @ 5.25	1,450
Ltg. arr.	276, " @ 5.00	1,380
Total		$20,961
Poles	2060 @ $20.00	$41,200
Crossarms	2060 @ 1.50	3,090
Sec. racks	.. @ 1.50	3,090
Total		$47,380
Grand total		$99,141

distribution transformers is 15 kv.-a., then the number of units exceeds 13,000 so that whatever becomes general practice for one transformer installation is multiplied 13,000 times.

Secondary system design is also very important from the point of view of increase of domestic load, because practically none of the overhead secondary systems which supply domestic load have any appreciable amount of excess capacity. The future increase in domestic loads also makes it important to study this question of secondary system design, because if load develops to a point where a change of wire size is necessary, considerable expense is involved in transferring wire and reconnecting services.

It is the opinion of some that, due to lack of careful investigation, the use of large kv.-a. distribution transformers with correspondingly large secondary copper has been overdone. Studies recently made show that for a given load in a given area a design based on using No. 4 secondary wire had a very large cost advantage over designs based on using larger secondary wire. For example, the investment in a system based on using No. 4 secondary wire was $6,000,000; using 1/0, $8,000,000; using 4/0, $11,000,000. Of course, there are very few 4/0 secondary systems but it is obvious that if such large wire is put up without careful consideration, the increase of the investment over the more economical No. 4 secondary system would be approximately 100 per cent. These figures take into account all factors and are fully comparable.

Another way of bringing out the importance of secondary system design is to break down the investment into various parts of the distribution system itself. For example, the distribution system of Fig. 1 is broken down in Fig. 17. Here it is observed that the secondary system, consisting of the distribution transformers and secondary copper, is by far the larger item. Really there is very little other than these two items for a distribution engineer to play with in balancing costs to determine the most economical design. Substantial savings can sometimes be effected by studying the details of such items as poles, fixtures, services and meters. Fig. 18 shows similar investment figures.*

Fig. 19 and Table 1 give a division of the typical distribution circuit in detail. Anyone can make such a set of figures for himself using values that he considers would be more representative than the ones here illustrated. Whatever figures he uses, he will be impressed with the importance of secondary system design and will observe that the major parts of the investment, losses and voltage regulation occur in the distribution transformers and in the secondary conductors. He will also find that a large investment can be made in primary copper and feeder regulators to secure good voltage regulation and yet the effect may be completely neutralized by poor secondary design. He will observe as well that distribution transformers and secondary copper constitute a large item in the total on the basis of proper design and a very much larger item if the system is not properly designed.

Another way of bringing out the importance of this subject is to show the amount the central station industry has spent in the purchase of equipment from manufacturers for use on their systems. Fig. 20 shows that the central station industry buys more cable than anything else and that the expenditure for distribution transformers is second, this latter being approximately 50 per cent greater than the expenditures for turbines. Including the accessories with the distribution transformers brings this expenditure almost up to that for cable. If the major portion of the expected increase in central station output is to come from domestic load, the distribution transformers and secondary copper together with other secondary system expenditures will constitute a still larger part of the total.

*_Electrical World_ and _N.E.L.A. Bulletin_ of July, 1931.

Such engineers as Seelye, Bullard and DeMerit have given considerable study to secondary system design and have shown conclusively that substantial economies are to be made. Some people may feel that the problem is elementary and does not require engineering of the best type. Such a notion can easily be corrected by considering the factors involved in the secondary system design, for this design requires a consideration of the permissible limits of voltage regulation as produced by the normal load and by the starting currents of motors. If the secondary system is designed for a normal drop of 2 per cent, that is one thing and if 3 per cent is allowed, that is another thing; the effect of the cost is very material. Motor starting currents giving instantaneous drops in excess of 2 or 3 per cent are also factors to be dealt with.

The most important factor in the secondary system design is the load supplied. Most discussions of secondary system design have considered systems as being static. Actually the load on a distribution system is transient, making it necessary for the distribution system to receive regular, careful and continued study. The initial load density is an important item and may be of the order of 10 to 20 kv.-a. per 1,000 feet and the rate of load growth 5, 10, or 15 per cent per year. The average demand for a consumer may be anywhere from 150 to 450 watts or even higher. The determination of the size, cost and spacing of distribution transformers involves a knowledge of their life and initial loading which may be 80 to 100 per cent with an ultimate loading which may be 125 to 150 per cent. The size, cost and losses of the secondaries are also to be determined and the life of the secondary wires must be considered and may be fifteen up to twenty years. Other factors such as equivalent hours for determining losses, demand charges and energy costs are important. It should also be recognized that conditions frequently occur causing the system to be dismantled in about one-half the expected time.

The foregoing brief reference to the factors involved in the study of secondary design is sufficient to impress

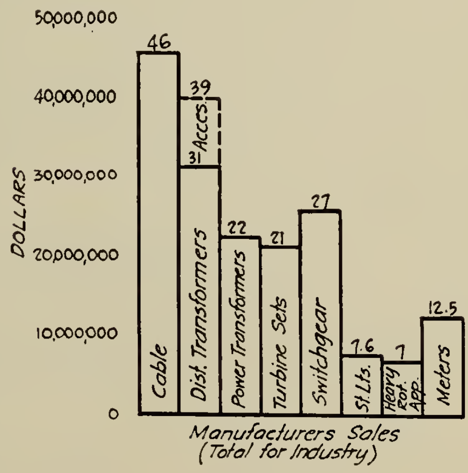


Fig. 20

anyone that careful study is required to balance these factors so as to obtain the most economical design. It requires the accumulation of considerable data and what is more important, requires the exercise of the very best judgment in evaluating these factors, interpreting the data and drawing conclusions. The work is laborious and for that reason the present time is appropriate for the study of this problem, which is simple, but its analysis and solution considering all factors is complex and therefore requires the best engineering attention available in the industry.

The low-voltage a-c. network system has almost become universal for the commercial area. Many cities contain only a nucleus of the network but the number of companies which have started this method of distribution for that area indicates that it will form the ultimate system for higher load density areas.

All transformation and protective devices have been reduced to a minimum and because of this simplicity further advances and improvements must of necessity pertain to detail. When the system was first proposed, many serious difficulties were predicted. However, operating experience shows that these were not as numerous or as serious as expected, and the low-voltage a-c. network system has been very satisfactory.

The success of the secondary network system in underground areas has created a desire for application of the same ideas to overhead areas. Network protectors have been developed in low ampere ratings to fit the transformer sizes needed, and for pole mounting, so that as far as equipment goes, the overhead secondary network system can be applied at any time. The costs in this system are very similar to those discussed for higher voltage distribution, with the added expense of the network protector, the heavier secondaries and the reserve capacity in the feeders and distribution transformers themselves. A sufficient number of cost comparisons based on field conditions between various systems have not been made to establish the relative position of the overhead secondary network system. Enough is known, however, from the economics of the underground secondary network system to be reasonably sure that there will be many cases where overhead secondary network systems will be economical. There will also be cases where they will be desirable even at a slightly higher cost because of their simplicity and the high order of service rendered.

Low-voltage a-c. network systems have been applied to very tall buildings with the conductors running from top to bottom and are referred to as vertical networks. In some cases the vaults which are located on several floors above the street are tied together with network cables. In all cases, however, each transformer vault has several banks of network transformers supplied from as many transmission feeders and supply a common network bus from which the load feeders radiate to the various floors and rooms. Industrial establishments can also make use of the same principle, taking energy direct from transmission voltage, omitting all high-tension switching equipment and stepping down directly to the utilization voltage at one or more points in the establishment. There will also be applications for the secondary network systems in territories where underground construction is necessary for reasons other than high load density. Probably, considerable development in lower cost underground construction will be made and it is possible that many secondary networks will be installed in connection with the use of buried cable which will permit them to be economical in many cases where they are not at present.

This discussion by no means covers distribution system economics completely and is intended solely for the purpose of stimulating interest in the subject and indicating possible improvements, as well as some of the more significant work which has been done.

Discussion on "Lighting the Welland Ship Canal"

Paper by Lewis P. Rundle, M.E.I.C.[1]

W. Hamilton Munro, M.E.I.C.[2]

The chairman, Mr. Munro, in introducing Mr. Rundle, remarked that the work that had been done in designing the lighting system for the Welland Ship canal would no doubt have great influence on the lighting of the subsequent canalized sections of the St. Lawrence Waterway, and the good results obtained had been due to a careful study of the whole subject and by experimental installations, and further that great weight had been placed on the opinion of those most interested in the lighting, that is, those in charge of ships using the canal.

Mr. Rundle, in presenting his paper, showed a large number of views illustrating the canal in general and the lighting installation in particular. He also commented on the valuable assistance which had been received by the engineers of the Department from the active co-operation of the manufacturers of the equipment installed, and from the ship captains, especially when viewing the trial installations.

John Murphy, M.E.I.C.[3]

Mr. Murphy paid a tribute to the excellent results which had been obtained by the author and his colleagues on the lighting of the Welland Ship canal, and remarked on the absence of glare in the lock and prism lighting.

Mr. Murphy had visited the Welland canal in 1906, at which time an attempt had been made to light each lock by four arc lamps, which had resulted in a great deal of glare due to the horizontal beams. This state of things had been considerably improved by painting one half of the globes.

B. Ottewell, A.M.E.I.C.[4]

Mr. Ottewell inquired as to the method of adjustment of the lighting units both for the locks and canal prism, and the author stated that this was done by measurement and by adjusting the units until the desired even illumination was obtained. When once adjusted satisfactorily they remained in position.

In reply to other questions, Mr. Rundle stated that though many of the ships using the canal are fitted with search-lights he had never seen them used, the captains of the vessels stating that the canal is so well illuminated that, under normal conditions they do not need to use search-lights.

J. W. Hughes, A.M.E.I.C.[5]

Mr. Hughes inquired whether flood lighting had been given consideration for lighting the prism of the canal, and in reply the author stated that a number of flood lighting units had been tried, but they were less satisfactory than the systems adopted, which gave a much more even illumination than would be possible with flood lighting.

L. P. Rundle, M.E.I.C.[6]

In reply to other questions, the author stated that the lights are turned on or extinguished by the lock operators, and that it had been only found necessary to clean the

(1) Paper presented before the General Professional Meeting of The Engineering Institute of Canada, Ottawa, Ont., February 8th, 1933, and published in the January, 1933 issue of The Journal.

(2) Montreal, Que.

(3) Electrical Engineer, Dept. of Railways and Canals and Board of Railway Commissioners, Ottawa, Ont.

(4) Canadian General Electric Co. Ltd., Peterborough, Ont.

(5) Electric Engineer, Canadian Pacific Railway Company, Montreal.

(6) Senior Assistant Engineer, Welland Ship Canal, St. Catharines, Ont.

lights once a year, all the lighting units being dust-proof and bug-proof.

M. B. Hastings[7]

As representing one of the manufacturers who had the privilege of co-operating with Mr. Rundle during the study period of his problem, Mr. Hastings was naturally interested in the results from a practical point of view, and would like to ask the following questions:

Have there been any comments from the ship captains relative to glare, which would lead the author to believe that visor shields, either horizontal or vertical, would improve conditions in some locations?

Does the present system meet fully the requirements for both the loaded and unloaded boat? It will be observed that in the case of the loaded boat the skipper is 16 to 20 feet lower than in the case of the unloaded boat.

Has the design adopted proved as moisture and dust-proof as expected?

Has there been any undue breakage of Fresnel lenses due to heat? Of course, the Fresnel lenses furnished were of heat resisting glass but there might be the possibility of expansion and contraction due to the mass of metal incorporated in the design of the unit.

He would be also interested in knowing how the surface of the chromium plated reflectors is standing up against the heat and other conditions.

Mr. Hastings felt that in view of the difficult nature of the problems it hardly seemed possible that even after the extensive study carried out by both the engineers and manufacturers, all conditions could have been met satisfactorily.

C. B. Stephens[8]

Mr. Stephens remarked that this paper illustrated quite clearly the excellent lighting effects obtainable by making full use of light distribution, curves and isolux charts pertaining to reflectors and Fresnel type lenses. Such effects were only made possible by co-ordinating the illumination data, so that angles of maximum candle power and foot candle values might be plotted on plans and sections of the canal prism. Studies of such sections assisted in determining spacing distances and mounting heights of light sources that would produce the required effect economically.

He noted that the 11-inch refractor units for lock lighting had been designed to take 750- to 1,000-watt lamps, although usually this refractor was not recommended for use with lamps larger than 500 watts. Had tests of heating and cooling shown that there is little danger of refractor breakage when burning lamps larger than 500 watts?

The navigation signal light as used at the locks was an interesting application of the scientific control of light for a particular purpose. He would expect, however, that each time a new lamp is used it would require adjustment for focus in order to develop the maximum beam candle power.

The paper states that the Fresnel lense in the prism lighting unit has a light amber colour, and absorbs somewhat less than a clear glass. It has been generally understood that clear glass absorbs less light in the visible spectrum than any tinted glass. Would the author cast some "light" on this apparent paradox?

L. P. Rundle, M.E.I.C.

In reply to the questions asked by Mr. Hastings, the author stated that there have been no adverse comments from the ship captains in regard to glare. Visor shields were discussed at length by the canal engineers and it was decided that, in so far as the prism lighting of the Welland Ship canal was concerned, visor shields were not necessary. The author, when at Port Colborne recently, talked to several ship captains who were unanimous in stating that the canal lighting was very good on both the locks and prisms and declared that if all canals were lighted like the Welland Ship canal there could be no cause for complaint.

Whether boats are loaded or unloaded did not appear to make any difference, the navigator being still above the maximum beam of light and usually several hundred feet away from any light in a direction in which he would be likely to be looking.

There had been no complaints about moisture or snow. The author examined some fixtures since presenting the paper and found that after the unit had been in use and undisturbed for a complete navigation season, a clean white handkerchief, when wiped over the inside of the lens and reflector, showed a very small trace of dirt. This did not appear to be dust, but was more likely a vapour or smoke from the cement between the lamp base and glass neck of the lamp. The surfaces of the chromium reflectors appeared to be free from any discoloration or stain and as bright as the day they were put in, i.e. in the summer of 1930. The lens and reflector are lightly wiped off with a soft cloth whenever a new lamp is put in.

In regard to the breakage of Fresnel lenses, there had been no replacements. However, there is one that has a 45-degree crack in one corner, probably due to being shot. There had been a few replacements of the diffusing glass in the door but very likely some of these had been broken by stones, etc. It was quite evident that expansion and contraction of the metal mass did not injure the lens in anyway. It might be noted that the coefficient of expansion in this heat resisting glass is extremely small.

In reply to Mr. Stephens there had been no breakage of the 11-inch refractors due to heat from lamps. Some of these refractors had been using approximately 1,000-watt lamps for over two years with no breakage recorded.

The lights for the navigation signal were not focussed for each renewal. The lamps are quite uniform and the reflectors such that focussing each time of renewal is, for all practical purposes, not necessary.

In regard to the absorption of light being less in the heat resisting unit than for one of ordinary clear glass, this was probably due to the process of manufacture used in making a heat resisting glass which results in a glass of less impurities and which is optically superior to the ordinary commercial clear glass lens, but it should not be inferred that this would be true in the case of the better qualities of clear optical glass.

[7] Vice-President, Powerlite Devices Ltd., Toronto, Ont.
[8] Hydro-Electric Power Commission of Ontario, Toronto.

Relations of Aeronautical Research to General Engineering

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Aeronautical Engineering Division, Department of National Defence, Ottawa, Ont.

Paper presented at the General Professional Meeting of The Engineering Institute of Canada, Ottawa, Ont., February 8th, 1933.

SUMMARY.—Outlining the history of aeronautical research up to the achievement of mechanical flight in heavier-than-air machines, the author points out that subsequent investigations and experiments aimed at improvement as regards safety, economy and reliability. The paper then gives the trend of recent research and its main results as to supercharging, improvements in ignition and combustion and detonation in connection with the power plant, sketching also the progress on aerodynamic theory and its applications. Our improved knowledge of materials, particularly alloys, is considered, and it is noted that the principal results obtained from aeronautical research are of the greatest interest to engineers of other branches of the profession.

Introduction

The science of aerodynamics has written records which date back for more than two hundred and forty years. Galileo, Newton, Bernoulli, Euler, Borda and Coulomb, are among the names identified with original research on the forces caused by motion through the air. Since these early days aeronautical research has gone through several well defined stages, and has expanded to embrace, in addition to aerodynamics and aerostatics, a very wide range of scientific subjects, in some instances retaining a purely aeronautic application; in other instances merging into general research with an aeronautic bias. If the whole fund of the world's scientific knowledge be considered as a bank, then aeronautics first started as a pure debtor, and remained in that position for nearly two hundred years, but in the present century its standing has changed to that of an important depositor, contributing more to the general fund than is actually applied to aviation.

The first researches on the resistance of air were probably prompted by a desire for fundamental physical research, or were possibly incidental to other researches, in which air resistance was an awkward and unavoidable complication. Later on some measurements were made to determine the forces of the wind on buildings, bridges, cranes and other structures and mechanisms, and though these experiments are not strictly aeronautical research, the reports are justifiably included as part of the early literature on the subject.

In the latter part of the nineteenth century the possibilities of dynamic flight came very much to the fore and a lot of experimental work, aimed directly at its attainment, was commenced. From this time aeronautic research can be said to have attained a distinct individuality, and to have reached the stage of preliminary survey. The initial applied researches dealt mainly with the forces exerted by a stream of air on bodies of the shape of flat and curved plates, cylinders, solids of revolution, and so on, and an immense amount of facts were discovered and recorded. Concurrently with the amassing of these facts dynamic flight by means of man-lifting gliders was actually achieved, and with the aid of the information on structures, power plants, and materials that already existed as part of the general fund of engineering knowledge, the first successes were soon followed by the attainment of dynamic flight in engine propelled aircraft.

So far progress can be credited almost entirely to private enterprise, but when flight in heavier-than-air machines had definitely been demonstrated as possible, national governments began to take an intense interest, mainly because of the vital reactions which the employment of the new art of aerial navigation would have on the conduct of war.

The government of Great Britain, on the advice of the Committee of Imperial Defence, appointed on April 30th, 1909, an Advisory Committee for Aeronautics, and the following extract from the committee's first annual report may be of interest:—

"It is no part of the general duty of the Advisory Committee for Aeronautics either to construct or to invent. Its function is not to initiate, but to consider what is initiated elsewhere, and is referred to it by the executive officers of the Navy and Army construction departments. The problems which are likely to arise in this way for solution are numerous, and it will be the work of the committee to advise on these problems, and to seek their solution by the application of both theoretical and experimental methods of research. The work desired thus falls into three sections:

1. The scientific study of the problems of flight, with a view to their practical solution.
2. Research and experiment into these subjects in a properly equipped laboratory, with a trained staff.
3. The construction and use of dirigibles and aeroplanes, having regard mainly to their employment in war.

The Advisory Committee are to deal with the first section, and also to determine the problems which the experimental branch should attack, and discuss their solutions and their application to practical questions. The second section represents the work referred to the laboratory, while the duties connected with the third section remain with the Admiralty and the War Office."

Public interest was likewise aroused in other countries, and was expressed by the organization of national research bodies, or by the granting of subsidies to universities, technical schools, and in some cases to industrial enterprises. This may be described as the organization stage in the history of aeronautic research, and its commencement was marked by a focussing of the problems which required solution. The advent of the war in 1914 provided a stimulus which resulted in a very rapid advance in the more practical branches of the art, and a less rapid advance in fundamental theory. The cessation of the general war in 1918 found every big nation with an established aircraft industry representing a very large investment, and men's minds turned towards the peaceful employment of aircraft. Aeronautic research then entered into its present stage, which may be described as that of development.

Commercial unsubsidized exploitation of aircraft remained for a few years after the war an unprofitable business, except for a few isolated instances wherein competing methods of transportation were arduous and costly. The reason for this was that aviation was not up to the necessary standards of *safety*, *economy* and *reliability* Practically all research work undertaken since 1919 has had for its object improvement under one or other of the above heads.

Safety

Of the three qualities mentioned, that of safety is of the most vital importance from a commercial as well as from a humane point of view. It may be taken as an axiom that the general public can always be found willing to risk for a limited period their money, their comfort, or their time, but never knowingly their lives. The pursuit of safety has led to intensive study of aerodynamics, with particular reference to stability and control, involving much expansion of the fundamental mathematical theory of fluid motion, the development of accurate navigation and research instruments and indicators, the continual improvement in reliability of the spark ignited internal combustion engine, the production of a workable compression ignition engine using a fuel much less inflammable than gasoline, a special directive in the field of meteorology to investigate the intensity and structure of gusts and windstorms, in order to provide for the adequate structural strength of aircraft, and finally an impetus to the study of the fatigue of materials.

Economy

The quality of economy bears a curious relationship to that of safety, for though the desiderata appear to conflict all along the line, yet the prime requisite for economy is *safety* itself; if only by reason of lowered insurance rates and decreased overhead, in the nature of reserves for depreciation, maintenance and unforeseen incidents. This is true of many other human activities, but in aviation it is perhaps emphasized because of the dreadful penalty attached to infringement, and to the ease and rapidity with which the border line between profit and loss can be crossed in the wrong direction.

Aircraft can only make revenue out of their capacity for pay load, which is the difference between the allowable gross weight and the weight of the fully equipped, manned, and fueled machine. Increase in the small margin for pay load has been continuously sought, with due regard for safety, and this has entailed research into the theory of structures, the development and the properties of metallic and non-metallic materials, notably light alloys of aluminum and magnesium; and technique of construction as affecting safety, initial cost, maintenance and life. Aerodynamics enter the problem again in the determination of the air resistance or "drag" of bodies by themselves, and as affected by mutual interference with other bodies, in order that by improved streamlining higher speeds may be attained for a given power, or conversely a reduced power for a given speed with the attendant advantage of a smaller power plant and fuel supply.

Power plants have come in for a tremendous amount of experimentation under the head of economy. The four stroke spark ignited engine has benefited by material increases in thermal efficiency without prejudice to the reliability and life of the plant. Incidentally this brings up one of the most serious difficulties to be faced by the engineer in all his activities. Once the public has become educated to a certain standard of reliability and life, which has been painfully achieved by progressive development of a machine, that standard must be achieved by any new machine before it can be marketed successfully, no matter how the specific output of the new device has been increased.

The compression ignition engine which is already so desirable under the heading of safety has received a further impetus, because it is also desirable under the head of economy by reason of the possible high thermal efficiency of the compression ignition cycle, and the consequent reduction of the overall weight of the power plant plus fuel.

Reliability

If a flying machine has achieved the desiderata for safety and economy, the conditions for reliability can be considered as satisfied for the machine itself, but for reliable aerial navigation the path must be smoothed for the vehicle, and this has led to research on instruments of all kinds, the investigation of conditions affecting audible and visible signals through fog, the application of radio engineering to the peculiar needs of aircraft and a quickened study of meteorology, with special reference to rapid forecasting of weather conditions.

Aeronautic Research During the Past Few Years

The basic motives of aeronautic research have now been briefly explained, but to discuss the subject any further under the heads of safety, economy and reliability, would involve a lot of overlapping and repetition, so it is now proposed to trace the progress of the last few years in a few researches selected for their possible interest to engineers in general.

Power Plants

Of all the work done under the influence of aeronautical bodies, both public and private, that on power plants is undoubtedly of the greatest general interest. It has all been done in close co-operation with the automotive industry, the oil industries and other allied undertakings. The cumulative effect is observable to the man in the street by the much improved performance of the present day motor car and truck, and visible evidence is displayed in the charming blues, oranges, greens and reds, now so prominent at the corner filling stations. It is impossible to apportion the credit between air and ground undertakings, but it is perhaps pertinent to point out that progress which is merely incidental to commercial competition in ground undertakings is absolutely a vital necessity to aerial navigation.

Dealing with research which is applicable to all types of internal combustion engines, nearly all of which has been devoted to increase in thermal efficiency, the following subjects appear as of the most importance:

Supercharging.—The main object of supercharging aero engines is to maintain the full rated power of the plant at an altitude. The power of an ordinary internal combustion engine falls off with altitude as a function of density and pressure, and supercharging provides a compromise wherein a certain amount of the total available ground level

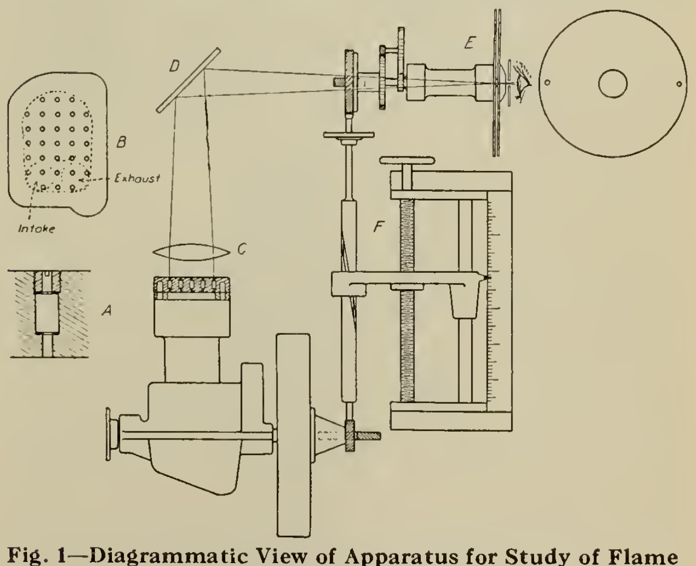


Fig. 1—Diagrammatic View of Apparatus for Study of Flame Movement and Pressure Development in an Engine Cylinder.

horsepower is sacrificed in order that full power may be obtained at the so called "supercharge height." Except under special circumstances, supercharged engines are not permitted to exceed the B.M.E.P. obtainable from a similar unsupercharged engine at ground level.

All kinds of air pumping units of the centrifugal and of the displacement type have been thoroughly investigated as machines in themselves for design, materials of construction, simplicity, cost, characteristics and efficiency.

The United States government laboratories at Langley Field have made extensive tests on Roots blowers, with particular regard to the minimum practicable clearances for the rotors, in an effort to increase the volumetric efficiency of this type. The method of drive has received much attention. The most common drive now in use is from the crankshaft through a train of gears and a centrifugal clutch to the blower, but the attractive possibilities of using the waste energy in the exhaust gases have by no means been neglected, though up to now the mechanical difficulties of getting a turbine to stand up to the heat of the exhaust, without undue sacrifice of lightness, have seriously retarded this development. The effect of supercharging on the engine itself and on the overall characteristics of the supercharger-engine-aeroplane combination has led to ramifications dealing with carburetion, cooling, detonation and fuels, and last but not least, further improvement in airscrews, with a notable advance in the adjustable pitch variety, as the full benefit of supercharging cannot be obtained with a fixed pitch screw.

Combustion.—The Bureau of Standards on behalf of the National Advisory Committee for Aeronautics of the United States have, for a number of years, been studying the phenomena of the gaseous explosive reaction and the fundamental nature of the factors which influence combustion in actual engine cylinders. The work has necessitated the preparation of some very interesting apparatus, notably an engine cylinder with a number of quartz windows in the walls of the combustion space. The light from the explosion is focussed through a lens on to stroboscopic discs, which are driven by the crankshaft of the engine. In this way the progress of the flame can be charted for different points in the cycle. Pressure measurements are made to synchronize with these observations, while a number of different cylinder heads have been made in order to determine the effect of variables, such as the number and position of sparking plugs and the shape of the combustion chamber, on flame travel and pressure development (Fig. 1).

Gases.—The intensive study of the mathematical analysis of theoretical cycle efficiencies has brought in its train the determination of the specific heats of steam, carbon dioxide, carbon monoxide, oxygen, hydrogen and nitrogen, from zero to 3,000 degrees C. The results of these investigations have been tabulated and constitute a useful addition to thermodynamic data.

Cooling.—The result of progressive increase in thermal efficiency and, therefore, of brake mean effective pressure is to introduce serious difficulties into the problem of cooling, particularly of air cooled cylinders. A theoretical investigation has been made to determine the effect of bore-stroke ratio and shape of cylinder head on the heat losses from an engine cylinder, due to radiation and conduction. Measurements of the heat transfer from the gases to the cylinder head and walls have also been made experimentally, and in addition to this a great number of experimental facts have been obtained relating to the cooling of plane and finned surfaces in a current of air. Evaporative cooling, which was tried at least twenty years ago in aircraft, and which is quite familiar to automotive engineers, has recently received renewed attention on account of the attractive possibilities of economy in weight and air resistance of the cooling plant of liquid cooled engines. The present tendency towards improved streamline shapes of motor cars will probably bring in its train the general introduction of this form of cooling on road vehicles.

Weight of Crankshafts and Pistons.—The search for lightness has led to an attack on the heaviest single component of the aero engine, namely, the crankshaft, and an extensive mathematical and experimental study has been made in England on the torsional vibration of crankshaft-airscrew combinations. In addition to producing results of immediate practical use to designers, the work has been of a pioneering nature in experimental technique, and has produced methods and instruments which will be powerful tools in the hands of workers in similar fields.

Closely related to the strength of crankshafts is the weight of reciprocating parts, and within the last five years considerable advance has been made under aeronautic influence in the material and design of internal combustion engine pistons. While achieving greater lightness the strength has been satisfactorily maintained, the lubrication of the thrust faces has been materially improved without any increase in oil consumption, the piston temperature has been lowered, the life of the piston and cylinder liner has been lengthened, and as there is nothing like success to breed success, engine operation has become quieter at all speeds and loads (Fig. 2).

Fig. 2—Various Forms of experimental Pistons.

As a means of increasing thermal efficiency by improving combustion, the effect of turbulence and the methods to be employed for producing the right kind of turbulence have received much attention, not by any means confined to the work of the United States Bureau of Standards on combustion in an engine cylinder.

As incidentals to the general programmes of research there has been a notable advance in the measurement of pressures in the cylinders of engines, a problem of no small difficulty in view of the ever increasing severity of conditions under which indicators are asked to operate (Figs. 3 and 4). The effect of air humidity on engine performance has been investigated, and with the assistance of the oil companies a very considerable improvement in the qualities and performance of lubricating oils has been effected.

Gasoline Fuels.—Turning now to research applicable to the spark ignited engine, perhaps the most important effect is observable in the general increase in compression ratios now commonly employed. This increase with its resultant improved thermal efficiency has only been made possible by a most outstanding improvement in fuel. Though largely affected by piston design, combustion chamber design, valve design and cooling problems, detonation or "knocking" is more than anything dependent upon the characteristics of the fuel. The conceptions of the criteria on which a fuel for spark ignited engines should be judged have been revolutionized within the last decade. In some instances the ugly ducklings among fuels of a few years ago have now come into a place of honour. Volatility was once held in high esteem, and the words "hi test," "low test" and "gravity" were heard about the corner filling stations, and were discussed by every motor car owner with due solemnity. The wisdom of past days is certainly not to be despised, and these qualities are not neglected, but who hears them mentioned today with the same respect? The magic "octane number" is now the shibboleth.

Detonation has been attacked *ab initio*. On the one side the measurement of anti-knock rating of fuels had to be studied and standardized as an elementary necessity of

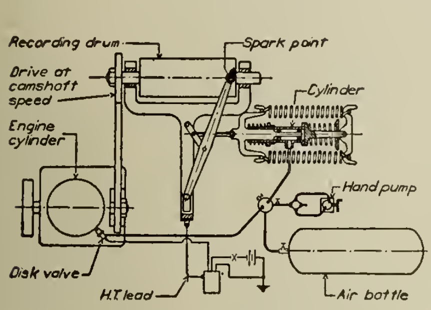


Fig. 3—Electrical Balanced Pressure Disc Type Indicator.

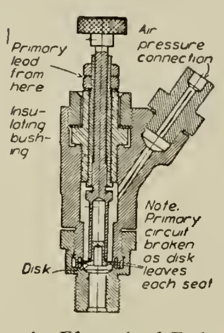


Fig. 4—Electrical Balanced Pressure Disc Valve.

product control and marketing; while on the other side the fundamental chemical and physical reasons for detonation had to be sought in order that satisfactory antidotes might be found for use in those fuels which are not naturally anti-detonant. The admixture of benzol is beneficial, but unfortunately in cold climates the benzol is apt to freeze out and cause endless trouble in the fuel distribution system.

On the North American continent by far the most common anti-detonant is tetra-ethyl-lead, and the use of this highly toxic substance is the reason for the warning colours mentioned earlier in the paper. It is interesting to note that in a side line investigation of the subject it was found that the mixing of lubricating oil with a fuel containing an anti-detonant resulted in a virtual destruction of the anti-knock properties. Aeronautic research has contributed materially to this entire development, not only by original experimentation in aeronautic establishments, but also by providing the so often effective spur of urgent necessity.

The rapid rate of climb of modern aircraft has introduced a difficulty in the fuel problem in the form of vapour locks, and this problem has induced much work to produce fuels which will carburize satisfactorily without introducing the volatiles, which will choke the fuel feed system during a rapid increase in altitude. The same problem has led to improvements in carburettors and fuel distribution systems.

Two-Stroke Cycle.—The four-stroke cycle has always irritated people because of the wasted motion during the exhaust and suction stroke. The most important disadvantage of the two-stroke cycle has been the high specific fuel consumption which has come to be regarded as inherent in the type. This disadvantage makes the specific power output on a weight basis compare unfavourably with that of the four-stroke engine, except for flights of a very limited duration. To get nearly twice the power from the same cylinder capacity is, however, a very tempting prize, and one way of combating the fuel consumption problem is to do away with the carburettor altogether and to inject a measured quantity of fuel in the form of a spray directly into the combustion space after the exhaust valve has closed, thus side-stepping the difficulty of unburnt fuel following the exhaust gases out.

The study of gasoline sprays has been prosecuted, and the Langley Field laboratory of the United States National Advisory Committee for Aeronautics has constructed, and is energetically developing, a single cylinder two-stroke test unit, from which encouraging results are being obtained. The direct injection system is also being applied to four-stroke engines with excellent results, and the next two years should witness some very interesting applications. The carburettor is a very prolific source of trouble in extremes of temperature, and its elimination is very desirable, provided the substitute is not more troublesome still.

An interesting development is being energetically pursued in England in the laboratories of Mr. Ricardo with a high speed single sleeve-valve gasoline engine. An aluminum cylinder working at 1.76 atmospheres inlet pressure, 5,500 r.p.m., and a compression ratio of 6.36 to 1, gave an output of 246 pounds per square inch B.M.E.P., corresponding to 107 B.h.p. per litre of piston displacement.

To obtain a better idea of the significance of these figures a rather highly rated aero engine in common use today gives an output corresponding to about .41 B.h.p. per cubic inch, which is just a little less than one quarter of the output of 107 B.h.p. per litre. Allowing for the fact that in the one engine the power required to drive the supercharger is deducted from the total B.h.p. available, while in the experimental unit this power is not reckoned in, there still remains a very large difference. The dependability and life of the experimental bench unit have so far proved to be exceptionally good.

The following extract from the 1929 report of the British Aeronautical Research Committee may be of interest:—

> "To obtain the fullest advantage from supercharging at any altitude, it will be essential to do away with hot exhaust valves. The single sleeve valve engine appears to offer the only possible solution. On these grounds we think it is worth developing, as offering the greatest scope for advance in the production of the high duty engine of low weight per horsepower. The success of the single cylinder investigations warrants the early production of an experimental design of a complete engine."

Compression Ignition.—Short of the internal combustion turbine, which is still more or less confined to dream-

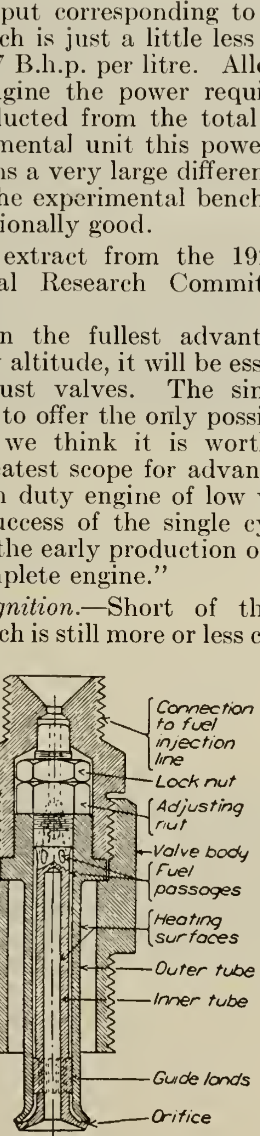


Fig. 5—Section Through Annular Orifice Automatic Injection Valve.

land and the files of the Patent Office, the high duty low weight compression-ignition engine represents the fondest aspirations of the power plant fraternity in aeronautical circles. The work of developing this type of engine in a satisfactory form for aircraft use has been carried on energetically in several different countries, and in the United

States and Germany compression-ignition aircraft engines are actually on the market, although they are by no means in general use.

The problem of producing high power for a low enough weight to compete with the spark-ignited gasoline engine is a very formidable one. To start with, the cycle demands high compression ratios and high pressures, and then in order to get a high specific output on a weight basis it is

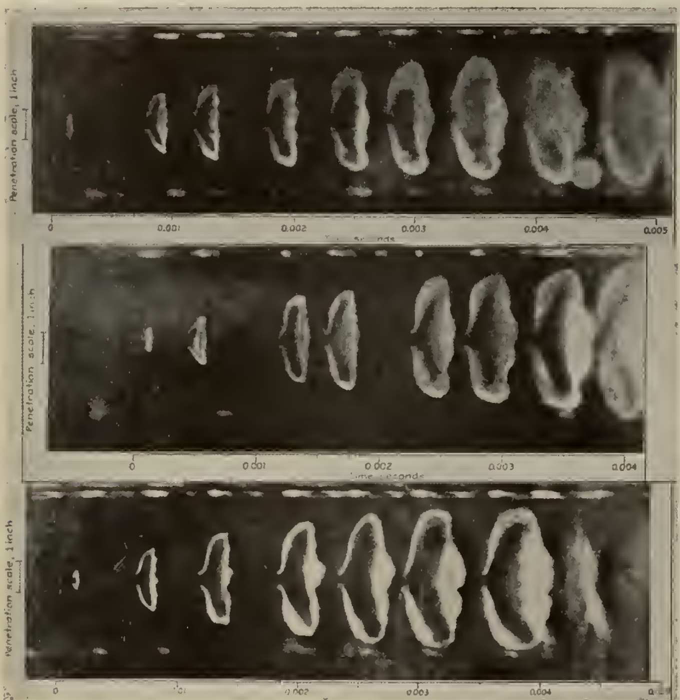


Fig. 6—Spray Photographs from Annular Orifice Automatic Injection Valve.

Chamber Pressure in all cases, 210 pounds per square inch.
Injection Pressure: A— 6,000 pounds per square inch.
B— 8,000 pounds per square inch.
C—10,000 pounds per square inch.

necessary to run at high speeds, and one of the big difficulties has been to get good and complete combustion in the extremely short time available.

In order to achieve fuel economy and good combustion, it has been the practice to supply a good deal of excess air, and though advances in metallurgy and in detail design have been such as to make the weight of a compression-ignition engine quite comparable with that of a spark-ignition engine on a piston displacement basis, the specific power output still lags considerably behind.

In order to reduce the excess air and obtain rapid and perfect combustion the whole range of engine variables has had to be considered and experimented with in a most painstaking manner. The subject of fuel injection alone has involved the fuel distribution system, whether by a single large pump into a pressure header or by a battery of pumps, each delivering to a single cylinder; valves mechanical and automatic; many different forms of nozzles; the direction, shape, structure and penetration of sprays in a dense medium; the phenomena of combustion and the lag of auto-ignition, and as a corollary the time, direction, duration, and rate of injection, including the best characteristics of start and cut off (Fig. 5). Other problems which do not actually come under the head of injection, but which have an important effect on the ideal type of injection are, compression ratio, combustion chamber design and turbulence, whether natural or induced, and finally fuels and fuel accelerators.

The Langley Field laboratories of the United States National Advisory Committee for Aeronautics have perfected an apparatus for the high speed photography of fuel sprays, and have for several years been obtaining records of sprays from many different kinds of nozzles under a wide range of chamber pressures and injection pressures (Figs. 6 and 7).

The same laboratories have completed an important photographic study of the motions of a timing valve and injection valve stem in connection with injection time lag and distribution and penetration of spray, for different ratios of orifice diameter to orifice length in a single orifice nozzle, and within the last three years they have expanded their spray photography equipment to record combustion characteristics as well as injection characteristics (Figs. 8 and 9).

Similar and complementary studies have been carried on in other countries. For instance, England has been paying a good deal of attention to dopes for lowering the ignition temperature of fuel oils. A small addition of ethyl nitrate has been found to effect a considerable improvement in the rate of combustion in engines of the directed spray type, though in engines in which the distribution of the fuel is dependent on air movement or turbulence the effect is not so great.

In England again, while the development of the four-stroke compression-ignition engine both of the poppet valve and sleeve valve types is being systematically continued, very great hopes are being entertained as to the possibilities of the two-stroke sleeve-valve type. A single

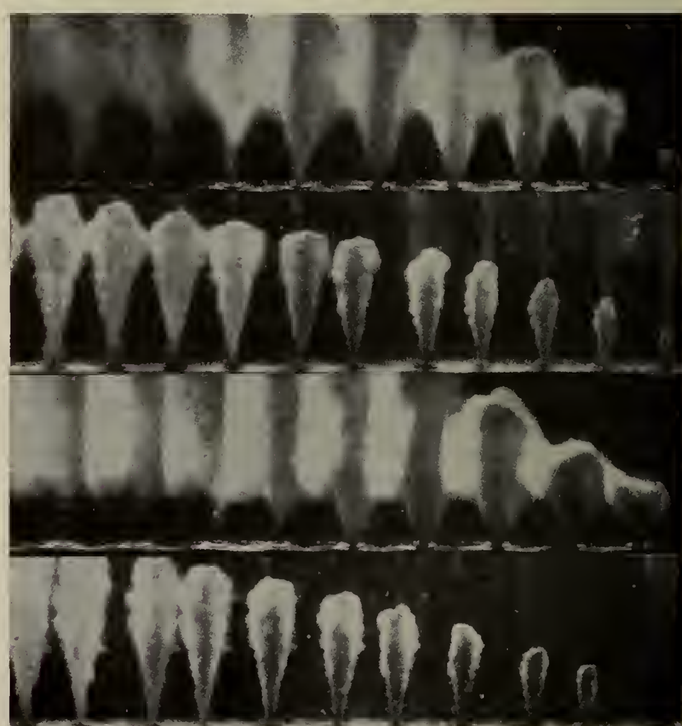


Fig. 7—A and B—Oil Spray with Secondary Discharge.
C and D—Oil Spray wthout Secondary Discharge.

Injection Pressure in all cases, 8,000 pounds per square inch.
Chamber Pressure: A and C—Atmospheric.
B and D—400 pounds per square Inch.

cylinder bench unit of this description is giving most encouraging results in the Ricardo research laboratories.

Aerodynamics and Instruments

The research that has been prosecuted in recent years on aerodynamics and its dependent and related subjects is possibly of less direct interest to the general engineering profession than that on power plants, but every now and again one finds instances in which the results of aerodynamic research may be of direct utility to engineers of other branches, or in which the tools and equipment developed for aeronautic research may be with benefit applied to experiments for other branches. The range is wide, and at one end borders on the province of the ordnance engineer, and at the other touches the field of the ventilating engineer at speeds as low as two feet per second. The incidental work entailed in the development of experimental equipment has led to considerable contributions to the general

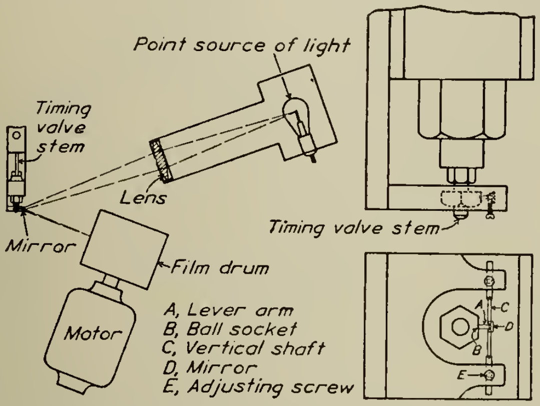


Fig. 8—Apparatus for Recording Motion of Timing Valve Section.
At Right—Enlarged Views of End of Timing Valve.

knowledge of instrument manufacture, and experimental technique.

Since the termination of war in 1918 there has been a very considerable impulse in the fundamental research on fluid motion, and the mathematical theory for both liquid and gaseous fluids has been greatly extended and experimentally confirmed. There is little doubt that in the future a study of this subject as an extension to the present day courses in hydrostatics and hydraulics will form part of the curriculum leading to engineering degrees.

Owing to the difficulty of making the motion of air visible, a great deal of this work has been prosecuted in water, in which the streams can be rendered visible by the introduction of dyes or drops of oil. The analogy between liquids and gaseous fluids is not, however, perfect, especially in those problems in which the kinematic viscosity of the medium is important, and, therefore, strenuous efforts have been made to render the air visible or to explore its motions by other means. For qualitative work the use of titanium tetrachloride fumes has proved useful, but for quantitative work this is not quite satisfactory. One method depends on the fact that the distribution of temperature in the wake behind a body in an airstream depends upon the type of flow, whether laminar or turbulent, and exploration is done by means of a highly sensitive thermocouple.

Another method which is being experimented involves the use of stethoscopes or microphones, while still another method takes advantage of the change of the refractive index of air with temperature and the use of stroboscopic photographic equipment for charting and recording. A research institute in Japan has made some excellent records of air flow over various objects at a photographic speed of many thousands of pictures per second, the air being made visible by the heat method.

Cavitation and Ballistics.—The Langley Field laboratories have a small water tunnel, having a two and half inch throat diameter, and in which a speed of 45 feet per second may be obtained. This equipment has been used for the study of cavitation on aerofoils of various shapes, the results of which may be of interest to hydraulic machinery and to marine engineers.

The Bureau of Standards, in co-operation with the United States Arsenal at Edgewood, where there is a large air compressor plant, have made measurements of the resistance of projectiles at speeds up to and greater than the speed of sound in air. The opportunity was taken by the United States National Advisory Committee to obtain data on the pressure distribution over aerofoils at these speeds.

Resistance.—Popular enthusiasm fired in America by Lindbergh's Atlantic crossing greatly accelerated the boom in commercial aviation, which began about 1926, and carried on both in the air and on the stock market for two or three years. It is significant to note that the effect of competitive commercial interest on aeronautical research was to focus attention on subjects of immediate application, and an immense amount of experimentation was done on drag and the mutual interference effects of bodies in proximity to each other. The drags of engine nacelles (Fig. 10), wheels, floats, undercarriages and other components of aircraft, have been measured by themselves, and also in relation to the other parts of the complete structure, and the tangible result has been a notable increase in the speed range or ratio of maximum to minimum speed of aircraft. This ratio is a direct reflection of efficiency.

One of the results of the public interest in aviation was an immense increase in written matter on the subject, which appeared in technical and popular periodicals, and a demand arose for the application of aerodynamic research equipment to all sorts of problems, in which air in motion is involved. This demand was not new by any means, but it became more widespread. The National Physical Laboratories in England, the Bureau of Standards in the United States, the National Research Council laboratories in Ottawa, and several universities have applied their wind tunnels to problems in connection with the air resistance of structures like tall buildings, bridge trusses, large roofs, and of vehicles like automobiles and locomotives (Fig. 11). The magnitude of the upward loads on the lee side of certain roofs is astonishing, and the author ventures to suggest that it is purely fortuitous that many buildings retain their coverings. These loads are not caused by the wind getting inside, but are the direct result of aerofoil effect.

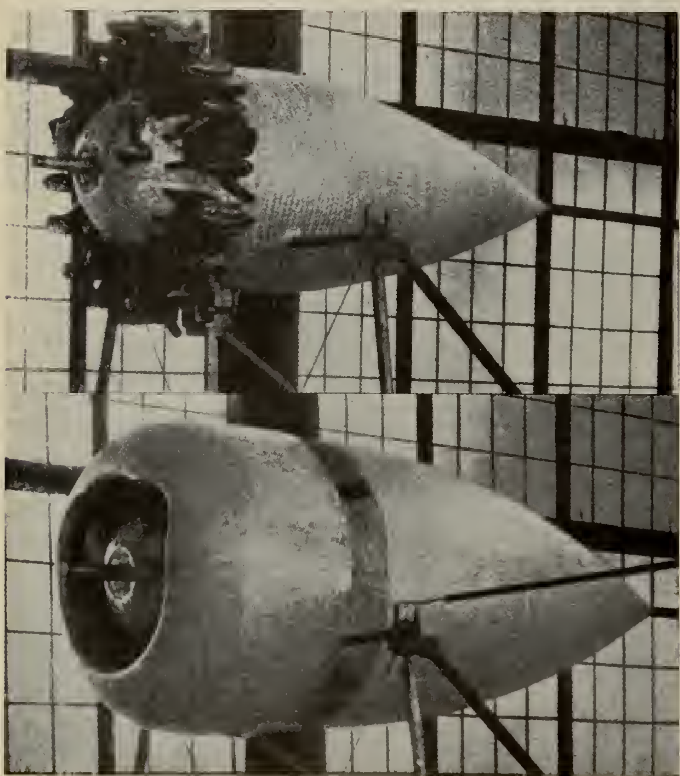
The automotive engineer is fully cognizant of the benefits to be derived from proper streamlining of the motor vehicle, and he now has the equipment and knowledge at his command to achieve a big step towards perfect stream-

Fig. 9—Record of Timing Valve Stem Motion—with 7-inch injection tube; Injection Pressure, 8,000 pounds per square inch; Initial Injection Tube Pressure, 1,000 pounds per square inch.

lining. The public, however, is conservative, even in America, and it is only in very recent years that popular knowledge of aviation has cultivated the public mind to a point where it is willing to accept radical alterations in the shape of vehicles. That these alterations are on the way is a certainty, but the date of the revolution is beyond the author's capacity to predict.

Instruments.—Incidental to the main body of research there have been a number of interesting investigations of fundamental importance to scientific instrument makers. A few among these are: physical measurements of the characteristics of damping liquids down to a temperature of 50 degrees below zero centigrade, the elastic properties of instrument materials, the friction of pivots, and the temperature coefficient of the elastic moduli of diaphragm and spring materials.

Of instruments which have been developed or perfected the following may be of interest outside the immediate sphere of aeronautics: a camera sextant for use in the navigation of airships, fuel flow-meters for small flows of a few gallons an hour, a three-component recording accelerometer and a sensitive manometer, which achieves an accuracy of one per cent for air speeds of two feet per second. This does not by any means exhaust the list, but serves to indicate the range of this work, a full citation of which would become wearisome.



A

B

Fig. 10—A—Conventional Nacelle.
B—Completely Cowled Nacelle.

Materials

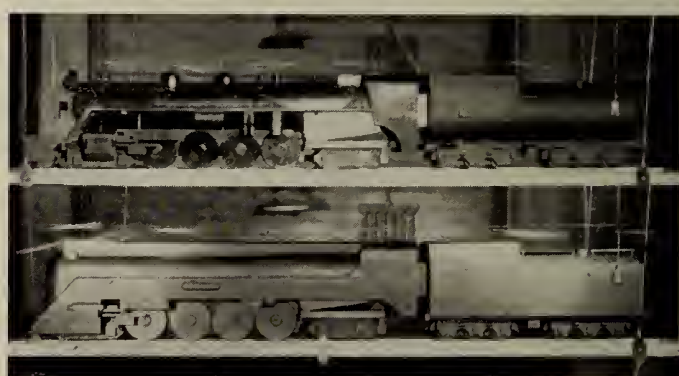
The structural design of large ground vehicles and of all aeroplanes bears an analogy to the design of large fixed structures, in that the mass of the vehicle provides the preponderant portion of the total load to be carried. Observe that the author has used the word "mass" rather than "dead weight," because it is desired to avoid any conception of "dead load" when referring to any vehicle, and particularly to aeroplanes in which the loads are very much of the "live" variety. Aircraft in manoeuvre, voluntary or involuntary, may be subjected to accelerations of great magnitude. Twelve times "*g*" has actually been recorded on military types in an effort to discover the worst loads that can be imposed by voluntary action on the part of the pilot. Such figures will explain why such tremendous importance is attached to weight saving in the design of aircraft, and why it becomes economical to use materials of a high basic price.

Specially selected and faultless wood, and high grade textile fabrics were originally the basic materials of aircraft construction. As the industry increased in size, and as the demand for materials increased, it became increasingly evident that wood suffers from many inherent disadvantages, not the least of which is that the quality and uniformity of the basic material is entirely outside human control. Even at that wood has certain qualities which ensure that it will never disappear entirely from the industry's inventory, and consequently a considerable amount of research work on wood adhesives and wooden structures appears on the records even up to very recent years.

The big metallurgical industries have taken an increasingly active interest in the production of materials for aircraft construction, not only in finding new materials, but in developing the methods of manufacture, to ensure absolute reliability and uniformity of the raw materials to closer limits than are acceptable in other industries, and methods of manipulation to ensure the most satisfactory finished product. In several cases materials and processes, whose original high costs were only justified by the stringent demands of aircraft, have been subsequently so simplified and cheapened as to make the product economically available for the general industrial market.

There are two great classes of metallic materials used in the construction of aircraft and aircraft engines, namely, the steels and the light alloys of aluminum and magnesium. This is not the place to dwell on the steels used for engines, as they are not peculiar to the aviation industry, but some mention may be made of those used for the aircraft structures.

In order that ferrous materials may be used economically in the primary members of aircraft structures, it is necessary to use them in the form of exceedingly thin walled sections, and from this necessity arose, particularly in European countries, the manufacture of high tensile steel strip rolled to very close limits and subject to the most rigid process inspection. Thin walls mean the danger of local instability, and much research, done mostly in the experimental departments of manufacturing firms, has been successful in building up an ingenious technique of corrugating, crinkling, flanging and assembling the strip into beams and columns, in which the material can be stressed to its ultimate strength before failure by local instability occurs. This technique cannot fail to be interesting to structural engineers of all kinds, and might conceivably be applied to cheaper materials for structures which are to be erected in out of the way places, where the cost of the material on the site of erection is largely made up of freighting charges.



A

B

Fig. 11—Model Locomotives Set up in Wind Tunnel Illustrating Turbulent Air Flow.
A—Simplified Wooden Model Locomotive.
B—Semi-"Faired" Locomotive.

Another problem introduced by thin walled sections is that there is a large amount of surface compared with the amount of substance, and consequently the depredations of corrosion are very dangerous. This has on the one hand vitalized the search for non-corrosive alloys, and on the other hand increased the demand for light and effective protective coverings.

The author ventures to say that the needs of aviation have provided the main incentive for the production of the strong alloys of aluminum, commonly referred to as "duralumin." This word is actually a trade name, but it has come to be used as a descriptive name for a large family of copper-aluminum alloys. Research on these alloys has been, and still is most intense, and materials of this class are being increasingly used outside the aviation circle, notably for large highway vehicles, such as tank trucks, whose gross weight is seriously restricted by state and provincial highway laws.

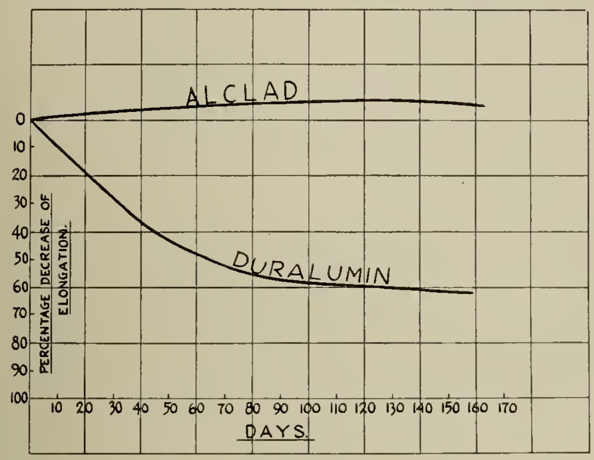


Fig. 12

Some years ago serious fears were widely entertained that duralumin would be useless as a structural material, because it seemed to be subject to a malignant form of intercrystalline corrosion. Such a useful material could not be left to die without strenuous efforts to save it, and these were rewarded after four or five years of research by the effective laying of the ghost. Everything from the composition of the alloy to its manufacture, heat treatment and subsequent processing into the finished article was critically examined with reference to the possible effect on the corrosion resisting properties, and the store of knowledge concerning the phenomena of corrosion has thereby been generously swelled.

The search for protective coatings for "duralumin" led to the production of a proprietary material known as "Alclad," which consists of a copper aluminum alloy coated with pure aluminum on each surface (Fig. 12). This coating is not a deposited one, but is introduced in the original cast of the ingot. The function of the pure aluminum is to provide electrolytic protection for the underlying material, and reasonable abrasion of the surface does not impair the protective qualities. This principle of an "electrolytic sandwich" is now being applied to steels, and will have a big sphere of usefulness, where the expense of using full blown stainless steels would be prohibitive.

Fatigue.—The fatigue properties of a material are an important criterion on which judgment for aircraft suitability is made and government aeronautical research laboratories, as well as those of the metallurgical industries, and of universities, have concentrated on this subject for several years. The effect of amplitude, the effect of cycle frequency, of electro-deposited coatings, of simple stresses and of combined stresses; fatigue at high temperature and at low temperature and in the presence of corrosive agents; all have been studied with instructive results. The deleterious action of corrosive agents, such as pickling liquids, on the fatigue properties of low and medium carbon steels is serious, amounting in some cases to 16 per cent reduction in fatigue strength.

The National Physical laboratories in England have for several years been working on large single crystals of metals, in order to get at the basic phenomena of fatigue.

Technique.—Aeronautical research has included many methods of fabrication and technical processes within its field. Among these may be included the study of welded joints in aircraft materials, the permanence of dimensions of heat treated light alloys, the elimination of gaseous inclusions in Y alloy castings for crankcases, and the modification of the nitriding process for hardening steels to make it applicable to a wider range of steels.

This section on materials cannot be concluded without mention of several useful extensions to the theory of structures, such as the strength of tubular columns subjected to combined flexural and axial stresses, the column strength and shear strength of thin plates, the strength under flexure torsion and axial load of "monocoque" or shell-like structures, and finally the complicated analysis of redundant frames like those of a rigid airship.

Conclusion

Earlier in this paper the author proposed to select researches of possible interest to engineers in general. It is a significant fact that those selected happen to include most of the more important from an aeronautical point of view, and this should serve to demonstrate that there is today no real necessity to make any distinction between aeronautical research and any other scientific research. It is the author's opinion that many of the distinctions and barriers which now exist could be broken down with benefit to science in all its forms. The very multiplicity of series and of form of presentation of scientific reports creates a physical barrier to effective reading, which is particularly serious to those who have not large library facilities at their command. The researches mentioned in this paper are mostly included in the reports and memoranda series of the Associate Air Research Committee of Great Britain, and in the technical report series of the National Advisory Committee for Aeronautics of the United States, and there is little or no reason why a number of them should be confined to aeronautic publications. A good step towards simplification would be made if the reports of all publicly financed scientific work were published in a uniform manner in a single series.

It is difficult in a paper of this sort to avoid a catalogue style, but the author hopes that he has presented an impression of aeronautical research which will be of sufficient interest to arouse the reader's curiosity, and inspire in him the desire to learn in greater detail what aeronautical research has to exchange.

Acknowledgment: Figs. 1 to 10 inclusive are reproduced by kind permission of the National Advisory Committee for Aeronautics and Figs. 11 and 12 through the courtesy of the National Research Council of Canada.

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Engineers' English

An inquiry was recently carried out by one of the largest industrial organizations in the United States in an endeavour to find out from the engineers in their employment, and from their superior officers, the extent to which the duties of the younger men involved written or oral expression. It was also desired to ascertain whether difficulty was found in doing work of this kind satisfactorily, and in what directions improvement was desirable. The replies in general indicated that the use of the English language occupied a very substantial part of the time of these young engineers, that in many cases difficulty was experienced, and that in their opinion it would have been better had more emphasis been placed on instruction in English during their college days. Quite a number found it hard to express the results of their engineering work, either in written reports or verbally. The work of a few seemed open to criticism, as lacking clarity, correctness of expression, and logical arrangement. Those who had had academic training in addition to an engineering course, generally had a better choice of words, showed more tendency towards brevity, and were more interesting and forceful in their presentations.

This inquiry was carried out under service conditions, and its results are instructive as regards the use of English by our younger engineers. The writing of really good technical articles or reports is not easy, even for those who have had considerable practice, and the results of the inquiry should by no means discourage those who have for years been urging the importance of the subject. It seems more natural for an engineer to express himself by mathematical or graphical means than in writing articles. In fact many engineers are better able to deal with materials or kilowatt hours than with words.

In preparing a report or a technical paper it is necessary to do more than merely make the proper selection from the data and figures available. The facts must be clearly set forth with proper explanations and arguments, and marshalled in due order. The manner in which they should be presented requires consideration, for this depends on the purpose to be served, the kind of readers or audience, and the amount of detail desirable. The length of the article is of first importance, particularly if it is to fall into the clutches of an editor. An engineer who has been in the editing business for years, and should know, tells us that "editors are ruthless folk. If they are not born with an element of ruthlessness in their natures they soon acquire it in the practice of their vocation. Shears, paste pot, and the blue pencil are the symbols of their craft. Exercising their prerogative of expressing themselves as they see fit in their own editorials and special columns, they change, cut and delete the literary products of others with what their contributors must frequently believe to be a truly fiendish glee*."

We agree with Mr. Stetson that the editor's joy in cutting and destroying exists only in the contributors' imagination, and heartily support him when he insists on brevity in technical writing. Fortunately for the authors, editors are not really so formidable as he would have us think, but the waste paper basket is always near the editorial desk. How seldom do authors bear in mind that the printing of their compositions, if they are to attain the dignity of print, must be paid for, and that the cost per page has no relation to the technical or literary value of the matter printed. The driest disquisition costs the same per line as a concise article full of well presented information. What is known as fine writing has no place in a technical paper. The fewer long-winded sentences, and the simpler their construction, the better.

Passing to another topic, it is surprising to note the results which can be achieved with a limited but well chosen vocabulary. The advocates of Basic English, who hope that their simplified language will some day be used all over the world, state that the average educated user of English has over twenty thousand words at his command. They assure us that with proper use, the eight hundred and fifty words which they have selected as "basic" will do all the work of the larger vocabulary. It is true that they also permit the use of fifty additional words for each special branch of science or technology, and another hundred for general scientific purposes, but even with these additions there is a great contrast between the two lists. Apparently we do not really need to use our present multitude of words, for articles written in Basic seem quite easy to understand, if we may judge from the examples available. Whether the compilers of the Basic Dictionary are right or not, there is no doubt that clear English can be written without sprinkling the page with unusual words and without dredging the dictionary for adjectives. Technical writing requires practice, and the study of guiding ideas such as those set forth in the pithy sentences of Mr. Stetson's article.

Few engineers realize that their written and spoken communications with their professional brethren or employers form the basis of their reputation with their associates and with the public. The publicity resulting from the presentation and discussion of a technical paper is legitimate and commendable. To put it bluntly, there is considerable personal advertising value in a first rate paper, when presented before an engineering society and then printed, circulated and discussed. Why, then, are so many members reluctant to put their professional experience and knowledge on record, and, by contributing papers to Branch and Institute meetings or to the Journal, help to facilitate "the acquirement and interchange of professional knowledge."

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*G. A. Stetson, "The Art of Technical Writing", Journal of Engineering Education, February, 1933.

The Past-Presidents' Prize 1932-1933

The subject prescribed by Council for this competition for the prize year July 1st, 1932, to June 30th, 1933, is **"The Relations of Economics to Engineering."**

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 no 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 the Council at the beginning of the prize year, which shall be July first 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 during the prize year by the General Secretary of The Institute, either direct from the author or through a local Branch.

Students' and Juniors' Prizes

Students and Juniors of The Institute are reminded that five prizes, each of the value of twenty-five dollars, may be awarded to Students and Juniors of The Institute for the prize year 1932-1933 as follows:

The H. N. Ruttan Prize in the four Western Provinces.

The John Galbraith Prize in the Province of Ontario.

The Phelps Johnson Prize for an English Student or Junior in the Province of Quebec.

The Ernest Marceau Prize for a French Student or Junior in the Province of Quebec.

The Martin Murphy Prize in the Maritime Provinces.

Papers in competition for these prizes must be received by Branch secretaries before June 30th, 1933. Further information as to the requirements and rules may be obtained from the General Secretary.

Meeting of Council

A meeting of Council was held at Headquarters on Friday, February 24th, 1933, at eight o'clock p.m., with President O. O. Lefebvre, M.E.I.C., in the chair, and eight other members of Council present.

The Secretary presented a report of the conference of the representatives of the construction industry held in Toronto on February 6th, 7th and 8th, 1933, sponsored by the Royal Architectural Institute of Canada, The Engineering Institute of Canada, and the Canadian Construction Association. Eighteen organizations were represented at this meeting, at which the problems of the construction industry had been discussed, and a number of resolutions adopted looking to a definite plan for its revival. These resolutions had now been forwarded to the Prime Minister with a request that he meet a small committee from the conference to discuss them. It had also been decided to form a permanent body to be known as the National Construction Council of Canada to carry on the work of the conference.

The Secretary's statement was considered, and after discussion, during which appreciation of the work of the conference was evident, the Secretary was directed to send a letter to the Prime Minister expressing the hope that he would give the conference resolutions his serious consideration, and, if at all possible, arrange for a meeting with the committee to discuss them.

With regard to the request of the Halifax Branch for permission to hold a Professional Meeting at Liverpool, N.S., during the last week of July or the first week of August, it was unanimously resolved that permission be granted for the holding of such a meeting, on the understanding that that Branch would have the co-operation of the other Maritime Province Branches. The Council was also pleased to note that the co-operation of the Associations of Professional Engineers in Nova Scotia and New Brunswick is expected.

Discussion followed regarding the proposed Plenary Meeting of Council to consider the report of the Committee on Development and the discussion on that Committee's work which took place at the Annual Meeting. It was felt that in view of the preparatory work necessary this meeting could not in any case be convened until the end of September, and the Secretary was directed to write to the various Branches to ascertain their views regarding the matter.

As regards the Committee on Development, it was decided that this committee be discharged, and a small committee of Council consisting of Messrs. J. L. Busfield, M.E.I.C., chairman, H. Cimon, M.E.I.C., C. S. L. Hertzberg, M.E.I.C., and P. L. Pratley, M.E.I.C., was appointed to take over its work and the communications which had been addressed to it, and prepare a report for discussion at the Plenary Meeting.

In considering the budget for 1933, the chairman of the Finance Committee pointed out that in view of the shrinkage in The Institute's revenue, expenses must be further curtailed if the budget was to be balanced. Discussion followed, as a result of which it was resolved to approve the budget as presented by the Finance Committee but with a further reduction in the salaries of the staff.

It was noted that L. H. Robinson, M.E.I.C., member of Council for the Moncton Branch, had been moved to Halifax and had therefore resigned as councillor. Nominations for the vacancy having been received from the Executive committee of the Moncton Branch, in accordance with Section 13 of the By-laws, it was unanimously resolved that H. J. Crudge, A.M.E.I.C., be appointed councillor representing the Moncton Branch until the next annual election of officers.

The membership of the Finance Committee, as selected by the chairman and approved by the President, was noted as follows:

J. L. Busfield, M.E.I.C., Chairman
J. B. Challies, M.E.I.C., Treasurer
A. Duperron, M.E.I.C.
F. Newell, M.E.I.C.
P. L. Pratley, M.E.I.C.

The membership of the following standing committees, as submitted by the chairmen, was approved as follows:

Library and House Committee:
D. C. Tennant, M.E.I.C., Chairman
H. Massue, A.M.E.I.C.
A. R. Roberts, A.M.E.I.C.
E. A. Ryan, M.E.I.C.
J. H. Trimingham, M.E.I.C.

Legislation Committee:
F. Newell, M.E.I.C., Chairman
C. A. Bowman, A.M.E.I.C.
A. S. Gentles, M.E.I.C.

Publication Committee:
- H. Cimon, M.E.I.C., Chairman
- J. A. Duchastel, M.E.I.C.
- A. A. MacDiarmid, M.E.I.C.
- P. L. Pratley, M.E.I.C.
- H. L. Trotter, M.E.I.C.

Papers Committee:
- J. J. Traill, M.E.I.C., Chairman
- R. B. Young, M.E.I.C., Vice-Chairman
- A. C. R. Yuill, M.E.I.C.
- R. S. Trowsdale, A.M.E.I.C.
- H. A. Lumsden, M.E.I.C.
- H. Cimon, M.E.I.C.
- K. L. Dawson, M.E.I.C.

The appointment of the medal and prize committees was held over until the April meeting of Council which will be held in Toronto, and the appointment of the Committee on Biographies and the Committee on Engineering Education until the March meeting of Council.

The following committees were re-appointed as follows:

Board of Examiners and Education:
- W. Gore, M.E.I.C., Chairman
- R. W. Angus, M.E.I.C.
- F. C. Dyer, M.E.I.C.
- J. M. Oxley, M.E.I.C.
- A. M. Reid, A.M.E.I.C.
- C. E. Sisson, M.E.I.C.

Honour Roll and War Trophies:
- C. J. Armstrong, M.E.I.C., Chairman
- A. E. Dubuc, M.E.I.C.
- F. S. Keith, M.E.I.C.
- G. E. McCuaig

In accordance with the recommendation contained in the report of the Committee on Membership that committee was discharged, and D. C. Tennant, M.E.I.C., was appointed chairman of a new Committee on Membership, with a request to submit the personnel of the committee to Council at its next meeting.

It was noted that in accordance with Council's decision at the last meeting of Council, the names of one hundred and twenty-three members, in arrears for 1932 and who had not replied to several communications regarding the matter, had been removed from the list of members as of February 7th, 1933.

Thirteen resignations were accepted, forty-six members were placed on the Suspended List for the year 1933, one Life Membership was granted, a number of special cases were dealt with, and ten Students were admitted.

The Council rose at eleven fifty p.m.

Progress Report on Proposals of the Committee on Development.

The Committee of Council which is studying the interim report of the Committee on Development with the object of preparing recommendations for discussion at the Plenary Meeting of Council has commenced its deliberations and its review of the report of the opinions presented by Branches and by individuals.

The Committee has found that in some matters there is a wide divergence of opinion, in fact some criticism touching upon the underlying principles of the re-organization of The Institute and stressing the importance of the strictly professional viewpoint and in others fairly universal approval. It is obvious therefore that any recommendations that can be made must be in the nature of a compromise, not only between the opinions of individuals, but between the opinions of the various Branch executives. It is hoped, however, that in such compromise a result will be reached that will be satisfactory and beneficial to The Institute and its members.

In order to explore the whole situation in a logical manner the Committee decided to consider the subject under certain definite heads, taking one at a time and finally co-relating them in such manner as may be necessary. For example, one main division is the broad subject of the classes of membership, another is the qualifications for the classes, another is the fees, another is the objects, another is management and so forth.

As a starting point, and perhaps because it was an easy subject owing to the comparatively small divergence of opinion the subject of classes of membership was taken up. The original interim report of the Committee on Development recommended—Hon. Members, Fellows, Members, Juniors and Associates. This was subsequently modified by omitting Fellows, owing to considerable objection either to the class as such or to the proposed method of election. The broad principle of only one class of member, in other words the abandoning of the differentiation between Members and Associate Members has received very general approval. On the other hand, while there has been much approval for the class of Associate there has also been considerable objection.

The Committee is therefore of the opinion that it should recommend to Council in due course, the following classes:—

Hon. Member—as at present defined.
Member —qualification yet to be discussed.
Junior —qualification yet to be discussed.
Affiliate —very much as at present, but with a lower entrance and annual fee.

The later recommendation definitely being a compromise between divergent views.

The Work of the Committee on Membership

The attention of members of The Institute has recently been called to the fact that there are no doubt many engineers who are qualified for admission but who do not apply because they are already members of some other technical society or because they fail to see the desirability of membership or for various other reasons.

As all members will appreciate, the success of any movement to attract new members must lie very largely in the hands of the members themselves. Again, there are undoubtedly many present members entitled to a higher class of membership who have not thought of applying for suitable transfer.

With a view to canvassing the situation, Council, at its last meeting, appointed a special committee on Membership of which the chairman is D. C. Tennant, M.E.I.C., assisted by Dr. A. Frigon, M.E.I.C., F. S. B. Heward, A.M.E.I.C., and C. K. McLeod, A.M.E.I.C., with power to add to their number as may be necessary.

The plan which this committee proposes is to arrange that there will be available at least one member in each branch who is willing to co-operate in all matters relating to membership throughout the territory covered by his branch and, in this connection, the President of The Institute has very kindly consented personally to arrange for suitable appointees on the occasion of his forthcoming visits to all the branches.

When this step has been accomplished it is proposed to write each member of The Institute a reminder on this subject of membership which will briefly summarize the advantages offered by The Institute and will also be accompanied by a convenient form, carrying the name and address of the nearest Branch Representative on Membership, which the member will be invited to fill in, giving the names of any of his friends who he considers might be interested and qualified for membership or, if already members, might like to be transferred to a higher class of membership.

Once these forms are returned, members may rest assured they will receive prompt attention and in due course it is hoped a further and substantial growth in the membership of The Institute will result.

OBITUARIES

Maurice J. Leahy, M.E.I.C.

The death is recorded at New York, N.Y. on January 27th, 1933, of Maurice J. Leahy, M.E.I.C.

Mr. Leahy was born at Holyoke, Mass., on April 3rd, 1880, and was educated at Dartmouth College and the Thayer School of Civil Engineering, receiving the degree of C.E. from the latter institution in 1903. Following graduation Mr. Leahy joined the staff of Mr. George F. Hardy, mill architect and hydraulic engineer, New York, and remained with Mr. Hardy for a number of years, acting as engineer in charge of the construction of paper and pulp mills in the United States and Canada.

Prior to his death Mr. Leahy was for some time engaged in private practice in New York.

Mr. Leahy became a Member of The Institute (then the Canadian Society of Civil Engineers) on April 20th, 1915.

Sir Henry Worth Thornton

The death in New York on March 14th, 1933 of Sir Henry Worth Thornton, former chairman of the Board of the Canadian National Railways, Montreal, closed a notable career.

Born at Logansport, Ind., on November 6th, 1871, he graduated from the University of Pennsylvania with the degree of B.Sc. in 1894.

In the same year he began his railroad career with the Pennsylvania Railroad as draughtsman in the chief engineer's office, and held successively the positions of assistant engineer of construction on the Cleveland and Marietta Railway, topographer on various surveys, assistant of engineering corps, division engineer and division superintendent. In 1911 he was made general superintendent of the Long Island Railroad, which had been acquired by the Pennsylvania Railway. In this capacity, Sir Henry had much to do with the opening of the Pennsylvania Railway terminal in New York, and the organization of the electrical train service on the Long Island Railway. While employed as assistant in the engineer corps of the Pennsylvania Railway, Sir Henry was selected to develop a students' course in transportation, and worked in every department of the railroad for a sufficient time to become familiar with its operation.

In 1914 he was called to England as general manager of the Great Eastern Railway. When war broke out in 1914, that railway, serving the east coast, became an important military line of communication and Sir Henry was made a member of the executive committee of general managers, which under the direction of the government, controlled and worked all the English railroads. In 1916 Sir Henry was made deputy director of inland water transportation, with the rank of Colonel in the Royal Engineers. In 1917 he was sent to Paris as assistant director general of the movements of the railways, and in that capacity, represented the director general and the Army Council in negotiations with the French, Italian and American governments relating to transportation. In December 1917, he was promoted to director-general with the rank of Brigadier-General, and in 1918, was made inspector-general of transportation, with the rank of Major-General.

Sir Henry came to Canada in 1922 to assume the presidency of the Canadian National Railways, which office he filled until his retirement in July 1932.

Sir Henry was naturalized as a British subject in March, 1919, and in May of the same year, was gazetted a Knight Commander of the Order of the British Empire. He was also a Commander of the Legion of Honour in France, Officer of the Order of Leopold of the Belgians, and holder of the Distinguished Service Medal conferred by the American government. In 1929 he received from the King of Norway the Order of St. Olav.

Sir Henry was a member of the Institution of Civil Engineers, the Institute of Transportation and the American Society of Mechanical Engineers.

He became a Member of The Institute on September 23rd, 1924.

PERSONALS

D. A. Ross, M.E.I.C., a member of the firm of Pratt and Ross, consulting engineers and architects, Winnipeg, has been appointed a member of the Assessment Board for the city of Winnipeg.

Walter G. Hunt, M.E.I.C., president and managing director of Walter G. Hunt Company, Ltd., Montreal, was recently elected vice-president of the Builders Exchange Inc., of Montreal, and chairman of the General Contractors Section.

J. W. Sanger, A.M.E.I.C., chief engineer of the Winnipeg Hydro-Electric System, Winnipeg, Man., was elected president of the Manitoba Association of Professional Engineers at the Annual Meeting of that Association held on January 19th, 1933.

A. U. Sanderson, A.M.E.I.C., assistant mechanical and electrical engineer, Department of Works of the City of Toronto, Ont., was elected chairman of the Canadian section of the American Waterworks Association at the annual business meeting of the Association held in Montreal on March 24th, 1933.

J. P. Fraser, A.M.E.I.C., has been appointed statistical engineer of the Manitoba Power Commission, Winnipeg, Man. Mr. Fraser, graduated from the University of Manitoba in 1914 with the degree of B.E.E. and following graduation, joined the staff of the Canadian Westinghouse Company as an engineering apprentice, remaining with that firm until 1929 when he became electrical engineer with the Northwestern Power Company at Winnipeg.

ELECTIONS AND TRANSFERS

At the meeting of Council held on March 21st, 1933, the following elections and transfers were effected:

Member

KINGHORN, Andrew A., B.A.Sc., (Univ. of Toronto), president and manager, Kinghorn Construction Co. Ltd., Toronto, Ont.

Associate Members

COGDELL, Herbert, (Liverpool Technical School), vice-president, National Supply Co. Ltd., Montreal, Que.

CROUCH, Milton Edwin, C.E., (Univ. of Toronto), private practice, Kingston, Ont.

Junior

TYSON, Albert Edmund, B.A.Sc., (Univ. of Toronto), engr. in charge of plant erection, Rayner Construction Ltd., Leaside, Ont.

Transferred from the class of Junior to that of Associate Member

CREGEEN, Kenneth Thomas, B.Sc., (McGill Univ.), res. engr., in charge of building operation and plant, Sun Life Assurance Company of Canada, Montreal, Que.

CROSS, George Esplin, B.Sc., (McGill Univ.), professor at Montreal Technical School, Montreal, Que.

LLOYD, David S., B.A.Sc., (Univ. of Toronto), service engr., Dominion Oxygen Co. Ltd., Toronto, Ont.

MILLS, Charles Perkins, B.Sc., (McGill Univ.), industrial engr., Ebro Irrigation & Power Company, Barcelona, Spain.

Transferred from the class of Student to that of Junior

WILLIAMS, Richard Louis, B.Sc., (McGill Univ.), 159—24th Ave., Lachine, Que.

Students Admitted

BARNHOUSE, Frank William, (Univ. of Alta.), 10658—104th St., Edmonton, Alta.

BRAINE, Arthur Wentworth, B.Sc. (Forestry), (Univ. of N.B.), 3800 Dewdney Ave., Regina, Sask.

ELLIOTT, Lisgar Webster, (Univ. of Alta.), 9639—105th St., Edmonton, Alta.

GOLD, William John, (Univ. of Alta.), 11208—126th St., Edmonton, Alta.

GORDON, Hugh John, (McGill Univ.), 772 Sherbrooke St. W., Montreal, Que.

McMULLEN, William Francis, (Univ. of Toronto), 132 Close Ave., Toronto, Ont.

NEWMAN, William Cyril, (Univ. of Alta.), Lloydminster, Sask.

OUTHOUSE, Holland Wilbur, B.Sc., (N.S.T.C.), Halifax, N.S.

PILKEY, Gordon Everett, (Queen's Univ.), Myrtle Station, Ont.

PITFIELD, Barclay Wallace, (Univ. of Alta.), 10214-125th St., Edmonton, Alta.

RYLAND, Herman Gugy, (Laval Univ., Quebec), 9 St. Hubert St., Shawinigan Falls, Que.

SANGSTER, Andrew Gordon, (Grad. R.M.C.), (McGill Univ.), 100 Drummond St., Sherbrooke, Que.

SINCLAIR, George, (Univ. of Alta.), 12123—97th St., Edmonton, Alta.

STEWART, Duncan Edward, (Queen's Univ.), Waba, Ont.

STEWART, Walter Duncan, (Queen's Univ.), Lennoxville, Que.

SWIFT, John William, (McGill Univ.), 642 Belmont Avenue, Westmount, Que.

TINKLER, Howard H., (McGill Univ.), 3474 deBullion St., Montreal, Que.

WEBB, David Roland, (Univ. of N.B.), 89 Victoria St., Saint John, N.B.

WILLIAMS, David Gabb, (Univ. of Alta.), 10152—113th St., Edmonton, Alta.

RECENT ADDITIONS TO THE LIBRARY

Proceedings, Transactions, etc.

The Society of Engineers, Transactions for 1932.
Royal Society of Edinburgh, Proceedings, Vol. LII, part 5 and Vol. LIII, part 1.
Institution of Civil Engineers, List of Members, January, 1933.
City Manager Yearbook, 1933.
National Research Council of Canada; A statement on the work of the National Research Council, February, 1933.
Consolidated List of Government Publications, H.M. Stationery Office, 1932.

Reports, etc.

Dept. of Mines, Mines Branch, Canada:
Geological Survey (Map) Kenora, Ont.
Peat, Lignite and Coal (1914).
The Department of Mines, Its Organization, The Services it Performs.

Department of Trade and Commerce, Bureau of Statistics, Canada:
Preliminary Report, Central Electric Station Industry in Canada, 1931.

Department of the Interior, Canada:
Geodetic Publication No. 29—Triangulation in Southwestern Ontario.

American Railway Association:
American Railway Signaling Principles and Practices; Chap. 14, Definitions; Chap. 17, Mechanical and Electro-Mechanical Interlocking; Chap. 20, Interlocking Circuits.

Technical Books, etc., Received

C.E.S.A. Canadian Electrical Code, Part 2, Specification No. 3. Construction and Test of Electrical Equipment for Oil-Burning Apparatus. *Presented by Canadian Engineering Standards Association.*
Canadian Railway Development from the Earliest Times, by Norman Thompson and Major J. H. Edgar. *Presented by MacMillan Co. of Canada.*
Modern Materials Handling, 1933, by S. J. Koshkin. *Presented by Wiley and Sons.*
Market Data Book, 1933. *Presented by Class and Industrial Marketing, Chicago.*
Summary of the Trade of Canada. *Presented by the Dominion Bureau of Statistics.*
Edward Orton Jr., A Memorial. *Presented by the Engineering Experiment Station, Ohio State University.*

BULLETINS

Lubrication—The Tide Water Oil Company, New York, N.Y. have recently issued a 112-page manual on lubrication and fuel. This manual is well illustrated and contains a considerable amount of data on lubrication problems for numerous types of vehicles, laboratory tests of oil, greases, gasoline, etc., conversion tables, weights and measures, etc.

Excavators—A four-page folder has been received from Priestman Brothers, Limited, London, England—agents for Canada, Busfield, McLeod, Ltd., Montreal—describing and illustrating their new one-quarter cubic yard "Cub" excavator and its uses.

Surface Waterproofing—A four-page booklet has been received from The Master Builders Company, Cleveland, Ohio, containing data regarding their new all-weather surface water-proofing. This may be applied to either wet or dry surfaces at any temperature above 32 degrees.

Alloyed Cast Irons—An eight-page booklet has been received from the Robert Mitchell Company Ltd., Montreal, describing special applications for alloyed cast irons.

Low Speed Geared Motor Units—Lancashire Dynamo and Crypto Co. of Canada Limited have recently issued a four-page circular describing the manufacture and application of low speed geared motor units.

CORRESPONDENCE

March 14th, 1933

The Editor,
The Engineering Journal,
Montreal, Que.

Dear Sir,

In the discussion on a paper by Mr. G. L. Wiggs, A.M.E.I.C., (Engineering Journal, March 1933) there appears a contribution from Mr. Karel R. Rybka, A.M.E.I.C., referring to my tests on radiators, and citing certain results by Rietschel, Brabbée and others.

I must point out that my results on the ordinary cast iron radiators differ from those of the authors mentioned above in that I do not find any difference between the heat transmissions from steam and water *in those cases.* In confirmation of this I am sending (under separate cover) Bulletin No. 9 Section No. 2 of the School of Engineering Research, University of Toronto. Figures 5 and 6 show the tests made on ordinary cast iron radiators, both bare and enclosed. There are no breaks in any of the curves when the transition from steam to water takes place. Further investigation has indicated that the discrepancies in the results obtained on concealed radiators is a function of their heights and that if the height exceeds about 10 inches there is little difference in the two results. The low water velocity is also a controlling factor.

The reason for the large differences that occur with radiators of the finned type has been fairly conclusively proved to be due to the difference in surface coefficients, as Mr. Rybka indicates. The temperature difference between the heating fluid and the outside of the tubes is much greater in the case of water than where steam is used.

The evidence in this connection, together with the results of many other tests, will be published within the next few months.

Yours faithfully,

E. A. ALLCUT, M.E.I.C.,
Professor of Mechanical Engineering,
University of Toronto.

Employment Control

Abstract of a paper presented before the Montreal Branch of The Engineering Institute of Canada on January 26th, 1933
by Gordon McL. Pitts, A.M.E.I.C.

At a meeting of the Montreal Branch held early in the year, it was suggested that some expression should be recorded by The Institute as to the manner in which the present employment situation, especially with regard to the technically trained, was being dealt with by the government and suggestions were asked for.

With this in mind, the author observed that the present crisis was a national emergency, the whole country's resources should be martialed to combat its effects as in 1914.

In that emergency, the government provided men with clothing, food, shelter, transportation, equipment, medical care and munition in great quantities. These operations were placed in the hands of capable administrators. To-day a large portion of the population is pressed under economic conditions similar to the conditions of war.

It has been found that the agencies for providing relief were inadequate to deal with the burdens placed upon them, and governments, Federal, provincial and municipal, promoted the idea of government subsidy through the construction of public works as a means of relief for unemployment. These schemes proved expensive, the relief obtained insignificant, so that the idea has largely been abandoned.

An Unemployment Relief Act in 1930, an Unemployment and Farm Relief Act in 1931, and an Unemployment Relief Act in May, 1932 provided for various expenditures whereby contributions were made by the several governments. Notwithstanding the provisions of these acts, unemployment became an increasingly serious problem and the advisability of the continuance of relieving unemployment by the methods in the foregoing acts is very seriously questioned.

The present acute state of this depression was not an appropriate time to launch complicated unemployment insurance programmes, which required the setting up of reserves. To meet the emergency, it was suggested that a national scheme of unemployment relief should be undertaken which would be a temporary policy to meet the present situation.

It must be a sincere effort in which the resources of the country were scientifically and economically mobilized to definitely obtain a certain objective in the most direct manner and in the shortest space of time. Petty politics and sectionalism must be eradicated. Such a scheme must be designed to stimulate the national spirit and pride of every citizen who took part in the enterprise through his conviction that he was making a contribution to the national welfare.

To this end, the government should provide for the formation of what might be designated as "A National Service Corps," organized under the department of the government best suited to undertake its direction and maintenance. This corps would be voluntarily recruited from all classes of citizens who were not employed, and would include technical, semi-technical men, skilled artisans and unskilled labour.

It should have a definite system of organization and administration and a nominal wage scale, and the government should provide for the complete maintenance of the individual. The men of higher qualifications and experience should be entrusted with the planning and executive work of the corps, and the others adjusted into the scheme in relation to their capabilities and experience.

The work of this corps should be the carrying out of developments of public character, Federal, provincial or municipal, which could be shown to have great future value to the community, but which it would be impossible for the community to provide by any normal activity, or expenditure within the period of the next ten years. For example, under its provisions and direction abandoned farm lands could be reclaimed and developed. In as far as practical that section of the corps employed in any one province, should be recruited from that locality. In the case of married men, a separation allowance should be provided. Only men of Canadian domicile should be included under this scheme and the recruiting should be entirely voluntary, but certain rules and regulations should be drawn whereby a man could be discharged from the corps on certain definite grounds, prejudicial to the interests of the corps and of the community. A man so released could not again be recruited. Also, regulations should provide that a man may be discharged from the corps upon his own application, provided he could show that he had obtained a reasonably permanent situation in industrial or other works, or had some means of support. Aged and infirm men should be cared for by the municipality or province.

Such a scheme should be Dominion-wide in its scope and not a half-hearted local or provincial effort. It should be a real, honest and practical effort by the Dominion government to end unemployment and to provide consistent and respectable work for our citizens. It should be financed from the consolidated funds of the country and the necessary temporary taxes applied to maintain it. Such an effort would have the effect of stabilizing normal labour conditions by removing from the sphere of labour the pressure of a considerable number of unorganized unemployed. This in itself would have a tendency to stimulate prosperity. It would maintain the morale of the population generally, as the constructive work thereby provided was a direct contribution by the individual to the nation of his effort and labour at a very reduced cost.

All questionable forms of contract manipulation, local patronage and other inherent evils of present employment relief schemes, would be definitely removed. The work itself, as carried out by this National Corps would add to our national well-being and stimulate the return of more prosperous conditions by carrying out developments which would in turn provide the opportunity for and encourage private investment. It would stimulate business by the circulation of money in normal channels, through the purchase of supplies to carry out the work and to feed the men, which would in turn, be reflected in all branches of organized labour. And finally, the country would get the maximum of value for the amount of money expended, in that this form of relief would cost in the neighbourhood of $1.47 per man as compared with the previous schemes of relief work which have run as high as $7.00 per man.

This was the finest example of the utilization of latent human energy which forms one of the tenets of the new creed of "technocracy." Honest labour was no disgrace. Technical men with university training were available to direct and plan, skilled labour to execute, and the conscientious worker to assist. Let an earnest and effective national effort be made, free from all petty politics, to maintain our citizens in self-respect, self-confidence and loyalty, during this period of great national emergency.

BRANCH NEWS

Kingston Branch

L. F. Grant, M.E.I.C., Secretary-Treasurer.

A joint meeting of the Kingston Branch and of The Engineering Society was held on Thursday, February 9th. The speaker was Mr. G. C. Monture, of the Mines Branch, Ottawa, and the subject "Writing for Engineers."

Writing for Engineers

Mr. Monture pointed out the importance to engineers of a measure of writing ability, and regretted that the attitude of most of the profession was to ignore this feature of work in the natural anxiety to complete the actual job. Writing is man's only means of communicating with most of his fellows, and inability to express himself well upon paper places any professional man under a severe handicap.

Considering the exactness demanded by his work, the engineer as a writer, is generally surprisingly careless, and comparitively few scientific papers are satisfactory considered on their literary merits.

The ordinary man reads for one of three purposes: to obtain information, to absorb or criticize propaganda, and for entertainment. Only the first of these is concerned with technical writing. The technical writer should therefore put himself in the position of the man reading for information, and should try to write as he would wish to read. It follows that the requirements are accuracy, clarity, and conciseness.

Correctness depends on the industry and judgment of the writer himself. Lack of clarity is generally caused by hazy thinking. Conciseness may be overdone, but this fault is unusual.

A plan and title of the article should be thought out before writing begins, and the title should be a short one. Information should then be sorted out and each item written on a separate piece of paper. These may be arranged in the proper order, and it will generally be found that this process will result in discarding many irrelevant and superfluous items.

The writing may now begin. The writer should avoid pretentious words, and verbosity, which Mr. Monture defined as the art of saying a great deal about nothing. The writer should be sure of the exact shade of meaning of each word he uses. In general he should write as he would talk to a senior member of the profession, remembering that what he writes may stand in print for years.

Revision gives an opportunity to polish up the work, and to view it as a whole.

Aviation To-Day

The regular monthly dinner of the Kingston Branch of The Engineering Institute of Canada was held at the Badminton Club on February 17th, after which the following talk on "Aviation To-Day" was given by Squadron-Leader G. E. Wait, R.C.A.F.

In presenting the subject of aviation it is difficult to steer a fair course between too many technicalities on one hand and too much romancing on the other. In the last twenty-five years a great deal of highly technical development has been done by physicists, mathematicians, engineers, artisans and pilots, to say nothing of the assistance given by financiers. It was therefore easy to become very technical. On the other hand, the somewhat spectacular side of aviation often made it the subject of highly-coloured and unreliable comment.

The development of the lighter-than-air craft is at present at a standstill in the British Empire, although the United States are building a ship of 6½ million cubic feet for naval use. The characteristics of lighter-than-air craft are air-keeping qualities and value for air-reconnoissance in its favour. Against it are fragility, vulnerability, lack of speed, dependence on the weather, and the excessive cost of air-ports. Its cost is about the same as that of an ocean liner, length for length, and it carries about one hundredth of the paying load. Its future is questionable.

In the heavier-than-air machines, the factors to be considered to obtain increasing performance are:

Lift from the wings, in steady level flight exactly equal and opposite to *weight;* and *thrust* from the engine, which, for steady flight, is exactly equal and opposite to *drag*. The broad principles of development are therefore to cut down weight, increase lift; and to cut down drag and increase thrust. Obviously the result must be a compromise.

Equally important to performance are the safety factors, of decreasing fire risk; increasing engine reliability; structural strength; improvement of control, navigational aids, and, as a last resort, the parachute.

In seeking for increased performance along the lines indicated above, the engine is first considered in endeavouring to increase power and at the same time decrease weight. Noise is due partly to the engine and partly to the impact of the blade tips on the air. If the engine should be entirely silenced, it would decrease noise by only about 3 per cent. In the latest types cabin walls are lagged and the exhausts carried aft, reducing the noise in the cabin to about 70 decibels, from about 100 outside. It may be noted that the talking voice gives about 40-70 decibels, and that the limit of human endurance is about 130.

Following the engine, the next consideration is the flying structure, the effort being to decrease weight and drag and to increase lifting power. In the first of these objects, the use of the new aluminum alloys has been of great assistance.

The problem of decreasing the drag is mainly one of streamlining the body, smoothing the airflow and eliminating eddies.

Lift is increased by improving wing sections, all of which are now developed mathematically.

The essential of stability may be next considered. In all airfoils the lift, within normal speeds, varies as V^2. At less than 45 m.p.h. however, this relationship breaks down and brings about the condition of the "stall," the danger point in flying. This cannot be eliminated, but it can be flattened out over a wider range of flying by introducing small auxiliary airfoils along the leading edges of the wings. These smooth out the airflow at low speeds, and help to give lateral control at the stalling speed. These were developed in England by Handley Page, and are now on all commercial and many service types.

Navigation consists in getting from A to B, and the only real obstacles are fog and bad visibility. The best of pilots cannot maintain direction in a fog without special instruments. The solution is the use of the gyroscope, which is very sensitive and enables the pilot to fly "blind" indefinitely. The Royal Air Force has developed the gyro automatic pilot, which is a gyro geared to aeroplane controls by valves, relays, and servo-motors.

Ground aids include radio beacons, which tell the pilot whether he is on his course, and if not on which side he is, and whether he is pointing in the right direction. Air routes require landing grounds within aircraft range of one another and depots every 1,000 miles. Fuel supply is a simple matter in countries where rail or water transportation is available, but aircraft cannot carry enough weight to be themselves depot layers.

In conclusion, it is a matter of pride to note that the three outstanding aerial records are all held in Great Britain, namely:

Speed—407.5 m.p.h. (Schneider Cup, 1931.)
Height—43,976 feet. Westland Wallace 1932.
Distance—5,340 miles in 57½ hours, England to South Africa, 1933.

Lethbridge Branch

E. A. Lawrence, S.E.I.C., Secretary-Treasurer.
Wm. Meldrum, A.M.E.I.C., Branch News Editor.

The Annual District meeting of the Association of Professional Engineers of Alberta was held jointly with that of the Lethbridge Branch of The Engineering Institute of Canada, on Saturday, February 4th, 1933, at the Marquis hotel. The speaker of the evening was H. J. MacLeod, M.Sc., M.A., Ph.D., R.P.E., M.E.I.C., professor of electrical engineering at the University of Alberta. The meeting was presided over by Wm. Meldrum, A.M.E.I.C., chairman of the Lethbridge Branch, together with J. D. Baker, Deputy Minister of Telephones, and vice-president of the Association of Professional Engineers.

Following the dinner, an excellent musical programme organized by J. Haimes, A.M.E.I.C., was given, and during dinner, George Brown's orchestra presented their usual programme of enjoyable music and community singing took place. Vocal solos were given by Messrs. G. Evans, R. S. Lawrence and T. Smith, and two excellent violin numbers by Mr. Mac Moscovitch, Mrs. Georges Brown accompanying.

After introduction by the chairman, Mr. Baker gave a brief account of the work being done by the Association of Professional Engineers and of certain proposals which will be brought before its Annual Meeting in March. At the close of his remarks, Mr. Baker introduced the guest speaker, Dr. H. J. MacLeod, who gave an address on the Conquest of Distance.

The Conquest of Distance

In this, Dr. MacLeod's first topic was the extent to which man has been able to develop new means of communication and vision, and through the resulting conquest of time and space, to look upon the world in truer perspective. These developments have had a profound effect on modern life.

Referring to the "island universes" in space, separated from us by thousands of light-years, he drew attention to the changes which are going on in our own universe. The oldest rocks in our earth, said Dr. MacLeod, were laid down some twelve hundred million years ago, a period compared with which the time of man's existence on earth is very brief. Illustrating the mental equipment of mankind in early days, he spoke of the achievements four thousand years ago of the Egyptians in the construction and orientation of the Great Pyramid and in the vast irrigation works which kept famine away.

Our civilization, to-day, differs fundamentally from that of earlier times owing to the conquest of nature by modern science, an outward rather than an inward change.

In spite of wonderful material developments, equal progress has not been made in social advancement; the world at the present time has a good system of nerves and arteries but no central brain. Dr. MacLeod remarked that we now have power to produce all the comforts and conveniences which individuals or nations require, but nations are still living in fear of each other, and by individual action are interrupting that flow of trade which is the life blood of the world. Man must be given an opportunity to work, and he felt that by depending too much upon governmental action for initiating remedial measures we are going in the wrong direction.

Dr. MacLeod believed that the results of scientific and industrial progress have produced in mankind a materialistic point of view. During the period of prosperity we have forgotten the things of real value in life, and come to believe that money is the main object of existence, and that the man who makes money is the only man who is really successful. In his opinion the pleasure obtained from the development of the mind is the only thing that gives real value to life.

Mr. D. H. Elton, speaking on behalf of the visitors, expressed their thanks to Dr. MacLeod for his thoughtful address. The thanks of the Association of Professional Engineers and the Lethbridge Branch of The Institute were tendered to the speaker by Mr. H. Wm. Meech.

Architecture

The regular meeting of the Lethbridge Branch of The Engineering Institute of Canada was held in the Marquis hotel on Saturday, February 18th. The event took the form of a Ladies' Night and the speaker of the evening was Mr. H. Wm. Meech, M.R.A.I.C., R.P.E. Wm. Meldrum, A.M.E.I.C., chairman of the Lethbridge Branch Engineering Institute of Canada, presided.

During the dinner, Geo. Brown's orchestra presented a programme of dinner music and accompanied the community singing. Following the dinner, a splendid musical programme, arranged by J. Haimes, A.M.E.I.C., was featured. Mrs. Ralph Thrall and Mrs. H. Wm. Meech were heard in vocal solos and two duets were rendered by Masters Geo. Brown and Chris. Donaldson.

In order to understand the development of the several styles of architecture and their significance, it is essential to remember certain historical events, and these, which have a distinct bearing on architecture were woven into the address as the speaker proceeded.

Continuing with a short statement on Expression in Architecture, which he hoped might assist his hearers in judging the value of a building architecturally, whether ancient or modern, Mr. Meech then particularized in certain of the world's great buildings as illustrative of the changes in style from the zenith of Greek architecture to the beginning of the Renaissance.

The three periods of Gothic architecture were dealt with in some detail. Salisbury, York, Canterbury, Wells, and other cathedrals were used to illustrate the features of each style. The changes from Early English, the first of the pointed styles, to decorated and finally to the perpendicular style were all traced.

Christopher Wren, the speaker stated, ignored the Gothic styles and sought his inspiration from the classic and so evolved and created the outstanding building of the Renaissance in St. Paul's.

The lecture was well illustrated with slides kindly loaned by the Extension Department of the University of Alberta.

At the conclusion of the address, P. M. Sauder, M.E.I.C., tendered the speaker a very hearty vote of thanks.

London Branch

W. R. Smith, 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 February 15th, 1933 in the board room of the Public Utilities Commission.

The chairman of the Branch, V. A. McKillop, A.M.E.I.C., presided. He said this meeting was a departure from the usual procedure insomuch that a special speaker had not been retained, but was to be in the nature of a discussion on matters pertaining to the Branch, and the engineering profession as a whole with the objects of improving the status of the engineer and broadening and intensifying the scope of Branch activities. Several members had agreed to lead the debate by making suggestions and pointing out where developments along the lines mentioned might be introduced. He referred to a recent conference of American engineers where it had been resolved that owing to the changing times it was necessary for engineers to get together and study and promote the economic and social end of engineering and this was in harmony with the suggestions made by Dr. Fox at our Annual meeting last month.

W. C. Miller, M.E.I.C., brought forward a matter which affected the prestige and practice of township engineers, in Ontario particularly and was a distinct encroachment on their professional rights. He referred to the employees of the Department of Agriculture, not engineers, undertaking engineering work gratuitously with results that might be expected. He mentioned several cases where appointments to the position of township engineer had been made from men who were not engineers, selected from the Agricultural College at Guelph. Some of their assessments were now before the court and in one case the technical award was entirely upset by the judge. This state of things was not fair to the engineering profession and should be taken up by the Association of Professional Engineers.

A. O. Wolff, M.E.I.C., drew attention to the necessity of engineers cultivating the social and economic side of their work with a view to leadership in facing the problems of the future. He quoted from the address of the retiring President of The Institute, S. G. Porter, M.E.I.C., delivered at the Annual general meeting in Toronto, 1932.

Recently an editorial appeared in the London Free Press on the same subject—in which it was stated that the engineer's work does not regularly bring him into contact with the public and to the latter he may stand as a more or less romantic but little understood figure. His work with its necessary concentration tends to isolate him from his fellows.

It was time for the engineer to demonstrate his ability by applying that special training and experience he possesses to some of the non-technical problems with which our country is faced. As a means to this end he suggested the formation of a "Public Relations Committee."

S. W. Archibald, A.M.E.I.C., urged the principle of unity. He pointed out that in this area alone there were a considerable number of engineers who were not members of either The Institute or of the Professional Engineers Association of Ontario. It was imperative that engineers get together, this would strengthen the hands of The Institute and the Association and act as a deterrent to improper practice. He instanced the practice of sanitary engineering by so-called sanitary engineers who were not qualified for the work. Taking the matter still further, if all the provinces did likewise, the position of Headquarters would be so strengthened that co-operation with other Engineering Societies would be established, making possibly a standardized international unification of engineers. Thus the status and prestige of the engineer would be vastly increased and become world wide.

G. E. Martin, A.M.E.I.C., stated that the personal element of the Branch should be taken into consideration in the selection of papers, discussions, etc., as each man had necessarily to keep up his own end. Papers that are outside his scope or of academic interest only might not attract him as he had not the time or desire to follow them. They were of educational interest only.

Regarding the social side of the Branch, such as clubs, parties, dances, etc., which are necessary to promote friendly intercourse, he suggested that some scheme be formulated such as a committee, that will make the ordinary members responsible for the working of the Branch. The greatest criticism he could offer was that there was too much of a tendency to "let George do it."

The chairman made a brief summary of the points of the various speakers and called upon the appointed "critic" of the evening. E. V. Buchanan, M.E.I.C., referring to Mr. Miller's remarks said, the obvious action was to communicate with the Association of Professional Engineers of Ontario and ask them to deal with it. He very much deplored the failure of that body to get the desired legislation through the House last session, but hoped they would be successful this time.

He agreed with Mr. Martin that the work of the Branch should be something more than educational.

It would be a good thing to take up cultural studies with the object of broadening one's outlook. Education and individual thought were necessary in this direction.

He referred to the value of many papers which had been given before the Branch and suggested that they should be assembled in one volume for a work of reference.

Discussion

H. B. R. Craig, M.E.I.C., referring to Mr. Miller's remarks concerning the infringement of engineers' rights, endorsed Mr. Buchanan's suggestion. He also advocated the formation of committees to deal with and report on the various matters that had been brought forward.

D. M. Bright, A.M.E.I.C., stated with regard to the suggestion by Mr. Archibald, that he advocated paying particular attention to the inclusion of younger men as they had their future to look to and would be likely to take up the work with enthusiasm. He suggested co-operation with other bodies and social friendship as one means of advancing engineering status.

J. A. Vance, A.M.E.I.C., agreed with Mr. Craig and Mr. Buchanan that a letter of protest should be sent to the Association of Professional Engineers of Ontario and further, in view of the absence of enabling legislation that they be requested to take it up with the Minister of Agriculture. He also advocated the formation of a Public Relations Committee with its members established on various outside bodies such as the Chamber of Commerce, the Canadian Club, Rotary Club, etc.

The meeting concluded by those present adjourning for light refreshments.

Ottawa Branch

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

At the evening meeting held at the rooms of the R.C.A.F. in the Jackson Building on February 16th, Gordon McLeod Pitts, M.Sc., M.R.A.I.C., A.M.E.I.C., of Montreal, spoke upon the subject of "Transportation in Canada." C. McL. Pitts, A.M.E.I.C., brother of the speaker and past-chairman of the Ottawa Branch of The Engineering Institute, presided.

Transportation in Canada

Mr. Pitts covered the whole subject under the four heads of airways, waterways, highways and railways, concentrating upon the last mentioned phase of the problem.

With a population of 10 million people, we have, stated the speaker, 48,851 miles of railroad with 236 carriers, representing with their accessories an investment of over $3,000,000,000. We have an ever increasing waterway and harbour development representing over $600,000,000 together with a highway system of 394,372 miles of road, 85,500 miles of which are surfaced, costing with equipment over $2,000,000,000, not to mention the stupendous private investment in shipping. Our investment in aviation is beginning to mount as this new form of transportation comes into increasing popularity.

He read a monograph on the subject prepared by himself and presented to the Royal Commission on Transportation in January of last year. The report subsequently brought in by the Commission did not depart greatly from the recommendations of the monograph, excepting that the monograph specifically stipulated that co-operative administration of the railroads should be attained through a super-directorate of three representatives from each road, with a chairman to be appointed by the Royal Commission. This chairman would correspond to the arbitral tribunal proposed in the Report of the Commission.

The speaker was still of the opinion that a super-directorate definitely constituted was the best principle for administration of the co-operating systems. In view of the strong objection registered by the private company to a permanent chairman or the Arbital Board, to function as the deciding umpire in any case of disagreement as to principle or policy between the two component organizations, Mr. Pitts put forward the suggestion that a temporary chairman or arbitrator should be selected by them to adjudicate on any special cases under consideration. The principle of an emergent chairman or arbitrator would remove the apprehension of a dictatorship and would provide the opportunity of procuring a highly qualified man for a short period of time to assist in solving a problem on which he is eminently qualified to advise.

The soundness and practicability of a super-directorate, Mr. Pitts maintained, is indicated by the fact that at the present time the railroads are actually co-operating under a special committee of three representatives from the directorate of each road as had been suggested in his monograph.

Mr. Pitts stated that the country had reached the absolute end of possible expenditure and extravagance in railroad operation and that the Canadian Pacific Railway, by combining its effort with the National road, was directly stabilizing the business and finances of the publicly-owned road and thereby materially reducing the financial responsibilities of the Dominion of Canada. The only reward for this co-operation, which it appeared would accrue to the privately owned company, was a guarantee of the temporary cessation of a portion of the destructive (subsidized and expensive) competition.

In his concluding remarks, the speaker touched upon the changing nature of the transportation problem generally. All suggestions made to meet the present transportation problem, were based on today's development of the art, and he suggested that even at this minute a very large proportion of our equipment and ideas on the subject were antiquated, and that a few years would see a very considerable revolution in the science of this important activity. Transportation in this country should be reduced as quickly as possible to its most direct, simple and economic form compatible with efficiency and satisfactory service in the light of modern development and requirements.

He advised engineers generally to take a greater interest in public affairs. While not promoting the theories of what is popularly known as "technocracy" he was thoroughly convinced that the engineering profession, on the basis of its all-round education and experience, was definitely qualified to make a constructive contribution to the administration of the affairs of the country, and its return to prosperous and normal conditions.

In view of the fact that the government of the country has so largely gone into business, it is time for the economist and the engineer to take a more active part in the country's administration. In the House of Commons there are 245 members, of whom 30 per cent are lawyers. There are 5 engineers, or 2 per cent. The population of Canada is over ten million people, of whom 14,000 are engineers and some 7,000 are lawyers.

At the conclusion of the address an interesting discussion ensued and during this a revolutionary change in railway equipment was forecast by the speaker of the evening whereby merchandise would be handled in short light trains at a speed of 100 miles an hour. In elaboration of this point he emphasized the necessity of the railways meeting the growing competition of truck transportation and providing a service that would deliver goods to the merchant's shelves with the directness, speed and flexibility demanded.

The merchandise train as visualized by Mr. Pitts will consist of a small Diesel-engine equipped power unit, hauling ten cars, each with two containers for package freight. This train would be met at key points, where highways intersect, by motor-trucks provided with facilities for the rapid transfer of the merchandise containers to their destination. The speed of operation would be facilitated by the use of radio, both on train and motor-truck, providing direct communication at all times.

With two containers to each railway car, no outside facilities would be required for effecting the transfer from car to truck. In this respect the proposed system differed from the present arrangement in use in the United States where five containers are carried on each standard railway truck. The containers could, when required, be carried in a ship's hold and provision for their ready transfer to aeroplane might be arranged for.

Mr. Pitts stated that if such a scheme as he outlined were put into practice it would make the highways safer and would utilize to a greater extent than at present the railway rights-of-way. The cost of the equipment which he described would be very slight in comparison with present-day railway equipment. Its operation would help to give a better return on our present railway investment and would to a considerable extent lessen the necessity for expensive construction of our highways to accommodate the ever-increasing volume of heavy motor-truck traffic.

Theory and Practice of Lubrication

On Thursday, February 23rd, the guest speaker at the noon luncheon of the local branch was Gordon McIntyre, B.Sc., chief chemist of the Imperial Oil Company Limited, Sarnia, Ontario. Mr. McIntyre is a Fellow of the Royal Chemical Society; a Member of Committee D-2 of the American Society for Testing Materials; and a Member of the Fuel and Lubricating Division of the Society of Automotive Engineers. He served in the Great War from 1914 to 1919 in the Canadian Engineers and Royal Air Force; and has been connected with the laboratories of the Imperial Oil Company for approximately twelve years. He spoke upon the subject of "The General Theoretical Aspects of Lubrication."

Group Captain E. W. Stedman, M.E.I.C., Chairman of the Ottawa Branch, presided and in addition head table guests included: Major T. W. McDowell, V.C., J. S. Whitby, J. H. Parkin, M.E.I.C., B. F. Haanel, M.E.I.C., K. M. Cameron, M.E.I.C., E. Viens, M.E.I.C., C. McL. Pitts, A.M.E.I.C., P. V. Rosewarne, F. S. Neate, Squadron Leader R. J. Grant, D. H. Piper, H. Mc. Chantler, and Squadron Leader Alan Ferrier, A.M.E.I.C.

Illustrating his subject with lantern slides, Mr. McIntyre traced the history of lubrication from the early days down to the present, devoting most of his time to the methods of lubrication now in use for various kinds of bearings. In this connection the automobile engine was referred to at considerable length and particularly problems which have arisen with regard to free wheeling.

The meeting was well attended and great interest was shown by the audience in the address.

Peterborough Branch

W. F. Auld, Jr.E.I.C., Secretary.
W. T. Fanjoy, Jr.E.I.C., Branch News Editor.

Recent Developments in the Bakelite Industry

The commercial uses of bakelite protean synthetic resin compounded of phenol and formaldehide are almost endless, stated H. P. Mills, of the Bakelite Corporation of Canada, in his address at the Thursday evening, February 23rd, meeting of the Branch.

He featured his address on the Bakelite Corporation's research that has recently resulted in the practical demonstration of bakelite's valuable property as an "inhibitor of rusting" when applied with several pigments of which zinc chromate is perhaps the most effectual.

Not as strong as steel, or as flexible as rubber, nor as compressible as cast iron, nor as good an insulator as glass or porcelain, bakelite combines these qualities in a high degree, providing utility in many directions, varying to a large extent with the mixtures with which it is moulded. Mixed with "wood flour" it is able to withstand shocks, and in that respect is used on the ends of chisels, replacing leather that was formerly employed to protect the wooden handle.

In Europe it has replaced porcelain to a great extent as tableware. It is used as powder boxes, corks of bottles, caps of containers and so on, lending itself to very attractive designs heightened by a wide range of colors. Cut as gearing from thick sheets it brings silence when combined with steel gears.

In its purest form bakelite resists all chemical action, moisture, weather, and light, and because of its hardness has attracted the attention of the furniture industry for table tops, dresser tops and so on. In one form it looks like marble and costs only one-third as much and with all the colors that may be infused into moulded bakelite it is highly favoured in the modernistic modes of decoration.

Bakelite includes many products. Of its approximately 4,000 synthetic resinous forms probably only one in twenty-five have common application. Mr. Mills told of the corporation's research and tests that produced bakelite as a finish or varnish. Panels were prepared and treated with proprietary varnishes and also the bakelite product. They were left for five months on the Florida beach where they were exposed to tidewater and sun. These natural elements took off the proprietary varnish from all but the bakelite panel. It was left on the beach another five months, and because of its practically perfect resistance as demonstrated by these tests all high class marine varnishes are made of bakelite gums.

Bakelite was the invention of a Belgian chemist, Dr. Bakelin, some twenty years ago. He brought it to the United States as a process in photography by which prints could be developed with artificial light.

The paint industry was looking for a synthetic shellac about that time, but as the "stuff" subsequently to be known as bakelite was not soluble in alcohol it was thrown away in the course of various experiments.

But that insolubility suggested to Dr. Bakelin, a property that might be valuable and from that viewpoint he went on to the discoveries that have developed so in importance.

Developments in the Great Bear Lake Area

The mineral discoveries and developments in the Great Bear Lake Area of the North-West Territories was the subject of a very interesting and educational talk, given Thursday evening, March 9th, at Paragon Hall, by Major Bernhard Day, consulting engineer of the Great Bear Exploration and Radium Company, Limited.

He accompanied his talk by an exhibition of lantern slides illustrating the geography of the country. These were followed by four reels of cinematograph films, many of them taken by himself from the air. He thus introduced graphically to the audience the character of the country, its water and geological formations, the three means of transport, airplane, boat or dog-power and intimate sketches of camp-life. He mentioned that the average summer temperature in that part of the country was 80 degrees, the highest in three seasons being 88 and the lowest 62. The lowest winter temperature was 62 degrees below zero but such a temperature did not last very long and after about the middle of March it was possible to go about with only an overcoat over the ordinary clothes. The summer season, while short, crowds into its four months days which enjoy as much as 20 hours sunshine. The summer plagues were black flies, mosquitoes and deer flies.

The speaker proceeded to describe the location, history and accessibility of the area stating that Great Bear Lake was located 1,100 miles north of Edmonton and 810 miles or one day's journey by airplane from the end of steel at Waterways. The area, contrary to public opinion, had been known as a mineralized district for more than 150 years. He traced the history of the region from the year 1769 when Samuel Hearne was sent out by the Hudson Bay Company to determine where the Eskimos were securing the copper for their weapons, up to 1928, when extensive investigations were carried out by several mining organizations. In 1930 uranium stained manganese ore was discovered on Echo Bay by Gilbert La Bine and Charles St. Paul.

Since that time five major mineral discoveries have been made, both radium and silver, the latter being very rich deposits. Other ore discoveries have led the prospectors to believe that rich gold discoveries are a possibility.

Since that time several tons of high-grade pitchblende ore have been transported from Echo Bay to the reducing plant located at Port Hope, and this industry gives every indication of being able to compete with Belgium for the world's monopoly in radium. The uses and future market for radium were also touched on by the speaker.

Quebec Branch

Jules Joyal, A.M.E.I.C., Secrétaire-Trésorier.

The Chats Falls Development, Ottawa River

Le 27 février dernier, les membres de la Section de Québec et leurs amis étaient invités à se rendre au "Committee Room", Château Frontenac, pour y entendre le Lt-Col. H. L. Trotter, D.S.O., M.E.I.C., traiter des problèmes de la construction d'un récent développement hydro-électrique sur la rivière Ottawa, à "Chats Falls".

Cette conférence, illustrée par de nombreuses projections, fut des plus appréciée et fut pour ainsi dire un supplément parfait à l'article publié sous un titre à peu près identique dans l'édition de février 1933 du "Engineering Journal".

Le distingué conférencier qu'est le Lt-Col. Trotter sut si bien couvrir ce sujet, pourtant très vaste, dans tous les détails de quelqu'importance, qu'un très petit nombre des personnes présentes purent profiter de l'invitation faite à l'auditoire de lui demander des informations additionnelles.

Le Lt-Col. Trotter fut présenté à l'assistance par le président de la Section, M. Hector Cimon, M.E.I.C., et M. A.-B. Normandin, A.M.E.I.C., se fit l'interprète de ses confrères et amis pour adresser au conférencier les remerciements les plus sincères pour la très instructive et très intéressante conférence qu'il nous avait donnée.

L'Ingénieur dans l'Industrie

Le 6 mars, 1933, à un déjeuner-causerie, la Section de Québec avait le plaisir d'avoir pour hôte d'honneur et conférencier, M. Augustin Frigon, D.Sc., M.E.I.C., Directeur de l'École Polytechnique de Montréal et de l'Enseignement Technique dans la Province de Québec.

Partant de ce point que les ingénieurs cherchent de plus en plus à se tailler une situation prépondérante dans le monde industriel, le conférencier fait remarquer qu'il est nécessaire pour chacun d'eux de ne perdre aucune occasion de se faire valoir.

"Quel est, à l'heure actuelle, le rôle du Canadien français dans le domaine de l'industrie? On doit dire qu'il occupe le second rang et pourtant, il est bien souvent en mesure de prouver sa supériorité sur ses concurrents".

"On se plaint souvent que les Canadiens anglais se protègent trop; ceci est vrai, bien que les cas d'injustice flagrante soient très rares. Il n'est pas impossible de lutter contre cette protection excessive, la protection existera toujours; à nous de prendre les moyens d'y faire face victorieusement."

Le conférencier fait remarquer avec grande justesse que nous avons à lutter contre l'atavisme de nos concurrents établis depuis des générations dans les différentes branches de l'industrie, alors que nos pères furent plutôt, généralement parlant, les propagateurs de l'un des plus beaux systèmes agricoles qui soient au monde."

"Nous ne sommes pas nés industriels comme nos compatriotes de langue anglaise bien que nous possédions toutes les qualités requises pour le devenir un jour."

"Quelle est la ligne de conduite à tenir pour atteindre ce but? Développer de plus en plus le goût industriel chez les jeunes et cela par tous les moyens possibles, s'extérioriser davantage et ne pas craindre de s'afficher publiquement par des travaux de valeur, des conférences, etc."

"Nous possédons présentement des ingénieurs hors ligne, mais combien acceptant de se produire? Combien y en a-t-il qui ne craignent pas de prouver hautement des qualités qui ne manqueraient pas de leur donner de superbes opportunités? De nos jours il est devenu nécessaire de prouver sa valeur par des faits extérieurs."

"Un excellent moyen de préparer les générations futures vers le nouveau développement industriel qui ne manquera pas de se produire serait d'orienter davantage nos jeunes vers l'industrie: ce travail devrait commencer dès l'école primaire et se poursuivre régulièrement durant tout le cours d'études d'un jeune homme. Il serait important de déposer ce germe dans l'esprit de nos jeunes gens et cela contribuerait à orienter favorablement ceux-ci vers l'industrie."

Au cours de cette causerie, M. Frigon a fortement recommandé à notre classe dirigeante de s'intéresser davantage à l'industrie afin d'orienter un plus grand nombre des nôtres dans cette direction; il dit aussi que le travail soutenu a toujours été et sera toujours le plus grand facteur de succès et qu'il ne fallait pas trop compter sur le hasard pour atteindre une position enviable.

Le conférencier fut présenté par M. Hector Cimon, M.E.I.C., président de la Section, et remercié par M. A.-R. Décary, D.Sc., M.E.I.C., ingénieur en chef des Travaux Publics du Canada, district de Québec.

A la table d'honneur, en outre du président M. Cimon et du conférencier M. Frigon, on remarquait MM. A.-R. Décary, M.E.I.C., R.-B. McDunnough, A.M.E.I.C., A. Larivière, M.E.I.C., J.-A. Duchastel, M.E.I.C., A.-B. Normandin, A.M.E.I.C., et L.-P. Méthé, A.M.E.I.C.

Assistance, 45.

Saint John Branch

G. H. Thurber, A.M.E.I.C., Secretary-Treasurer.
G. C. Clarke, S.E.I.C., Branch News Editor.

On Thursday evening, January 26th, a joint dinner of the Saint John Branch of The Engineering Institute of Canada and the Association of Professional Engineers of New Brunswick was held in the Admiral Beatty hotel, Saint John, at which some sixty-five members of the two societies were present, with A. A. Turnbull, A.M.E.I.C., president of the Branch, acting as chairman. Others at the head table were Lieutenant-Governor McLean; Brigadier J. L. R. Parsons, O.C., M.D. No. 7; Mr. Justice Baxter; F. M. Sclanders, Commissioner of the Saint John Board of Trade; G. C. Torrens, A.M.E.I.C., newly elected president of the Association of Professional Engineers and A. R. Crookshank, M.E.I.C., retiring president.

The toast to the King was proposed by G. A. Vandervoort, A.M.E.I.C. The toast to the Association was proposed by A. R. Crookshank, M.E.I.C., who gave a brief resume of the history of that body since its inception in 1920 and the reply was made by G. C. Torrens, A.M.E.I.C., with a discussion of the responsibility of the Association.

J. K. Brooks, A.M.E.I.C., in a thoughtful address, proposed the toast to The Institute with a discussion of the respective fields of action of the various provincial associations and The Institute and urged that closer cooperation be the goal in the future as a means of arriving at uniform standards. He disagreed with the Busfield Report and stated that in his opinion the provincial acts could be administered by provincial divisions of The Institute. The toast was replied to by F. P. Vaughan, M.E.I.C., who spoke of the bright future of the profession once the present clouded economic situation is over.

The toast to the guests was proposed by J. N. Flood, A.M.E.I.C., and was responded to by Lieutenant-Governor McLean, Brigadier Parsons, Mr. Justice Baxter and Mr. F. M. Sclanders.

Foundations in Clay

After the dinner the members of both societies and their guests listened to an extremely interesting illustrated address entitled "Foundations in Clay," delivered by M. A. Ravenor, M.I.C.E., M.E.I.C., of Rothesay, in which he described his experiences in designing and building foundations in Georgetown, British Guiana, where the alluvial clay lies to a depth of 1,500 feet over the bed-rock with its top surface at mean tide level.

Mr. Ravenor described general conditions in Georgetown, a city of 60,000 people, where the alluvial flats lie at mean tide level and the city would be flooded at each high water if it were not for protective sea-walls. The condition is such that all sewage must be stored in underground drainage canals and pumped out during the six hours the tide is low.

The alluvial clay is electrolytic, is highly divided and contains about 30 per cent of moisture. A difference of 5 per cent one way or the other makes it as soft as molasses or as hard as firm cheese.

With foundation material such as this to work upon it was found that the Rankine formula did not go far enough, as all conditions had not been taken into consideration. He described how careful laboratory tests made on the site of the work showed that Rankine's coefficient k was a constant only up to the point of permanent deformation of the clay and that the clay really acted as a fluid after that point, the foundations of a building settling until a balance was struck between its weight and the weight of the material displaced.

He advised anyone who had to deal with a similar material to conduct a careful investigation before they relied too greatly upon the unaltered Rankine formula.

Mr. Ravenor illustrated his talk with a series of interesting slides which showed how some of the buildings in Georgetown had settled into the clay over a period of years.

Saskatchewan Branch

Stewart Young, A.M.E.I.C., Secretary-Treasurer.

The regular monthly meeting of the Branch, held in the Hotel Saskatchewan on Friday evening, February 17, took the form of a joint meeting with the Association of Professional Engineers.

After the dinner, at which fifty were in attendance, several matters having to do with the affairs of the Association of Professional Engineers were dealt with, when the chairman, L. A. Thornton, M.E.I.C., by arrangement turned the meeting over to the Branch for the transaction of any business and the introduction of the speaker of the evening.

After announcing that all matters of business pertaining to Branch affairs were deferred to the annual meeting on Friday, March 24th, when the chief topic of discussion would be "The Development of The Institute," the chairman, J. D. Peters, A.M.E.I.C., introduced the speaker of the evening, C. J. MacKenzie, M.E.I.C., Dean of Engineering, University of Saskatchewan, his subject being "The Construction of the New Saskatoon Bridge."

The Construction of the New Saskatoon Bridge

After briefly outlining the trying conditions under which the bridge was constructed, Dean MacKenzie, in a most interesting manner, reviewed the progress of the work, illustrating his address with an excellent series of lantern slides.

The work was commenced on December 28th, 1931, as a relief project. In eleven weeks the piers had been constructed, the thermometer at times registering −35 degrees, with a heavy gale blowing. The whole structure was completed according to schedule in October, 1932, the contractor supplying labour and lumber for form work.

At the conclusion of the address, J. D. Peters suitably expressed the thanks of the Branch when the meeting reverted to the former order of business, adjourning at 11.00 p.m.

Sault Ste. Marie Branch

G. H. E. Dennison, A.M.E.I.C., Secretary-Treasurer.

The Sault Ste Marie Branch of The Engineering Institute of Canada held its first meeting of the year on February 24th, at the Windsor hotel.

The meeting was addressed by Mr. Jas. Baxter, manager of the Royal Bank, who discussed in a general way monetary matters with particular reference to the problems the world is facing today. While bimetalism, a central bank, inflation etc., each has its proponents, and arguments, he expressed the view that it is not the fundamentals of our present system that are at fault but the phenomenal conditions through which we are passing. The economic fabric of the nations is essentially a delicately balanced, interdependent relationship, extremely sensitive to disturbing influences. Therefore although many reasons are quoted as being responsible for certain conditions which obtain today, economists agree that fundamentally the cause of the present collapse was the world war.

Mr. Baxter discussed trade and the necessity for a common basis of exchange even in the most elementary form of commerce. From earliest times gold has had an intrinsic value and been highly prized and sought after. It was therefore more or less natural that this metal should come to be recognized as a basis of value when the growth of trade, particularly that between nations outgrew the cumbersome methods originally adopted. England was the first of the modern nations to adopt the gold basis, in 1816. France, Italy and Belgium followed suit in 1865 and later Germany and Austria. He pointed out the economic principle that money, or gold is not wealth, a principle that is too often lost sight of.

In conclusion Mr. Baxter discussed England's abandonment of the gold standard when faced with bankruptcy, and its result on world trade. He however ventured the opinion that Britain as well as the other important nations of the world would in time return to the gold standard as the most suitable medium of exchange yet devised. This would not come however until England was ready to act and should properly be preceded by a balancing of national budgets and reduction of taxation, settlement of war debts, repeal of trade embargoes and quotas, a general lowering of all tariff barriers and a readoption of sound banking and credit.

An interesting discussion followed Mr. Baxter's talk and a very hearty vote of thanks was tendered the speaker.

Vancouver Branch

A. I. E. Gordon, Jr.E.I.C., Secretary-Treasurer.

On Wednesday February 1st, 1933, members of the Vancouver Branch were guests of the Military Institute of Vancouver at an evening meeting in the Hotel Georgia, when His Honour Judge Howay spoke on "The Royal Engineers and Their Work in British Columbia." The chairman, Professor Logan of the University of British Columbia, introduced the speaker.

The Royal Engineers and Their Work in British Columbia

In opening, Judge Howay stated that the discovery of gold on the lower Fraser river in 1858 and the sudden rush of population to the then totally unorganized territory which is now the mainland of British Columbia caused Sir Edward Bulwer Lytton, Secretary of State for the Colonies, to call for volunteers from the Royal Engineers for service maintaining order, surveying and opening up the colony. He chose a detachment of those best fitted for the work in such a manner that all trades likely to be of use in the new country were represented. Two advance parties came out via the Isthmus of Panama; the first, mostly surveyors, arriving in September 1858. The main body, over 200 strong, including the families of many of the men, took six months to come by way of Cape Horn in the sailing ship *Thames City*, and reached Victoria April 12th, 1859.

Colonel Moody, the commanding officer, condemned the original camp site of the advance party at Langley and moved to Sapperton. The year 1859 was spent in laying out the site of New Westminster as the capital of British Columbia and improving the Harrison Trail to Lillooet. In 1860 the Engineers improved this trail into a road and built the Dewdney trail from Hope to Princeton. In 1861 they built the North road from Sapperton to Port Moody on Burrard Inlet, made surveys for the Cariboo road through the Fraser canyon and built the Spuzzum suspension bridge across the Fraser river. So well did they design this bridge that the government engineers could find no better place for its successor when they came to carry the new Cariboo highway across the Fraser, so placed the new bridge exactly on the site of the old, even using one of the old piers. In 1862 the Royal Engineers built six miles of the Cariboo road out of Yale, completed surveys for the whole road, extending over 350 miles inland, and built several bridges.

In 1863 they were disbanded and all the officers and fifteen men returned to England. The rest settled in the territory, entering every line of life.

In closing, His Honour pointed out that from 1858 to 1863 the Royal Engineers were the principal ambassadors of civilization in the colony. They were responsible for all town surveys, main roads, bridges and public works, for the first school, church, library and printing office, for social activities such as plays, concerts and dances, and for the maintenance of law and order. He also mentioned that Vancouver owes them a lasting debt of gratitude for the existence of Stanley Park which, together with the present site of the University of British Columbia, was set aside by Colonel Moody as a Naval Reserve.

Following the address some excellent slides were shown, depicting officers of the expedition, samples of draughting and printing, the Spuzzum bridge and scenes on the old Cariboo road. P. H. Buchan, A.M.E.I.C., then moved a vote of thanks to the speaker. The meeting then adjourned.

INSPECTION OF THE NEW CARRALL STREET GAS PLANT

On Saturday afternoon, February 10th, 1933, through the courtesy of the B. C. Electric Power and Gas Company Ltd., members and friends of the Branch inspected the new Carrall Street gas plant, the first in Canada using intermittent vertical chamber coke ovens.

The party, to the number of forty-five, assembled at the plant at 2.30 p.m., and P. H. Buchan, A.M.E.I.C., chairman of the Branch, introduced Mr. John Kirkhope, operating superintendent for the contractors, Gas Chambers and Coke Ovens Ltd., London, England, who described the plant and gave directions for the visit. Guides then conducted the visitors over the plant in groups of about eight, and explained the operations in detail.

The party started at the loading dock, inspected the blending bunkers, conveyor galley, loading bunkers, main ovens and auxiliary producer gas plant, and were present at the charging and discharging of an oven. They then examined the condensers and scrubbers where foul gas from the ovens is purified and tar and other by-products extracted, and finished by ascending 250 feet to the top of the new 145 foot diameter gas holder.

Winnipeg Branch

E. W. M. James, A.M.E.I.C., Secretary-Treasurer.
E. V. Caton, M.E.I.C., Branch News Editor.

On February 16th the annual meeting of the Winnipeg Branch was held in the Engineering building, University of Manitoba. Reports were received from all sub-committees and accepted. The final report was presented by the Secretary and accepted. This report has already been published in the Journal.

The retiring chairman, T. C. Main, A.M.E.I.C., expressed his appreciation for the cooperation of the members during the year and briefly reviewed the work of the Branch. On the report of the scrutineers, the following members were declared elected:

T. C. Main, A.M.E.I.C., Immediate Past Chairman.
G. H. Herriot, M.E.I.C., Chairman.
F. G. Goodspeed, M.E.I.C., Vice-Chairman.

Executive Committee

E. V. Caton, M.E.I.C. — C. H. Fox, M.E.I.C.
L. M. Hovey, A.M.E.I.C. — D. L. McLean, A.M.E.I.C.
A. J. Taunton, A.M.E.I.C.

Committee Chairmen

Nomination Committee................T. C. Main, A.M.E.I.C.
Advisory Committee....................J. W. Porter, M.E.I.C.
Students Prize Committee..............J. N. Finlayson, M.E.I.C.
Research and Investigation Committee..Geo. E. Cole, A.M.E.I.C.
Programme Committee.................Fred V. Seibert, M.E.I.C.
Remuneration Committee..............D. A. Ross, M.E.I.C.
Legislation and Public Affairs Committee.C. H. Attwood, A.M.E.I.C.
Library and Publication Committee.....J. F. Cunningham, A.M.E.I.C.

Nominees for Councillor, 1934

F. G. Goodspeed, M.E.I.C. — W. P. Brereton, M.E.I.C.

Auditors

C. H. Attwood, A.M.E.I.C. — E. V. Caton, M.E.I.C.

Secretary

Eric W. M. James, A.M.E.I.C.

A motion expressing the appreciation of the Branch to the retiring chairman and retiring members of the Committee was moved by Cecil H. Gunn, A.M.E.I.C., and carried unanimously.

After the business of the evening Dr. T. Glen Hamilton gave an illustrated lecture on "Psychical Research." This paper was listened to with considerable interest and created an active discussion.

SUPPER DANCE

On February 14th the joint supper dance of the Winnipeg Branch of The Engineering Institute of Canada and the Manitoba Association of Professional Engineers took place at the Royal Alexandra Hotel. There was a large attendance of members and considering the times it was felt that the dance was an outstanding success and a credit to the committee who organized it.

ELECTRICAL CONTROL OF WELLAND SHIP CANAL

On the evening of March 2nd, J. P. Fraser, A.M.E.I.C., presented a very interesting paper on the electrical control of the Welland Ship Canal. Numerous slides were shown and considerable discussion took place following the paper.

At this meeting preceding the paper, E. V. Caton, M.E.I.C., presented the Students Prizes. These students are in the engineering faculty of the University of Manitoba. The winners were:—

Electrical Engineering

L. M. Howe, S.E.I.C.	Paper on "Oscillography."
Mr. Max Spigelman	Paper on the "Photo Electric Cell."

Civil Engineering

Mr. J. W. Youngman	Paper on "Refining of Asphalt from crude Petroleum."
Mr. M. Wadge	Paper on "Reinforcement of concrete piles in foundations, and footings of residences and medium sized buildings in the district of Winnipeg."

Diesel Express

Britain's first Diesel-electric express train service was established for the duration of the British Industries Fair between London (Euston station) and Castle Bromwich, where the Birmingham section of the Fair is held. The train, called the "Armstrong-Shell Express" is a 250 b.h.p. Armstrong-Whitworth Diesel-electric motor train. It is a self-contained unit generating its own electric power from an oil-driven engine and capable of maintaining a speed of 65 m.p.h.

For the 113 miles between London and Castle Bromwich the train was timed to take two hours seven minutes—that is an average of 53½ miles an hour.

According to a report issued on the first week's performance the train ran a distance of 1,157 miles without a hitch. Total fuel consumption for the five days was 225 gallons, costing £3 5s. 6d., equivalent to 0.68d. per train mile.

Electrical Firms Amalgamate

The amalgamation of four electrical companies, Canadian subsidiaries of British electrical engineering firms, became effective on April 1st. Through this action Bruce Peebles (Canada) Limited, Crompton Parkinson (Canada) Limited, Harland Engineering Company of Canada Limited and Lancashire Dynamo and Crypto Company of Canada Limited, have been merged into a new Canadian company known as Bepco Canada Limited, this name being derived from British Electric Products Company. The new firm will have its head office at 1050 Mountain street, Montreal, and a branch office at 43-45 Niagara street, Toronto, Ontario, using the offices and service shops of the Lancashire Dynamo & Crypto Co. of Canada Limited in both locations.

The officers of the new company include those formerly associated with the four original companies, as follows: President and General Manager, C. G. Abbey, formerly President of Lancashire Dynamo & Crypto Co. of Canada Limited; Vice-President and Ontario Manager, Brian M. Burt, formerly Director and General Manager of Harland Engineering Co. of Canada Limited; Secretary-Treasurer, S. E. Gladwell, formerly Secretary-Treasurer of Crompton Parkinson (Canada) Limited; Director resident in England, S. A. Gaskell, formerly Vice-President and General Manager of Bruce Peebles (Canada) Limited. The new company assumes the responsibilities of the four previous companies and expects to be in a position to give even better service than previously given.

Situations Wanted

ELECTRICAL AND RADIO ENGINEER, B.Sc., '28. Experience in the design and testing of broadcast radio receivers, including latest superheterodyne practice, and capable of constructing apparatus for testing same. Also familiar with telephone and telephone repeater engineering. Thorough experience in design, and construction and inspection of municipal power conduits. Apply to Box No. 12-W.

MECHANICAL ENGINEER, Canadian, with technical training and executive experience in both Canadian and American industries, particularly plant layout, equipment, planning and production control methods, is open for employment with company desirous of improving manufacturing methods, lowering costs and preparing for business expansion. Apply to Box No. 35-W.

MECHANICAL ENGINEER, A.M.E.I.C. Married. Experience in machine shops, erection and maintenance of industrial plant mechanical and structural design. Reads German, French, Dutch and Spanish. Seeks any suitable position. Apply to Box No. 84-W.

YOUNG ENGINEER, B.A., B.SC., A.M.E.I.C., R.P.E., Ont. Competent draughtsman and surveyor. Eight years experience including design, superintendence and layout of pulp and paper mills, hydro-electric projects and general construction. Limited experience in mechanical design and industrial plant maintenance. Apply to Box No. 150-W.

PURCHASING ENGINEER, graduate mechanical engineer, Canadian, married, 34 years of age, with 13 years' experience in the industrial field, including design, construction and operation, 8 years of which had to do with the development of specifications and ordering of equipment and materials for plant extensions and maintenance; one year engaged on sale of surplus construction equipment. Full details upon request. Apply to Box No. 161-W.

STRUCTURAL ENGINEER, B.A.SC., '15, A.M.E.I.C., R.P.E., (Ont.) Married. Experience in structural steel and concrete includes ten years design, five years sales, two years shop practice and erection, and one year advertising. Available at two weeks notice. Apply to Box No. 193-W.

CIVIL ENGINEER, age 44, open for employment anywhere, experience covers about 20 years' active work, including 7 years on municipal engineering, 2 years as Town Manager, 3 years on railway construction, 3 years on the staff of a provincial highway department, 2 years as contractor's superintendent on pavement construction. Apply to Box No. 216-W.

REINFORCED CONCRETE ENGINEER, B.SC., P.E.Q., eight years experience in construction design of industrial buildings, office buildings, apartment houses, etc. Age 30. Married. Apply to Box No. 257-W.

MECHANICAL ENGINEER, B.SC., McGill 1919, A.M.E.I.C., P.E.Q., 12 years experience oil refinery and power plant design, factory maintenance, steam generation and distribution problems, heating and ventilation, etc. Available at once. Location immaterial. Apply to Box No. 265-W.

ELECTRICAL ENGINEER, B.SC., '28, Canadian. Age 25. Experience includes two summers with power company; thirteen months test course with C.G.E. Co.; telephone engineering, and the past thirty months with a large power company in operation and maintenance engineering. Location immaterial and available immediately. Sales or industrial engineering desirable. Apply to Box No. 266-W.

PLANE-TABLE TOPOGRAPHER, B.SC., in C.E. Thoroughly experienced in modern field mapping methods including ground control for aerial surveys. Fast and efficient in surveys for construction, hydro-electric and geographical investigations. Apply to Box No. 431-W.

ELECTRICAL ENGINEER, B.SC., A.M.E.I.C., AM.A.I.E.E., age 30, single. Eight years experience H.E. and steam power plants, substations, etc., shop layouts, steel and concrete design. Location immaterial. Available immediately. Apply to Box No. 435-W.

CIVIL ENGINEER, B.A.SC., A.M.E.I.C., JR.A.S.C.E., age 28, married. Experience: construction, design, cost estimating on hydro-electric and storage work, also railway. Desires work in engineering, industrial or commercial fields. Available at once. Apply to Box No. 447-W.

Situations Wanted

CIVIL ENGINEER, B.SC., A.M.E.I.C., with six years experience in paper mill and hydro-electric work, desires position in western Canada. Capable of handling reinforced concrete and steel design, paper mill equipment and piping layout, estimates, field surveys, or acting as resident engineer on construction. Now on west coast and available at once. Apply to Box No. 482-W.

MECHANICAL ENGINEER, B.SC. Age 28, married. Four and a half years on industrial plant maintenance and construction, including shop production work and pulp and paper mill control. Also two and a half years on structural steel and reinforced concrete design. Located in Toronto. Available at once. Apply to Box No. 521-W.

CIVIL ENGINEER, Canadian, married, twenty-five years' technical and executive experience, specialized knowledge of industrial housing problems and the administration of industrial towns, also town planning and municipal engineering, desires new connection. Available on reasonable notice. Personal interview sought. Apply to Box No. 544-W.

An Instructive Example

As an actual example of the possibilities of obtaining engineering and draughting work of a minor nature at the present time, the recent efforts of an unemployed group (The Technical Service Bureau) in Montrela are noteworthy.

The leader of the group learned that a new city by-law had recently gone into effect making it compulsory for manufacturing plants which drew water from the canal or river in addition to the regular city water supply to obtain a permit from the Health Department and to furnish complete diagrammatic plans of their piping systems to that department.

It was suspected that a number of firms in the city did not have the necessary plans available and with this in mind a list of those with dual water supplies was obtained. Some forty of the more likely of these were circularized bringing the provisions of the new by-law and the Bureau to their attention. They were then interviewed with the result that two contracts to trace piping systems were obtained from firms lacking plans, and the proper plans have now been drawn and submitted for approval.

A number of companies have still to be heard from, but even lacking further contracts, the remuneration has been well worth the effort made.

ELECTRICAL ENGINEER, A.M.E.I.C., University graduate 1924. Experience includes one year test course and five years on design of induction motors with large manufacturer of electrical apparatus. Four summers as instrumentman on highway construction. Several years experience in accounting previous to attending university. Available at once. Apply to Box No. 564-W.

MECHANICAL ENGINEER, A.M.E.I.C., with twenty years experience on mechanical and structural design, desires connection. Available at once. Apply to Box No. 571-W.

MECHANICAL ENGINEER, B.A.SC., '30, desires position to gain experience, and which offers opportunity for advancement. Experience in pulp and paper mill and one year in mechanical department of large electrical company. Location immaterial. Available immediately Apply to Box No. 577-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.

MECHANICAL ENGINEER, Canadian, technically trained; eighteen years experience as foreman, superintendent and engineer in manufacturing, repair work of all kinds, maintenance and special machinery building. Location immaterial. Available at once. Apply to Box No. 601-W.

CHEMICAL ENGINEER, S.E.I.C., B.SC., University of Alberta, '30. Age 31. Single. Six seasons' practical laboratory experience, three as chief chemist and three as assistant chemist in cement plant; one year's p.g. work in physical chemistry; three years' experience teaching. Desires position in any industry with chemical control. Available immediately. Apply to Box No. 609-W.

Situations Wanted

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.

CIVIL ENGINEER, A.M.E.I.C., R.P.E., Ontario; three years construction engineer on industrial plants; fourteen years in charge of construction of hydraulic power developments, tower lines, sub-stations, etc.; four years as executive in charge of construction and development of harbours, including railways, docks, warehouses, hydraulic dredging, land reclamation, etc. Apply to Box No. 647-W.

MECHANICAL ENGINEER, A.M.E.I.C., Canadian, technically trained; six years drawing office. Office experience, including general design and plant layout. Also two years general shop work, including machine, pattern and foundry experience, desires position with industrial firm in capacity of production engineer or estimator. Available on short notice. Apply to Box No. 676-W.

ELECTRICAL ENGINEER, B.SC., '29, JR.E.I.C. Age 26. Undergraduate experience in surveying and concrete foundations; also four months with Canadian General Electric Co. Thirty-three months in engineering office of a large electrical manufacturing company since graduation. Good experience in layouts, switching diagrams, specifications and pricing. Best of references. Available immediately. Apply to Box No. 693-W.

MECHANICAL ENGINEER, B.SC., '27, JR.E.I.C. Four years maintenance of high speed Diesel engines units, 200 to 1,300 h.p. Also maintenance of D.C. and A.C. electrical systems and machinery. Draughting experience. Westinghouse apprenticeship course. Practical mechanical and electrical engineer with a special study of high speed Diesel engine design, application and operation. Location in western or eastern Canada immaterial. Apply to Box No. 703-W.

COMBUSTION ENGINEER, R.P.E., Manitoba. A.M.E.I.C. Wide experience with all classes of fuels. Expert designer and draughtsman on modern steam power plants. Experienced in publicity work. Well known throughout the west. Location, Winnipeg or the west. Available at once. Apply to Box No. 713-W.

YOUNG ENGINEER, B.A.SC., (Univ. Toronto '27), JR.E.I.C. Four years practical experience, buildings, bridges, roadways, as inspector and instrumentman. Available at once. Present location, Montreal. Apply to Box No. 714-W.

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

MECHANICAL ENGINEER, age 41, married. Eleven years designing experience with project of outstanding magnitude. Machinery layouts, checking, estimating and inspecting. Twelve years previous engineering, including draughting, machine shop and two years chemical laboratory. Highest references. Apply to Box No. 723-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.

DESIGNING ENGINEER, M.SC. (McGill Univ.), D.L.S., A.M.E.I.C., P.E.Q. Experience in design and construction of water power plants, transmission lines, field investigations of storage, hydraulic calculations and reports. Also paper mill construction, railways, highways, and in design and construction of bridges and buildings. Available at once. Apply to Box No. 729-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.

CIVIL ENGINEER, M.SC., 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.

ELECTRICAL AND RADIO ENGINEER, B.SC. '31, S.E.I.C. Age 25. Nine months experience on installation of power and lighting equipment. Eight months on extensive survey layouts. Two summers installing telephone equipment. Specialized in radio servicing and merchandising. Available at once. Location immaterial. Apply to Box No. 740-W.

CIVIL ENGINEER, graduate '29. Married. One year building construction, one year hydro-electric construction in South America, fourteen months resident engineer on road construction. Working knowledge of Spanish Apply to Box No. 744-W.

Situations Wanted

SALES ENGINEER, B.Sc., McGill. 1923, A.M.E.I.C. Age 33. Married. Extensive experience in building construction. Thoroughly familiar with steel building products; last five years in charge of structural and reinforcing steel sales for company in New York state. Available at once. Located in Canada. Apply to Box No. 749-W.

DESIGNING ENGINEER, graduate Univ. Toronto '26. Thoroughly experienced in the design of a broad range of structures, desires responsible position. Apply to Box No. 761-W.

MECHANICAL ENGINEER, graduate, '23, A.M.E.I.C., P.E.Q., age 32, married. (English and French.) Two years shop, foundry and draughting experience; one year mechanical supt. on construction; six years designing draughtsman in consulting engineers' offices (mechanical equipment of buildings, heating, sanitation, ventilation, power plant equipment, etc.). Present location Montreal. Available immediately. Montreal or Toronto preferred. Apply to Box No. 766-W.

CIVIL ENGINEER, S.E.I.C., B.Sc. Queen's Univ. '29. Age 25. Married. Three years experience as construction supt. and estimator for contracting firm. Experience includes general building, bridges, sewer work, concrete, boiler settings, sand blasting of bridges and spray painting. Available at once. Apply to Box No. 767-W.

WORKS ENGINEER, A.M.E.I.C. Twenty-four years experience, responsible for the design and building of extensions to mill buildings, specifying and installing of equipment and maintenance of plant of large manufacturing company. Good references. Will take position abroad. Apply to Box No. 768-W.

ELECTRICAL ENGINEER, B.Sc. (McGill Univ. '29), S.E.I.C. Married. Experience in pulp and paper mill mechanical maintenance, estimates and costs and machine shop practice. Desires position with industrial or manufacturing concern. Location immaterial. Available on short notice. References. Apply to Box No. 770-W.

ELECTRICAL ENGINEER, Queen's Univ. '24, JR.E.I.C., age 32, married. Experience includes, student Test Course, Can. Gen. Elec. Co., four years dial system telephone engineering with large manufacturing company. Available at once. Apply to Box No. 772-W.

CIVIL ENGINEER, B.Sc., '25, JR.E.I.C., P.E.Q., married. Desires position, preferably with construction firm. Experience includes railway, monument and mill building construction. Available immediately. Apply to Box No. 780-W.

DRAUGHTSMAN, experience in civil engineering, forestry engineering, land surveying and house construction. Good references. Apply to Box No. 781-W.

SALES REPRESENTATIVE. Electrical engineer with ten years experience in power field interested in representing established firm for electrical or mechanical product in Montreal territory. Excellent connections Apply to Box No. 795-W.

CIVIL ENGINEER, S.E.I.C., graduate '30, age 23, single. Experience includes mining surveys, assistant on highway location and construction, and assistant on large construction work. Steel and concrete layout and design. Apply to Box No. 809-W.

CIVIL ENGINEER, college graduate, age 27, single. Experience includes surveying, draughting concrete construction and design, street paving both asphalt and concrete. Available at once; will consider anything and go anywhere. Apply to Box No. 816-W.

CIVIL ENGINEER, B.E. (Sask. Univ. '32), S.E.I.C. Single. Experience in city street improvements; sewer and water extensions. Good draughtsman. References. Available at once. Location immaterial. Apply to Box No. 818-W.

CIVIL ENGINEER, S.E.I.C., B.Sc. (Queen's '32), age 21. Three summers surveying in northern Quebec. Interested in hydraulics and reinforced concrete. Available at once. Location immaterial. Apply to Box No. 822-W.

CIVIL ENGINEER, B.Sc., A.M.E.I.C., with fifteen years experience mostly in pulp and paper mill work, reinforced concrete and structural steel design, field surveys, layout of mechanical equipment, piping. Available at once. Apply to Box No. 825-W.

Situations Wanted

ELECTRICAL ENGINEER, S.E.I.C., grad. '29, age 24, married; experience includes one year Students Test Course, sixteen months in distribution transformer design and eight months as assistant foreman in charge of industrial control and switchgear tests. Location immaterial. Available at once. Apply to Box No. 828-W.

ALES ENGINEER, M.E.I.C., graduate civil engineer with twenty years experience in the structural, sales, and municipal engineering fields, and as manager of engineering sales office. Available at once. Apply to Box No. 830-W.

CIVIL ENGINEER, B.A.Sc., D.L.S., O.L.S., A.M.E.I.C., age 46, married. Twelve years experience in charge of legal field surveys. Owns own surveying equipment. Eight years on technical, administrative, and editorial office work. Experienced in writing. Desires position on survey work, assisting in or in charge of preparation of house organ, on staff of technical or semi-technical magazine, or on publicity, editorial or administrative office work. Available at once. Will consider any salary, and any location. Apply to Box No. 831-W.

AERONAUTICAL ENGINEER, B.Sc. (McGill), M.Sc. (Mass. Inst. Tech.). Canadian. Age 26, recent graduate. Capable of aeroplane design and stress analysis. Apply to Box No. 838-W.

CIVIL ENGINEER, M.Sc., R.P.E. (Sask.). Age 27. Experience in location and drainage surveys, highways and paving, bridge design and construction city and municipal developments, power and telephone construction work. Available on short notice. Apply to Box No. 839-W.

CIVIL ENGINEER, S.E.I.C., B.Sc. '32 (Univ. of N.B.). Age 25, married. Two years experience in power line construction and maintenance; one year of highway construction; one summer surveying for power plant site, location and spur railway line construction. Available at once. Location immaterial. Apply to Box No. 840-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.

CIVIL ENGINEER, B.Sc. (Alta. '31), S.E.I.C., age 24. Experience, three summers on railroad maintenance, and seven months on highway location as instrumentman. Willing to do anything, anywhere, but would prefer connection with designing or construction firm on structural works. Available immediately. Apply to Box No. 846-W.

MECHANICAL ENGINEER, JR.E.I.C., technical graduate, bilingual, age 30. Two years as designing heating draughtsman with one of the largest firms of its kind on this continent handling heating materials; three years designing draughtsman in consulting engineers' office, mechanical equipment of buildings, heating, ventilation, sanitation, power plant equipment, writing of specifications, etc. Present location Montreal. Available at once. Apply to Box No. 850-W.

BRIDGE AND STRUCTURAL ENGINEER, A.M.E.I.C., McGill. Twenty-five years' experience on bridge and structural staffs. Until recently employed. Familiar with all late designs, construction, and practices in all Canadian fabricating plants. Desirous of employment in any responsible position, sales, fabrication or construction. Apply to Box No. 851-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.

MECHANICAL ENGINEER, B.Sc. '32, S.E.I.C. Good draughtsman. Undergraduate experience:—One year moulding shop practice; two years pipe fitting and sheet metal work; one year draughting and tracing on paper mill layout; six months machine shop practice; and eight months fuel investigation and power heating plant testing. Desires position offering experience in steam power plants or heating and ventilating design. Will go anywhere. Apply to Box No. 858-W.

MECHANICAL ENGINEER, age 31, graduate Sheffield (England) 1921; apprenticeship with firm manufacturing steam turbine generators and auxiliaries and subsequent experience in design, erection, operation and inspection of same. Marine experience B.O.T. certificate thoroughly conversant with Canadian plants and equipment. Available on short notice. Any location. Box No. 860-W.

Situations Wanted

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.

ENGINEER, McGill Sci. '21-'25, S.E.I.C., aerial mapping, stereoscopic contour work; lumber classification; highway, railway and transmission line locations; estimates; water storage investigations, etc. Five years ground surveys; three years aerial mapping. Bilingual. Available on short notice. Apply to Box No. 872-W.

CONSTRUCTION ENGINEER (Toronto Univ. of '07). Experience includes hydro-electric, municipal and railroad work. Available immediately. Location immaterial. Apply to Box No. 886-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.Sc., Montreal 1930, age 26, single, French and English, desires position technical or non-technical in engineering, industrial or commercial fields, sales or promotion work. Experience includes three years in municipal engineering on paving, sewage, waterworks, filter plant equipment, layout of buildings, etc. Available immediately. Apply to Box No. 891-W.

ELECTRICAL ENGINEER, grad. Univ. of N.B. '31. Experienced in surveying and draughting, requires position. Available at once. Will go anywhere. Apply to Box No. 893-W.

CIVIL ENGINEER, B.A.Sc., JR.E.I.C., age 29, single. Experience includes two years in pulp mill as draughtsman and designer on additions, maintenance and plant layout. Three and a half years in the Toronto Buildings Department checking steel, reinforced concrete, and architectural plans. Available at once. Location immaterial. At present in Toronto. Apply to Box No. 899-W.

ENGINEER, JR.E.I.C., specializing in reconnaissance and preliminary surveys in connection with hydro-electric and storage projects. Expert on location and construction of transmission lines, railways and highways. Capable of taking charge. Location immaterial. Apply to Box No. 901-W.

MECHANICAL ENGINEER, Canadian, age 25, B.Sc. (Queen's '32). Since graduation on supervision of large building construction. Undergraduate experience in electrical, plumbing and heating, and locomotive trades. Available at once. Apply to Box No. 903-W.

DESIGNING ENGINEER, A.M.E.I.C. Permanent and executive position preferred but not essential. Fifteen years experience in designing power plants, engine and fan rooms, kitchens and laundries. Thoroughly familiar with plumbing and ventilating work, pneumatic tubes, and refrigeration, also heating, electrical work, and specifications. Apply to Box No. 913-W.

INDUSTRIAL ENGINEER, B.Sc. in M.E., age 25, married, is open for a position of a permanent nature with an industrial concern. Experience includes three years in various divisions of a paper mill and two years in an electrical company. Apply to Box No. 917-W.

ENGINEER, B.Sc., A.M.E.I.C., R.P.E. (N.B.), age 35, married. Seven years' mining experience as sampler, assayer, surveyor, field work, and foreman in charge of underground development; two years as assistant engineer on highway construction and maintenance. Available on short notice. Apply to Box No. 932-W.

CIVIL ENGINEER, B.Sc., '25, McGill Univ., JR.E.I.C., P.E.Q., age 32, married. Experience as rodman and instrumentman on track maintenance. Seven and one-half years with Canadian paper company, as assistant office engineer handling all classes of engineering problems in connection with woods operations, i.e., road buildings, piers, booms, timber bridges, depots, dams, etc. Apply to Box No. 933-W.

ELECTRICAL ENGINEER, Dipl. of Eng., B.Sc. (Dalhousie Univ.), S.B. and S.M. in E.E. (Mass. Inst. of Tech.), Canadian. Married. Seven and a half years' experience in design, construction and operation of hydro, steam and industrial plants. For past sixteen months field office electrical engineer on 510,000 H.P. hydro-electric project. Available at once. Apply to Box No. 936-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.

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R

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U

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V

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W

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THE ENGINEERING JOURNAL

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No. 5

MAY
1933

In this issue

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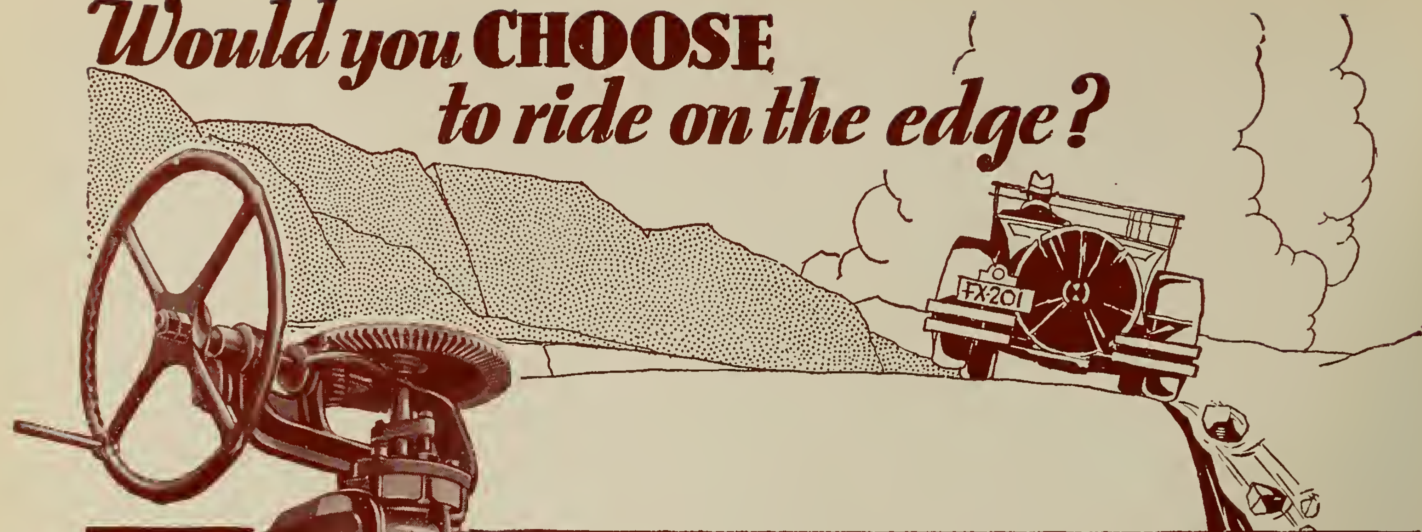

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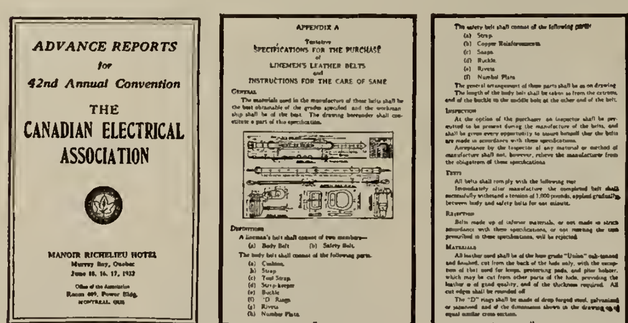

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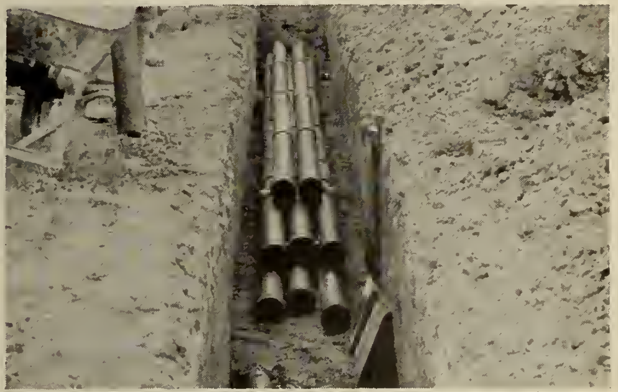

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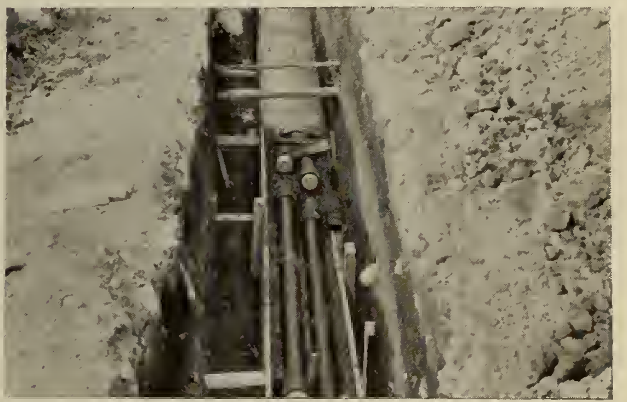

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Automatic Operation of Electric Boilers

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Paper presented before the Montreal Branch of The Engineering Institute of Canada, January 19th, 1933.

SUMMARY.—In the operation of electric boilers of the water resistance type on fluctuating loads, great variation in steam pressure may result due to the limited steam storage capacity of such boilers. The paper discusses two methods of automatic control, one based on varying the output of the boiler by changing the water level, and the other depending on changes in the electric resistance of the water. The two types of equipment required for these methods are described and the operation of the Eaton scheme of regulation by varying the temperature and specific resistance of the water is discussed in some detail. The paper also treats of control stability, the advantages of automatic control, and gives some operating results obtained in actual practice.

This paper will discuss the automatic operation of electric boilers of the water resistance types and more particularly those of the Kaelin design. These are built in two forms—the single tank type in which the three electrodes are enclosed in a single pressure vessel, and the three tank type, in which the electrode pertaining to each phase of the three-phase power supply is contained in a separate pressure vessel. The latter design is used for high voltage, large capacity boilers. The main object in separating the phases is to avoid the possibility of phase to phase short circuits.

Shawinigan Chemicals Limited was the first manufacturing company to use the Kaelin type of electric boiler and was also one of the first to depend entirely on this source of steam for a fluctuating load. On account of the very limited inherent steam storage capacity of such boilers, and their insufficient speed of response to the usual methods of manual control, it was found impossible to hold the boiler pressure within satisfactory limits. This led to the development of a system of automatic control, which this company has had in service for over two years, and which has resulted in satisfactory performance under severe conditions. A description of this control has been published*, but recently new features have been added by way of improvement, which merit further consideration.

At the present time this form of automatic control is installed for ten Kaelin electric boilers having an aggregate capacity of 127,000 kw., or approximately 10 per cent of the total installed electric boiler capacity in Canada. Of these ten electric boilers three are used in the chemical plant of Shawinigan Chemicals Limited, three in newsprint mills, one in a Kraft paper mill, two others supply steam for thermal purposes in cotton manufacturing, and the other is used by an aluminum manufacturing company. Nine are of the single tank type varying in sizes from 2,000 kw. to 25,000 kw., and the other is a 35,000 kw. boiler of the three tank type. In most of these applications the electric boilers supply the total steam demand independently.

*See "Power", September 29th, 1931.

Electric Boiler Operation

In order to understand the operation of electric boilers it is necessary to know something about their internal operating conditions. Fig. 1 shows a cross sectional view of a 25,000-kw., 6,600-volt, Kaelin electric boiler of the single tank type. The water level, as shown, would correspond with about full load. The current enters the electrodes and passes from phase to phase through the boiler water. Part of the current passes directly from one electrode to the other, the remainder passes first to the grounded neutral and then from the neutral to an opposite phase.

The grounded neutral serves a number of useful purposes. (1) It prevents current passing to the outer shell. If this occurred pitting of the shell would result. (2) It obtains a fairly uniform distribution of current over the surface of the electrodes, and (3) it divides the boiler into two vertical zones which permit free circulation of the boiler water. The inner zone is the active steam generating space, in which the escaping steam carries the boiler water and incoming feed water upwards, and induces a down current of water in the outer, inactive zone. The neutral is slotted to allow the water to pass through at any elevation.

These circulating currents are indicated in Fig. 1 by means of arrows. A number of advantages result from them. (1) Organic matter, held in suspension, is carried down to the sump where it can be blown off. Without effective circulation of the boiler water a greater amount of this organic matter would adhere to the electrodes as scale. (2) The steam being released with less disturbance to the boiler water, the load current is steadier. (3) The down current only reaches the bleed off connection and consequently the bleed water contains the maximum concentration of impurities.

To avoid the possibility of incoming feed water passing directly to the bleed connection the feed water inlet pipe is carried up as close to the bottom of the electrodes as is possible without causing too much electric current to pass directly to it, and is terminated with a nozzle. This nozzle is probably required only under very light load conditions.

Means of Controlling Power Input

Since the voltage applied to an electric boiler is constant, the power taken varies directly with the current.

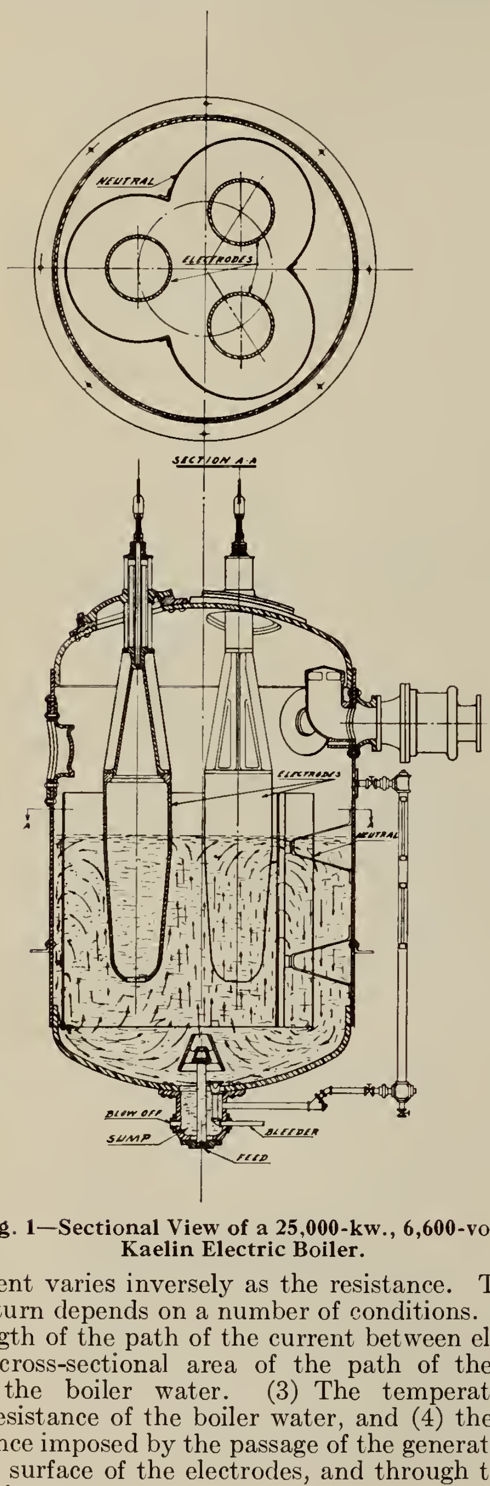


Fig. 1—Sectional View of a 25,000-kw., 6,600-volt Kaelin Electric Boiler.

The current varies inversely as the resistance. The resistance in turn depends on a number of conditions. (1) The mean length of the path of the current between electrodes. (2) The cross-sectional area of the path of the current through the boiler water. (3) The temperature and specific resistance of the boiler water, and (4) the amount of resistance imposed by the passage of the generated steam along the surface of the electrodes, and through the water in the active zone.

Of these conditions only (2) and (3) can be varied and thereby used as means of controlling the power input. The cross-sectional area of the path of the current through the water is varied by changing the water level on the electrodes. The specific resistance of the boiler water may be controlled by varying the concentration of salts in solution. Raising the water level increases the cross-sectional area of the path of the current and consequently decreases the resistance. Increasing the concentration of salts in solution also decreases the resistance of the path of the current and obtains the same result.

The incoming feed water carries with it a certain amount of salts in solution that affects the resistance of the boiler water. As evaporation goes on the steam is carried off and these conducting salts are left behind. Their concentration in the boiler water consequently tends to increase. The rate of increase depends on the purity of the feed water. This again depends on the quality of the make up water and the percentage of condensate in the feed water.

In order to maintain any given concentration of salts in the boiler water a certain amount of bleed off is required. The electrode spacings are such that in order to carry the load corresponding with any given water level the concentration of salts in the boiler, or bleed water, must be several times that of the feed water. If the concentration in the bleed water is ten times that of the feed water the bleed off required to maintain this concentration is 10 per cent. If the bleed water concentration is twenty times that of the feed water a 5 per cent bleed will maintain it. By varying the rate of bleed off the concentration of conducting salts in the boiler water may be varied and in this way the power input corresponding with any given water level may be varied. The concentration in the boiler water can be rapidly decreased by bleeding off water more or less saturated with salts in solution, and replacing it with comparatively pure feed water. The rate of increase obtained by stopping the bleed off depends on the purity of the feed water and is usually slow, though it may be made as fast as desired by admitting a regulated amount of salt solution with the feed water.

Manual Control

Manual control of the Kaelin electric boiler is usually carried out as follows:—On decreasing steam demand and rising pressure the feed water valve is closed, thus allowing the water level on the electrodes to fall as evaporation proceeds. At the same time the bleed off is increased to accelerate the fall in water level and decrease the concentration of conducting salts. This is continued until the pressure is normal. On increasing steam demand and falling pressure the bleed valve is closed and the rate of admission of feed water increased. This results in the water level being carried up on the electrodes and the concentration of salts being gradually increased. As previously explained, lowering the water level and decreasing the salt concentration reduces the power input. Similarly raising the water level and increasing the concentration of salts results in increased power input. The bleed valve is operated to reduce or maintain the salt concentration. In some applications means is provided for feeding salt solution. This is used when the response to closing the bleed valve and raising the water level is not fast enough.

General Electric Automatic Control

Fig. 2 represents a General Electric boiler equipped with automatic control which functions to maintain constant pressure. This electric boiler has an upper compartment in which the electrodes are located, and a lower compartment. A feed water regulator, (V3), maintains a fixed water level in the lower compartment. A circulating pump carries water from the lower to the upper compartment.

Water from the upper compartment continually runs down to the lower compartment through stand pipes (P1, P2, etc.) If the rate of circulation of the boiler water is increased by increasing the opening of valve (V1) the water level will rise on the electrodes, and similarly decreasing the opening of valve (V1) causes the water level to fall. This produces a corresponding increase or decrease in power input provided the concentration of salts is maintained constant. This is accomplished by the operation of bleed valve (V2).

The lower compartment and circulating pump provide means of rapidly lowering the water level on the electrodes without the necessity of bleeding. The lower compartment also contains water at boiler temperature and with the same concentration of salts as the water surrounding the electrodes. Raising the water level on the electrodes with water taken from the lower compartment is therefore more effective in obtaining an increase in power input than would be occasioned by raising the water level with comparatively pure and cool feed water.

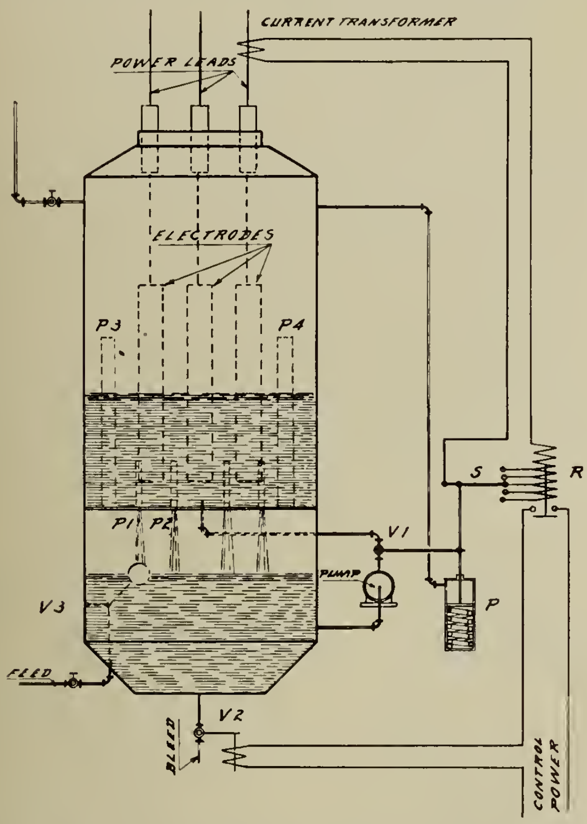


Fig. 2—Diagram of a G.E. Boiler equipped with Automatic Pressure Control.

The automatic control functions as follows:—P is a pressure device in which a piston is subject to boiler pressure on one side and spring pressure on the other. If the boiler pressure increases the spring is forced down. This decreases the opening of valve V1, and results in the water level being lowered on the electrodes, consequently the power input is correspondingly reduced. The pressure then tends to return to normal, similarly reduced boiler pressure causes an increase in the opening of valve V1, and the water level on the electrodes is consequently raised. This results in increased power input which tends to re-establish normal pressure.

For every opening of valve V1, there is a corresponding water level on the electrodes, and a corresponding position of tap-changing switch S, connected with the operating solenoid of relay R. As the water level is raised switch S cuts out turns in the solenoid winding and consequently more current must be taken from the current transformer to operate the relay. If the current corresponding with any given water level and corresponding position of tap-changing switch S exceeds a predetermined amount, relay R will operate causing bleed valve V2 to open, and the concentration of salts to be reduced. With low water level on the electrodes less current is required to operate relay R than with higher water level. In this way the upper compartment and electrodes constitute a conductivity cell to which the bleed valve operation is made responsive in such a way that substantially constant concentration of salts in the boiler water is maintained.

The apparatus shown in Fig. 2 serves only to describe the principle of operation. In order to obtain satisfactory performance much more complicated control apparatus and wiring are required. Valves V1 and V2 are motor operated and by means of reversing magnetic switches and relays are made respectively responsive to an electrical pressure instrument and a contact making ammeter with automatically adjustable load control rheostat. These instruments replace the pressure device P and relay R with switch S.

Eaton Automatic Control

Fig. 3 represents a single tank type of Kaelin electric boiler equipped with the system of automatic control developed by Shawinigan Chemicals Limited. This control will function to maintain either constant adjustable pressure or constant adjustable power input. The connections for pressure control only are shown.

The feed water flow to the boiler is controlled by feed water regulator valve V1 and thermostat. A hand wheel operated mechanism is provided for raising or lowering the thermostat. Flexible steam and water connections F1 and F2 permit its movement. Since the thermostat position determines the water level, this is made adjustable over the full range of the electrodes.

Electrically operated valve V3, differential tube D and connections form a bypass to the feed water regulator valve V1. A salt solution tank T is connected with the differential tube. Needle valves V5 and V6 are located in the connections.

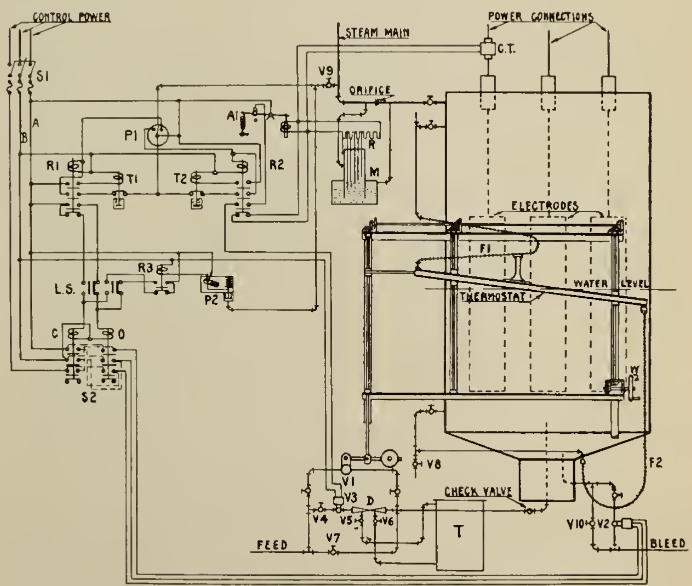


Fig. 3—Control and Connections for Kaelin Electric Boiler with Eaton Automatic Control.

V2 is a motor operated bleed valve. P1 is an electrical pressure instrument to which the control is mainly responsive. A contact making ammeter A1 and Mercoid control P2 are auxiliary regulating instruments.

The current required to break contact in instrument A1 depends on the current taken from current transformer C.T. and the value of shunt resistance R. This is automatically adjusted by means of a steam flow meter body mercury switch M.

The solenoid of A1 is normally short circuited by the bottom pair of contacts of relay R2. This makes the contacts of A1 normally closed. When R2 operates the short circuit is automatically removed.

Relay R2 controls the operation of bypass valve V3. Relay R1 and magnetic reversing switch S2 control motor operated bleed valve V2. This valve has a two-stage opening. The second stage operation is controlled by Mercoid control P2 and relay R3.

Bleed valve V2 must be motored in both directions, whereas bypass valve V3 is self reclosing.

Limit switch LS is mechanically connected with the bleed valve operating mechanism in such a way that any movement of the bleed valve is accompanied by a corresponding movement of the limit switch contacts.

The water level on the electrodes is adjusted to correspond with the mean operating load and is not altered except for load changes of considerable duration. The power input is controlled by regulating the concentration of salts in the boiler water. This is the reverse of the General Electric control according to which the salt concentration is maintained constant and the load is controlled by varying the water level on the electrodes. The General Electric control may be termed water level control, whereas the other is water resistance or conductivity control.

The operation is as follows:—

Bleed valve V2 and bypass valve V3 are normally closed. The feed water regulator maintains the water level corresponding with the mean load.

If the pressure rises to a predetermined value P1 energizes relay R1, which in turn energizes one of the directional contactors of reversing switch S2 causing the bleed valve to open the first stage. The resulting bleed reduces the power input tending to restore normal pressure. When contact is again broken in instrument P1 relay R1 becomes de-energized. The reclosing of the bottom pair of contacts operates the closing contactor of S2 thus returning the bleed valve to its normally closed position.

The first stage operation of the bleed valve takes care of the bleeding required to maintain a constant concentration of salts in the boiler water and load changes up to about 15 per cent. If a decrease in steam demand in excess of this occurs the pressure will continue to rise after the bleed valve opens the first stage and, at a predetermined value, Mercoid control P2 operates, and through its associated relay R3, causes the bleed valve to open a second stage. This results in a more rapid reduction in power input. When the pressure falls below that required to operate P2 relay R3 becomes de-energized. The reclosing of its bottom pair of contacts returns the bleed valve to the first stage opening.

When the bleed valve opens the water level on the electrodes begins to fall. The feed water regulator immediately responds to increase the rate of admission of feed water and thereby maintain the water level. It is the combined effect of bleed and increased flow of feed water that obtains the desired results. The increased flow of feed water momentarily decreases the rate of evaporation and tends to hold the pressure under control while the power-input is being reduced by the reduction in salt concentration resulting from the bleed water being replaced with comparatively pure feed water.

If an increase in steam demand occurs at a higher rate than the increase in power input, resulting from the bleed valve being closed, the pressure will fall and at a predetermined value P1 energizes R2, which in turn causes the bypass valve V3 to open.

Feed water then bypasses the feed water regulator valve V1 and as it passes through differential tube D salt solution is taken from tank T. The rate of admission of salt solution depends on the adjustment of valve V4 and needle valves V5 and V6. V4 should be adjusted so that the flow through the bypass is comparatively small. The water level on the electrodes rises until the feed water regulator functions to reduce the flow through V1 an amount equal to the flow through the bypass.

The admission of salt solution increases the concentration in the boiler water causing a rise in power input. As soon as the increase in power input corresponds with the increase in steam flow, which is responsible for the fall in pressure, the feeding of salt solution is cut off. This is accomplished by contact making ammeter A1 with its connected apparatus C.T., M and R. When the power input is made to correspond with the steam flow the pressure rises to normal and becomes stabilized.

Time delay relays T1 and T2 form holding circuits which function to avoid arcing at the contacts of instrument P1. As soon as contact is made in P1 the connected relay, R1 or R2, is energized and held in for the period of its associated time relay. This must be of sufficient duration to obtain appreciable corrective effect but not long enough to cause hunting.

When two or more electric boilers are operated in parallel means must be provided to prevent one of them taking more or less than its share of the load. This is accomplished by current balance relay supervision of the operation of the bleed valves. If the load taken by one boiler falls below its correct proportion of the total load its bleed valve is not allowed to open, on first stage bleeding only, until this condition is corrected. The same scheme applies to the balancing of the three phases of a three tank type of electric boiler.

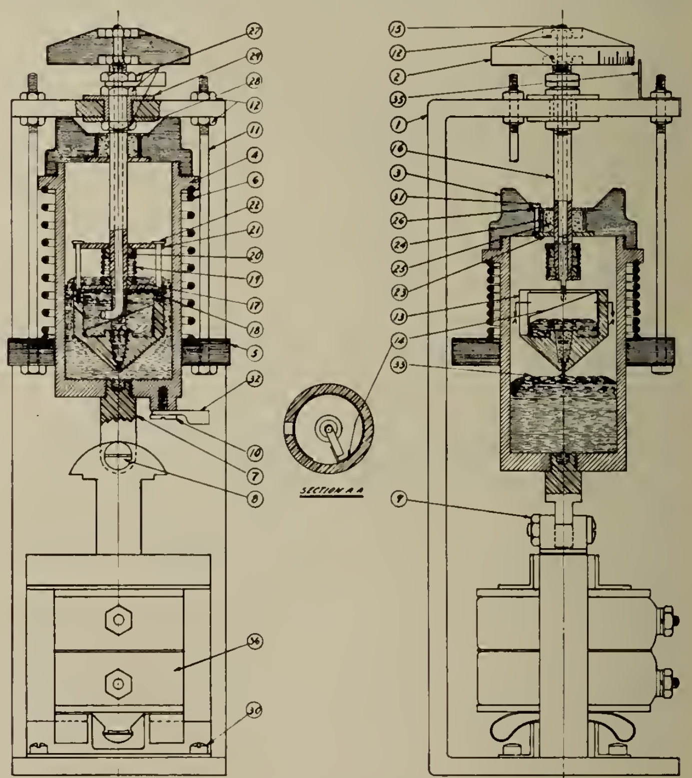


Fig. 4 Fig. 5

Special Time Delay Relay Developed for Eaton Automatic Control.

An electric boiler equipped with the automatic control apparatus shown in Fig. 3 is capable of maintaining the pressure within satisfactory limits under severe operating conditions. If the operating conditions are not severe the control may be simplified and the cost reduced accordingly. Each application requires separate consideration to determine the necessary control apparatus.

A special time delay relay was developed for use in connection with this boiler control. Figs. 4 and 5 show cross-sectional views of it. A cup, 4, containing a quantity of mercury, is supported by a spring, 6, from the top of a bracket 1, by bolts 11, and support 5, which is made of non-conducting material. The bottom of the cup is connected with the plunger of solenoid, 36, by a link, 7, also made of insulating material.

An inner dipper, 13, is supported by spring, 19, and rod, 16. This dipper has a gate opening cut in the side, and has an orifice through the lowest point. The relay terminals 27 and 32 are at the extremities of a circuit passing through the inner cup and mercury.

Fig. 4 shows the moving parts of the relay in their normal position. When solenoid 36 is energized, cup 4 is pulled down, as shown in Fig. 5 compressing its supporting spring. The mercury then begins to run through the orifice in the dipper. The stream of mercury carries the current and serves to interrupt the circuit when the mercury ceases to flow.

It is found that the stream of mercury forms a continuous conductor only in a short gap. In order to maintain a short gap the dipper is supported by a spring 19. When the operation of the relay causes a dipperful of mercury to be taken from the cup, this spring is compressed an amount corresponding with the distance the surface of the mercury in the cup falls. As the mercury runs out of the dipper the diminishing weight on spring 19 causes the dipper to be carried up and the short gap maintained.

When solenoid 36 is de-energized spring 6 carries the cup back to its normal position thus effecting instantaneous resetting.

The time period is determined by the effective size of the dipper and the size of the orifice. The period is made adjustable by varying the size of the gate opening and hence the effective size of the dipper. This is done by adjusting the position of the gate, shown in Fig. 5, by means of hooked rod, 15, terminating in a graduated knob, 2. The relay used in connection with the boiler control is made adjustable over a range of 7½ to 30 seconds.

Control Stability

An automatic regulator consists in general of two parts: an instrument for detecting and measuring the variations in the condition under control and a mechanism for correcting these variations. Unless the response to both is instant the controlled condition will tend to go alternately over and under the control point. In order to avoid this hunting, the regulator must be made to anticipate the amount of correction required. This is known as floating or throttling control.

Although the correcting mechanism of the automatic regulator described above, performs as in an over and under type of control, there is sufficient inherent stability to obtain the effect of floating control.

Considering the operation of the bleed valve, it has been pointed out that the opening of the bleed valve introduces three conditions that tend to reduce the pressure and hold it under control. These are the reduced rate of evaporation due to the increased flow of feed water, the lowering of the boiler water average temperature with consequent reduction in power input, and the reduction in the concentration of conducting salts causing a further fall in power input. When the bleed valve recloses the first two of these conditions are removed, and instead of the pressure continuing to fall it tends to recover. This compensating effect is also proportional to the rate of bleeding, and consequently is proportional to the rate of reduction in power input or steam pressure.

On feeding salt solution, the rise in power input at any instant corresponds with the amount of salt solution fed. The pressure, however, does not follow up instantly and if the control were responsive to the pressure regulating instrument only, overfeeding of salt solution would result. This is avoided by cutting off the feeding of salt solution as soon as the rise in power input corresponds with the increase in steam flow, which is responsible for the fall in pressure. This is equivalent to anticipating the amount of power input correction required to recover normal pressure.

Conductivity Control vs. Water Level Control

The advantages of conductivity control as compared with water level control, when applied to the Kaelin electric boiler, are best shown with a numerical example.

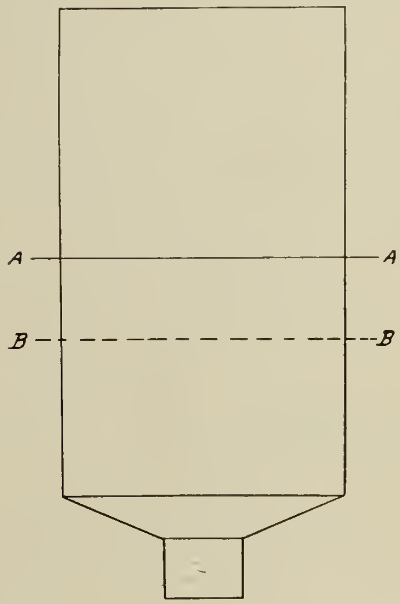


Fig. 6

Assume that an electric boiler, Fig. 6, is operating with water level "AA" and that the boiler pressure is 175 pounds, and feed water temperature 180 degrees F.

The boiling point, corresponding with 175 pounds pressure, is 378 degrees F. and latent heat of evaporation 847 B.t.u. per pound.*

The heat required to raise the feed water temperature to the boiling point is 202 B.t.u's per pound.

The total electric heat energy required to heat one pound of feed water to boiling temperature and evaporate it is 1,049 B.t.u's.

Now let us assume that a 30 per cent instantaneous reduction in steam demand occurs, causing the pressure to rise.

According to the automatic conductivity control performance the bleed valve would open to the second stage. The feed water regulator would then respond to increase the flow of feed water an amount equal to the rate of bleeding.

Assuming that the momentary bleed is equal to the rate of evaporation, the feed water flow is doubled, and for every pound of water evaporated two pounds must be heated to boiling temperature.

The amount of water evaporated by 1,049 B.t.u.'s of electrical heat energy then becomes $\frac{1{,}049 - (2 \times 202)}{847}$ or 0.76 pounds instead of one pound. This represents a 24 per cent decrease in the rate of evaporation.

The increased feed water flow also results in a decrease in the average boiler water temperature, particularly near the bottom of the electrodes. This causes an increase in resistance and consequently a decrease in power input. The rate of evaporation is thereby decreased a further amount of approximately 5 per cent.

*Calculated from Marks and Davis' Steam Tables.

The combined effects, enumerated above, result in a 25 per cent to 30 per cent momentary reduction in the rate of evaporation and are independent of the quality of the feed water. The advantage is that the pressure is held under control while the power input is being more permanently reduced by the reduction in the concentration of salts in the boiler water resulting from the bleed water being replaced with comparatively pure feed water.

Now let us consider the response to water level control. On rise of pressure, resulting from the 30 per cent reduction in steam flow, the feed water is cut off, to allow the water level to fall, and the bleed valve is opened. The resulting fall in water level is due to evaporation and bleeding.

With the feed water flow stopped no heat energy is expended in raising the temperature of feed water. 1,049 B.t.u.'s of electrical heat energy will then evaporate $\frac{1,049}{847}$ or 1.24 pounds instead of one pound as occurs with normal feed water flow. The rate of evaporation is consequently increased 24 per cent just when an effort is being made to reduce the pressure and hold it under control. This accelerates the rise in pressure and tends to carry it to blow off.

Again let us compare the performance of the two systems of control when the 30 per cent reduction in steam demand is recovered. If the reduction was momentary the water level, on conductivity control, would not be altered, and as a result the inherent steam storage, which varies with the volume of water in the boiler, is maintained. At a pre-determined fall in pressure, resulting from the increase in steam demand, the power input is increased by feeding sufficient salt solution to restore the original concentration.

Assuming that, on water level control, the water level was lowered to "BB," Fig. 6, corresponding with the 30 per cent reduction in steam demand, it is now necessary to return the water level to "AA." This is done by closing the bleed valve and increasing the rate of admission of feed water. If the feed water flow is increased to twice that at which constant water level was maintained, the amount of heat energy required to raise the temperature of the feed water to boiling point is doubled and the rate of evaporation is decreased 24 per cent. By lowering the water level to "BB" the inherent steam storage was also reduced. The decreased rate of evaporation, and decreased steam storage capacity, occurring at the instant of increased steam demand tend to produce a rapid fall in pressure, which will be carried too low for satisfactory operation unless sufficient external steam storage is provided to stabilize it.

The 24 per cent decrease in the rate of evaporation obtained with conductivity control is due to losses in the bleed water. Similar losses occur on water level control but without the same effect. With average feed water a 50 per cent bleed will effect a 25 per cent decrease in power input in about one minute. Assuming that the power input must be decreased 25 per cent thirty times a day, which is more than the average, the required bleed is equivalent to 50 per cent for 30 minutes. The corresponding losses in the bleed water result in a decrease of only one half of one per cent in the average efficiency.

Electric Boiler Efficiency

The electric boiler losses, which determine its efficiency, may be classified as follows:—

(1) Losses resulting from the bleed-off required to maintain the concentration of conducting salts corresponding with a given load and water level.
(2) Losses in the bleed required to effect load changes.
(3) Losses due to the blow-off of steam through the safety valves.

The first class of losses depends on the quality of the feed water. As previously pointed out, the rate of bleed required to maintain a constant concentration of salts in the boiler water depends on the ratio of boiler water concentration to feed water concentration. If the feed water is bad the bleed is heavy and the efficiency is unavoidably low.

According to the automatic control described for the Kaelin electric boiler the bleed valve is normally closed, and as a result full advantage is taken of the natural increase in the concentration of salts in the boiler water to effect load changes. On increasing steam demand the bleed valve remains closed thus obtaining an increase in power input, which tends to maintain the pressure. The bleed off is reserved for periods of decreasing steam demand and rising pressure. It is necessary to feed salt solution to the boiler only when the increase in steam demand is faster than the increase in power input due to the bleed valve being closed. Obviously the load changes that can be effected by controlling the bleed-off of natural salts carried in by the feed water are greater with impure feed water than with relatively pure feed water.

The efficiency of electric boilers is usually high, being in the order of 95 to 98 per cent. If the efficiency is low on account of impure feed water it may be considerably improved by recovering heat from the bleed water.

When bleeding is accompanied by a corresponding increase in the flow of feed water, the bleed make up water enters the hot well at the same instant, and in equal proportion, thus producing an ideal condition for recovering heat from the bleed water. If sufficient heat can be recovered from the bleed to maintain or raise the temperature of the hot well the bleed losses become very much reduced.

The usual method of obtaining a heat recovery of this nature is by means of a heat interchanger. Some scheme might also be devised whereby the bleed water flash steam is carried into the hot well water where it condenses and gives up its latent heat. The pure make-up water resulting from the condensed flash steam would prove an advantage in locations where the water is impure.

Advantages of Automatic Control

Automatic control is most advantageous in applications where the electric boiler supplies a fluctuating steam demand independently. On account of the limited inherent steam storage capacity, load changes must be effected faster, and must be better timed and more closely regulated than is usually possible on manual control. In any application it has inherent advantages over manual control. The attention of the detecting apparatus is sustained and corrections to the controlled condition are made in the most effective manner.

On manual control the performance depends entirely on the operator, who is incapable of sustained attention and will often adopt control methods of his own, which do not obtain the most satisfactory results.

Ideal operating conditions result from the use of a steam accumulator. These are designed to absorb all fluctuations in steam demand and thus permit the electric boilers, supplying the steam, to operate at steady load. The maximum advantages are obtained only if the electric boiler load is correctly adjusted. If this is allowed to fall too low the steam accumulator becomes undercharged and, on an increase in steam demand, the pressure is liable to fall below the control limit. Similarly if the electric boiler load is too high the accumulator becomes overcharged and, on a decrease in steam demand, blow-off pressure is liable to be reached. The tendency, on the part of the operator, is to maintain the overcharged condition.

On automatic control the electric boilers would operate at constant adjustable load. The load would be adjusted manually once a day, or once a week, to make it correspond with the mean steam flow. Automatic means would be provided to make limited load corrections at predetermined overcharged or undercharged conditions of the steam accumulator. These corrections would be effected in such a way that the steam accumulator would continue to operate through its full normal range of pressure, and consequently its maximum storage capacity would be utilized. The investment in automatic control would be justified by the increase in useful storage capacity resulting from its use.

In any application a gain in efficiency may be expected from the use of automatic control. This is due to the more closely regulated conditions, and the avoidance of steam losses through the safety valves.

There are also applications in which labour saving may be effected by means of automatic control. This is possible where more than one boiler room attendant is required for manual control, or where the electric boiler is located in the same room as some other equipment requiring an attendant, who is able to give the electric boiler attention in the event of trouble.

Electric Boiler Operation in Newsprint Mills

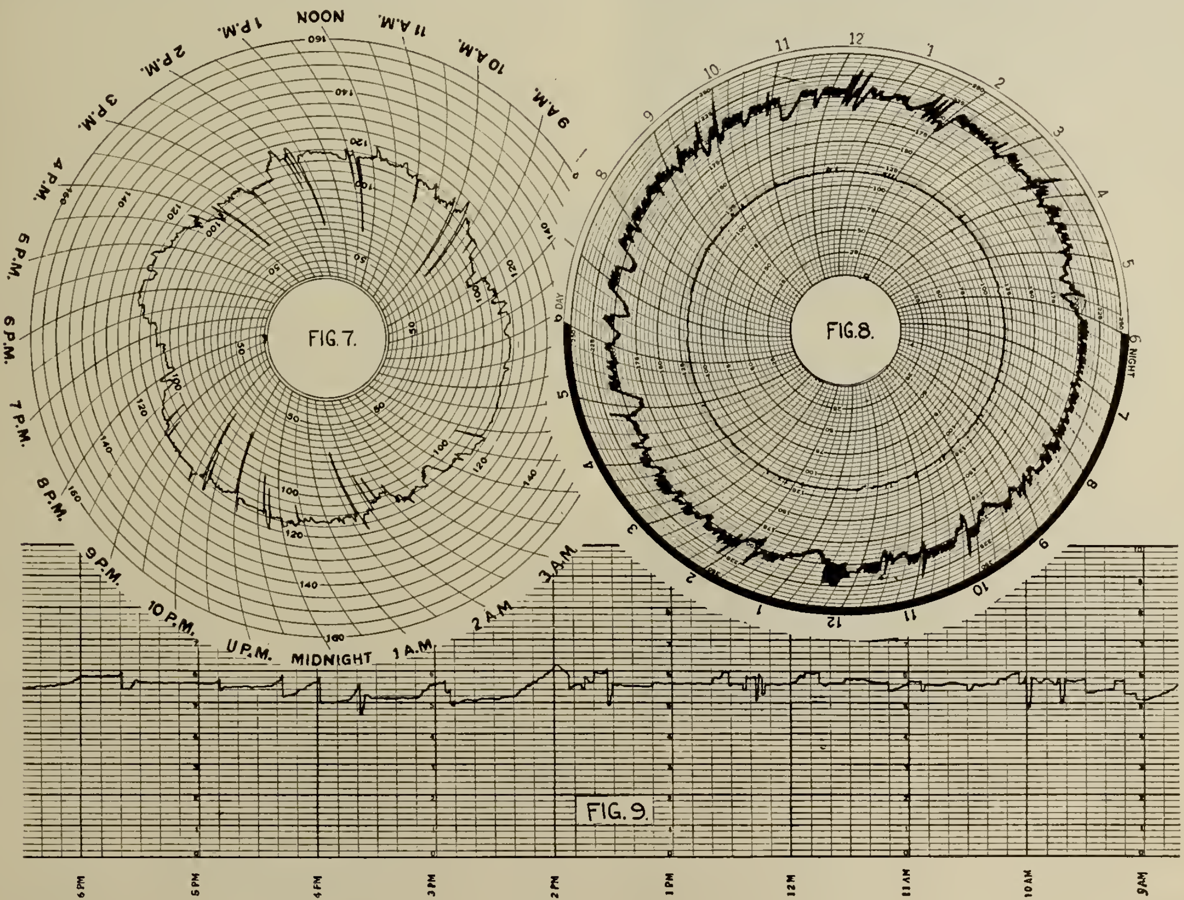
The newsprint mill electric boiler load is difficult to regulate due to the violent fluctuations in steam demand occasioned by interruptions of the paper machines. Conditions are improved if one or more coal-fired boilers supply part of the load. This is on account of the steam storage supplied by the coal-fired boilers rather than their ability to effect load changes more quickly. The necessity of load fluctuations may also be avoided entirely by the use of a steam accumulator.

The inherent steam storage capacity of an electric boiler may be made appreciable if the steam pressure is allowed to vary over a sufficiently wide range. This is done in newsprint mill applications where electric boilers are depended on for the total steam demand and no external steam storage is provided.

In order that the pressure fluctuations, at the boilers, may not interfere with thermal or power uses of the steam, a pressure regulating valve is located in the steam main between the electric boilers and the steam consumers. This valve maintains a steady mill pressure provided the boiler pressure is not allowed to fall too low. The permissible range of boiler pressure is from a few pounds over the regulated mill pressure to just under blow-off pressure. In existing installations this range is from 75 pounds to 100 pounds.

This scheme proves satisfactory, but unfortunately, as the boiler pressure is allowed to rise, the boiler water temperature rises and consequently its resistance falls. This results in an increase in power input. Similarly a fall in pressure causes a decrease in power input. These power changes amount to about 4 per cent for each 25 pounds change in pressure, and tend to increase the extent of pressure fluctuations. Again if the pressure is allowed to fall considerably below normal the power input required to maintain the lower pressure becomes too high as the pressure rises to normal. Similarly the more the pressure is allowed to rise above normal the greater is the required reduction in power input to stabilize it. For these reasons the range of permissible pressure fluctuation should be restricted as much as possible.

There are two newsprint mills in the province of Quebec in which Kaelin electric boilers, equipped with automatic control, are operating under conditions described above. In these applications it would appear that the automatic control may be so adjusted that it will hold the pressure within 25 pounds of a mean pressure for all steam flow fluctuations. This may not apply to starting



Figs. 7, 8 and 9—Steam Flow and Corresponding Steam Pressure and Power-Input Charts obtained from Electric Boilers, equipped with Automatic Control.

up conditions, but at these times the pressure may be held over a minimum, and allowed to reach blow-off on occasions of almost complete interruption in steam flow. With 125 pounds regulated mill pressure and 210 pounds blow-off pressure the optimum control point would be about 175 pounds. The control would then function to hold the outside limits of pressure fluctuations between 150 pounds and 200 pounds.

The charts shown in Figs. 7, 8 and 9, show the performance of one of these two electric boiler installations. Two 25,000-kw. single-tank type boilers supply the steam requirements. The steam is used by two paper machines, taking 40,000 pounds per hour each. The sulphite mill takes a maximum of about 30,000 pounds per hour. Other miscellaneous uses bring the total steam demand up to a maximum of 120,000 pounds per hour. This is shown for a twenty-four hour period in Fig. 7. The steam pressure and power input changes corresponding with steam flow fluctuations are shown by Figs. 8 and 9.

The automatic control is adjusted for a mean pressure of 205 pounds. The regulated mill pressure is 117 pounds and blow-off pressure 250 pounds.

It is interesting to note that, in order to hold the pressure within the control limits, momentary fluctuations in steam demand do not require corresponding fluctuations in power input of the same magnitude. This is partly due to the steam stored during the permissible rise of 25 pounds in boiler pressure. It is mainly due, however, to the momentary decrease in the rate of evaporation, resulting

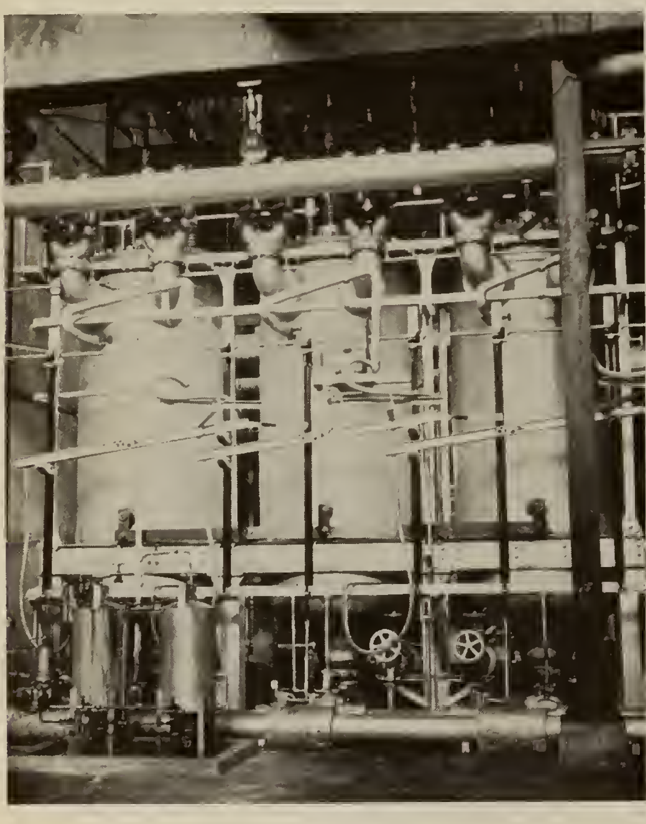


Fig. 10—A 35,000 kw. Kaelin Electric Boiler with Automatic Control.

from bleeding and increasing the rate of admission of feed water. This effect holds the pressure under control and permits the power input to be reduced less rapidly than would be otherwise necessary. In this way it has the effect of additional steam storage.

From the charts it will be seen that at 10 a.m. the steam flow fell from 113,000 pounds per hour to 72,000 pounds per hour, and after an interruption of two or three minutes, it rose momentarily to 117,000 pounds per hour returning again to 113,000 pounds per hour. The corresponding fluctuation in power input was from 35,000 kw. to 29,000 kw., the steam flow fell 35 per cent and the power input only about half of this. If the drop in steam flow were sustained for a longer period the power input would continue to fall until it reached an equivalent value.

The volume of water in each boiler, corresponding with the mean load shown in Fig. 9, is about 300 cubic feet. With this volume of water a change in pressure of 25 pounds effects a total steam storage of 450 pounds. A 40,000-pound per hour change in the rate of steam flow will therefore result in a 25-pound change in pressure in about 40 seconds, provided the power input is not altered. This indicates the control speed of response required to hold the pressure within the control limits.

Ninety-seven per cent efficiency is obtained with no heat recovered from the bleed water. If the amount of heat that can be conveniently stored in the hot well were recovered an average efficiency of 98 per cent would be expected.

Fig. 10 shows a 35,000 kw. three-tank type of electric boiler equipped with automatic control. The salt solution tanks and the feed water regulator thermostat adjusting mechanism may be seen. The three thermostats, which control the feed water flow to the three units, are so mounted that they may be raised or lowered simultaneously, by the operation of the upper shaft and connected bevelled gears. This is motor-operated and manually controlled from a push button station.

The thermostat required for the automatic control of a single-tank type of boiler is more easily raised or lowered and consequently this is done by means of a hand wheel.

The thermostat position is altered when necessary to adjust the water level to correspond with the mean load. This adjustment is required infrequently. In most applications once or twice a week is sufficient.

Fig. 11 shows the switchboard and electrical control apparatus used in connection with the automatic control of this three-tank electric boiler. The upper double throw knife switches are used to transfer from pressure control to power input control, or vice versa. The contact-making ammeter and load-adjusting rheostat face plate are on the top right. Six of the special time delay relays are in the row numbered 6, 7, etc. The two bottom left instruments are mercoid control pressure switches.

"Cascade Inn" Automatic Electric Boiler Control

A number of electric boilers used for the purpose of heating large buildings are of relatively low capacity and are operated at low pressure. In these applications the electric boiler and heating apparatus form a closed system in which all of the condensate is returned to the boiler. Since very little make up water is required the necessity of bleeding is practically eliminated. Under these conditions water level control is the more practical method of regulating the load.

Shawinigan Chemicals Limited has developed an automatic means of regulating an electric boiler of this class. This is a Kaelin type, rated at 500 kw. and operated from a 550-volt power supply at 40 pounds pressure. It is used for heating purposes in the "Cascade Inn," Shawinigan Falls. Steam at 40 pounds pressure is required by the laundry. Thermostatically controlled valves regulate the steam flow to heat interchangers for the hot water heating of the building. Similar valves control the heating of the hot water supply.

Fig. 12 shows the electric boiler and connected control apparatus.

The feed water flow from the make-up tank is controlled by the return trap and valves V4 to V8. The upper limit to which the water level can rise depends on which of these valves is open. If V6 is open and the lower ones closed, as soon as the water in the boiler rises to this level, water enters the line L2. The return trap will then cease to operate because the two water columns in L1 and L2 balance one another.

Fig. 11—Switchboard and Electrical Control Apparatus for Boiler, Fig. 10.

V1 and V2 are solenoid operated valves controlled by mercoid pressure switches S1 and S2. V1 is normally open and V2, normally closed. S1 is set to operate at 40 pounds and S2 at 45 pounds.

The load corresponding with any given water level on the electrodes is made adjustable by admitting salt solution. The salt concentration in the boiler water is adjusted to obtain the required power input variations corresponding with the range of water level fluctuations. A higher concentration is maintained during cold weather than during warmer weather.

The upper limit of water level is fixed by opening one of the valves, V4 to V8, corresponding with the desired level. The power taken at this level should be just over the maximum required to supply the peak steam demand.

When the pressure rises to 40 pounds mercoid control S1 operates to close valve V1. This cuts off the pressure at the top of the control tank and, on a further rise in pressure, water passes from the boiler into it, thus lowering the water level on the electrodes and reducing the power input. When the pressure returns to normal V1 re-opens and the water from the control tank returns to the boiler. This is a hunting cycle, the frequency of which depends on the throttling position of valve V9.

These cycles result in corresponding load fluctuations of about 50 per cent. As long as the power taken corresponding with the upper limit of water level is over the maximum demand, and that corresponding with the lower limit is under the minimum demand the pressure is held between 37 pounds and 43 pounds. The operation of the thermostatically controlled heat interchanger valves results in a fluctuating steam demand. There are three of these valves in use and when two or more close at the same instant a 50 per cent reduction in boiler load is not sufficient and the pressure continues to rise. At 45 pounds pressure mercoid control S2 operates to open valve V2. Steam is then released from the control tank, allowing the water level on the electrodes to fall still further. This steam bubbles up through the water in the make-up tank, where it condenses and gives up its latent heat. As the pressure rises reducing valve V3 closes, thus cutting off the admission of feed water. In this way the power input can be reduced to a very low value.

This is a typically over and under system of control resulting in continuous power input fluctuations. These fluctuations are not objectionable for low capacity boilers, but would not be satisfactory in the operation of large electric boilers.

A modified form of the control, in which the apparatus used would obtain the so-called "floating" control, has been considered for large electric boilers of the Kaelin type. The scheme drawn up was complicated and expensive. It was only partly automatic in that the bleeding was left on manual control. In view of these disadvantages the scheme of automatic conductivity control was preferred, and is now operating satisfactorily in the installation for which the other was intended.

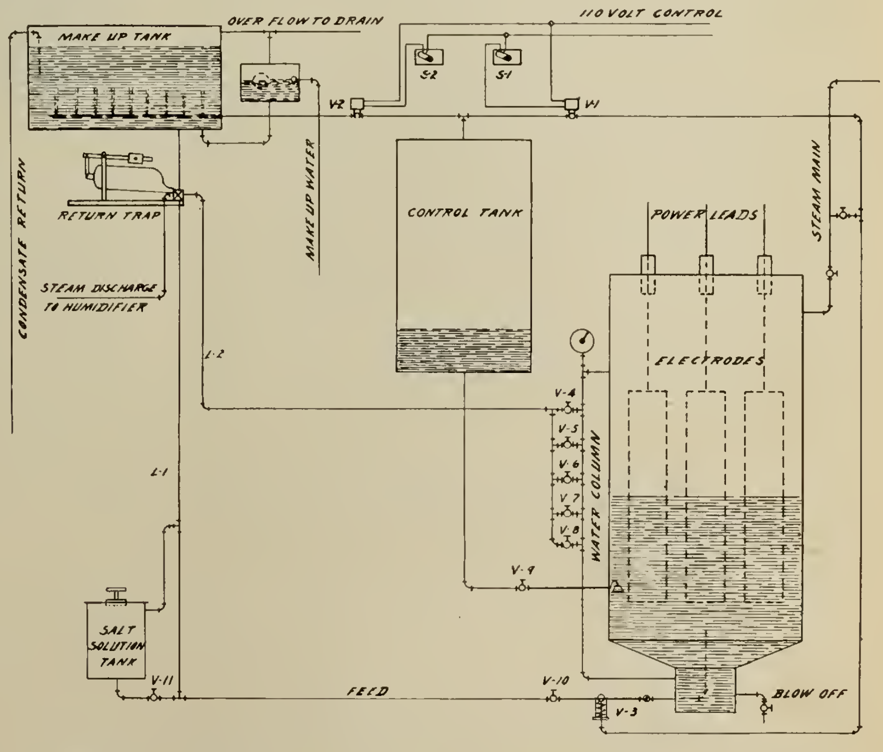


Fig. 12—Diagram showing Scheme of Automatic Water Level Control for 500 kw. Kaelin Electric Boiler.

Tests on Worm Gear Speed Reducers

For Power Capacity and Lubrication Data

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Paper presented before the Toronto Branch of The Engineering Institute of Canada, April 12th, 1933.

SUMMARY.—This paper is an experimental study of the power transmitting ability of worm gears under varied operating conditions. In it the author reports the results of eleven months of continuous engineering research work, and the full load and overload tests-to-destruction of a large number of standard high duty worms and worm gears. The paper develops a new basis for a possible rational formula for power rating of worm gear drives. It does not touch, except incidentally, the question of efficiency, nor consider the old style worm thread forms of unhardened material.

The purpose of the tests, which this paper reports, is the study of the power transmitting ability of worm gear speed reducers under varied operating conditions. It is hoped to establish a fundamental basis for power capacity ratings, which may perhaps be expressed in the shape of a formula, or, failing that, as a chart or graph. The work has not yet gone far enough to produce a formula.

The engineering data available on worm gear capacities are very meagre. The figures to be found in various sources are so contradictory that many of them must be in error. It is a fair assumption that much of the published information, including probably all the hand-book matter, is based on worms of a previous generation, both as to design and material. The technique of worm and worm gear production has undergone such improvement in recent years that the old is hardly even a basis for considering the new.

The Worm Gear Committee of the American Gear Manufacturers Association has been considering this, as one phase of its standardization programme, for a number of years. Several ambitious attempts at investigation failed, for various reasons. After the committee was reorganized under the chairmanship of Mr. Himes, an endeavour was made to collect data, which it was hoped would be useful, of the details of worm drives which had failed, with full reasons for failure, and also of gear drives which had succeeded under conditions known to be severe. It was hoped that thus a limit or line of demarcation between failures and successes might gradually be indicated. This attempt also came to naught, partly from lack of reports and partly from lack of complete or positive knowledge of all the conditions surrounding the cases reported. It was then decided that shop tests would have to be made on an assorted range of worms and gears, under definitely controlled and varied conditions. It was agreed that this work should be divided among the members most actively interested in the production of worm gears and worm gear speed reducers. Unfortunately, the hard times prevented all but two from doing anything on this, or at least anything they thought worth reporting. The reports herewith are of the author's own tests only, the other active member reporting separately.

The present programme has been under way in the author's plant since April, 1932, that is, nearly eleven months at the time of writing. Approximately six hundred tests have been made. Two gear housings were used, one of 7½-inch centre distance and one of 3½-inch centre distance between axes of worm and gear shafts. For reasons of economy most of the work was done with the smaller set. At the suggestion of the committee chairman, the load capacity tests were to be made with the same oil in all shops participating in this work. He selected oil 600-W made by the Vacuum Oil Company of Rochester, N.Y. This instruction was followed, but another series of tests

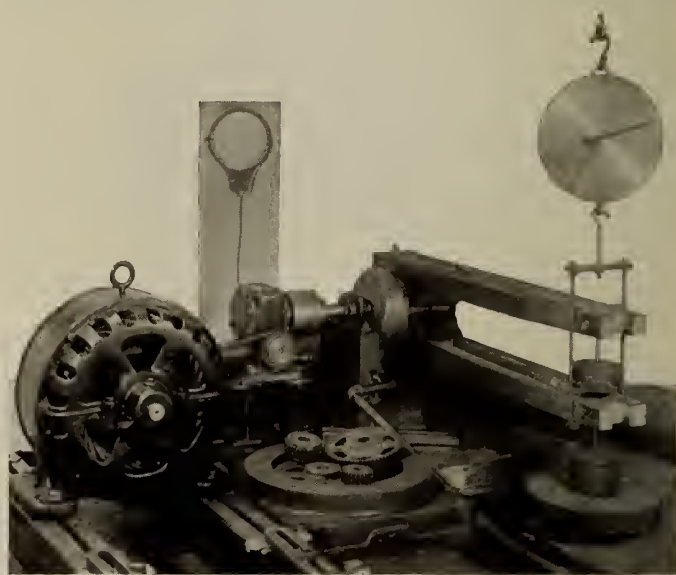

Fig. 2—Set up of Apparatus for Brake Test.

were made on a variety of oils, (see table Fig. 8), to compare their characteristics as to heating, i.e. the load which would cause an operating temperature of 210 degrees F.

The worms and gears tested are listed in table Fig. 1. The worms are of case hardened 3½ per cent nickel steel, S.A.E. No. 2315, 80 to 90 scleroscope hardness, and well polished. All gears are of nickel phosphor bronze containing 87½ per cent copper, 11 per cent tin, 1½ per cent nickel,

Fig. 1.—Table of Worm and Gear Dimensions

	Pressure Angle	No. of Threads in Worm	Circular Pitch	Pitch Diameter	Outside Diameter	Helix Angle	Ratio	No. of Teeth in Gear	Throat Diameter	Outside Diameter	Face of Gear	Working Depth
A............	30°	4	.4	1.550	1.750	18°10′	11¼	45	5.650	5¾	⅞	.200
B............	30°	2	.4	1.550	1.750	9°18′	22½	45	5.650	5¾	⅞	.200
C............	30°	1	.4	1.550	1.750	4°42′	45	45	5.650	5¾	⅞	.200
D............	30°	1	.25	1.520	1.646	3° 0′	71	71	5.604	5¾	⅞	.125
E............	14½°	1	.25	1.467	1.625	3° 6′	72	72	5.691	5¾	⅞	.158

with ¼ to ⅓ per cent of phosphorus. They were cast in sand with a chill ring about the outside diameter. Many more gears than worms were used up in the tests, as the worms never broke, and wore more slowly than the bronze gears.

In the housings, the worm was below the gear, both shafts being mounted in ball bearings. Both the 3½- and 7½-inch cases were cut open at the top, clear across the whole top area, and provided with a separate cover plate, so that the gear could be examined without disturbing bearing or contact relations. The oil level was kept constant, even with the inside of the rim of the gear, so that the gear teeth obtained ample lubrication and the worm was submerged. Temperature records of the oil bath were made continuously by a Bristol dial recording thermometer. The bulb was placed below the worm and as near to it as possible so as to receive the stream of hot oil as thrown off. Figs. 2 and 3 show the arrangement and details of the test apparatus.

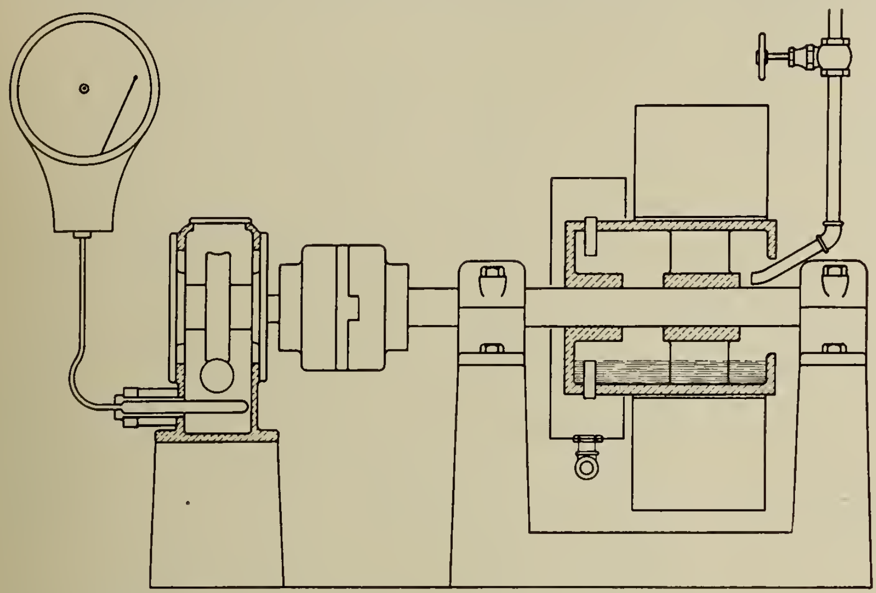

Fig. 3—Details of Arrangement of Brake and Thermometer.

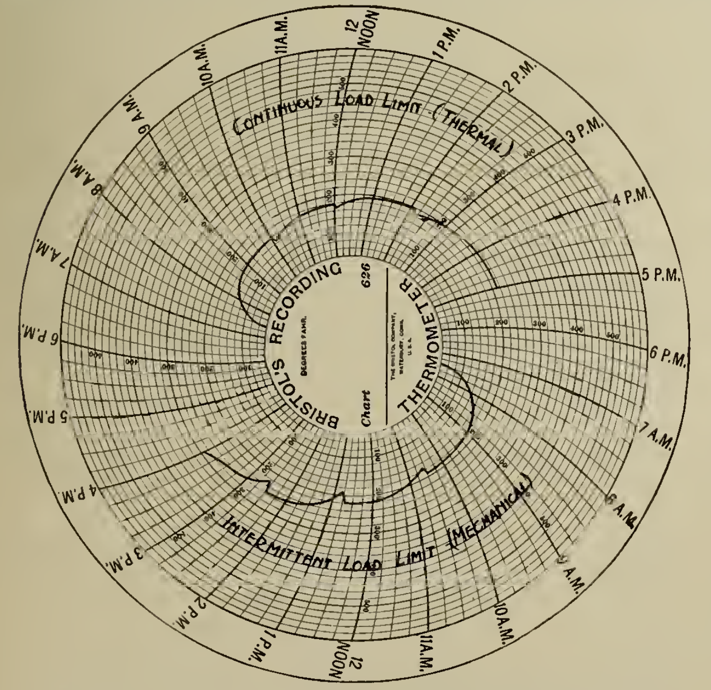

Fig. 4—Oil Temperature Record from Typical Brake Tests.

Power was supplied to the worm shaft from a motor by silent chain drives of various ratios to give the desired test speeds. Slip-fit sprockets with set screws gave an easy and quick way of changing speeds.

Output torque was measured by a water-cooled absorption brake of modified Prony form. It was of the full automatic, compensating, or nut-cracker style, in which no manual adjustment is made after being set. Each brake shoe has its own extended brake arm, the upper carrying suspended dead weights while the lower pulls down on a dial spring balance. The shoes are connected by one bolt only at the back of the drum. The readings are taken from the dial while running and standing, care being taken that the coupling between brake and gear shaft is free while the latter reading is taken. The spring balances were of 50-pound and 600-pound capacity, dial type, made by John Chatillon & Company, Philadelphia.

Two sizes of brakes were used: 24-inch dia. by 10-inch width with 63-inch arm, 10 pounds per h.p. per 100 rev., and 8½-inch dia. by 7-inch width with 42-inch arm, 15 pounds per h.p. per 100 rev. Both were water filled cast iron drums with polished surfaces. The shoes each embraced about 160 degrees of arc and were surfaced with motor truck brake lining, ¼ inch thick of good quality, with fastenings well countersunk. The water was not evaporated but circulated through the drum and discharged below the boiling point to avoid rusting machinery in the neighborhood from waste steam. Precautions were taken not to introduce any rubbing friction on the pipes.

The power capacity tests were of two kinds, or rather had two objects. First, to obtain the continuous load rating, which involved the thermal characteristics or radiating ability of the case. Second, to obtain the intermittent or short time load rating of the gears. The lubricant was constant, 600-W in both instances. The continuous load limit is the maximum load that can be transmitted continuously without exceeding 210 degrees F. (provided it is also below the point of mechanical failure). The intermittent load limit is the maximum load that can be transmitted without mechanical or metallic failure (breakage or abrasion). Neither is a commercial rating, as each must be divided by a suitable service factor or factor of safety.

WORM GEAR SPEED REDUCER TESTS

Reducer on Test - No. 36B Ratio - 22½ to 1

Worm - Double thread .400" C.P. 30° P.A. Mat'l. - SAE 2315 Gear - 45 Teeth Mat'l. - Chilled Bronze

Date	Time Test Started	Output load on scale: Stopped	Running	Net	Input RPM	Output RPM	Max. Red Temperature	Average Room Temp.	Reducer Temp. Rise	Oil
Feb. 18/33	8.00 A.M.	206	98	108	720	32	220	54	166	No. 13 M.C.F.
Feb. 20/33	8.00 A.M.	90	40	50	1820	81	200	58	142	No. 15 B.A.
" " "	9.30 A.M.	102	42	60	1820	81	215	60	155	No. 15 B.A.
" " "	12.10 P.M.	133	58	75	1530	68	230	60	170	No. 15 B.A.
" " "	1.30 P.M.	127	70	57	1530	68	205	62	143	No. 15 B.A.
" " "	3.00 P.M.	142	76	66	1530	68	215	62	153	No. 15 B.A.
Feb. 21/33	7.30 A.M.	190	104	86	720	32	190	58	132	No. 15 B.A.
" " "	10.30 A.M.	202	113	89	720	32	192	59	133	No. 15 B.A.
" " "	11.30 A.M.	226	130	96	720	32	200	59	141	No. 15 B.A.
" " "	12.00 Noon	240	138	102	720	32	205	59	146	No. 15 B.A.
" " "	1.00 P.M.	252	143	109	720	32	210	59	151	No. 15 B.A.
" " "	1.45 P.M.	258	140	118	720	32	225	59	166	No. 15 B.A.
" " "	3.00 P.M.	246	132	114	720	32	220	59	161	No. 15 B.A.
Feb. 22/33	8.00 A.M.	90	55	35	1820	81	190	58	132	No. 12B C.S.
" " "	9.00 A.M.	120	69	51	1820	81	220	58	162	No. 12B C.S.
" " "	11.00 A.M.	114	64	50	1820	81	218	58	160	No. 12B C.S.
" " "	12.00 Noon	133	70	63	1530	68	215	60	155	No. 12B C.S.

Fig. 5—Example of Log Sheet.

In making a series of tests on a certain pair of gears at a certain speed, a load was selected that they were sure to carry, and the curve drawn by the recording thermometer was watched till it turned over and flattened out to horizontal. Then heavier loads were applied in succession and the point at which the temperature curve flattened out noted in each case till the load was reached at which the corresponding stable or equilibrium temperature was 210 degrees F.

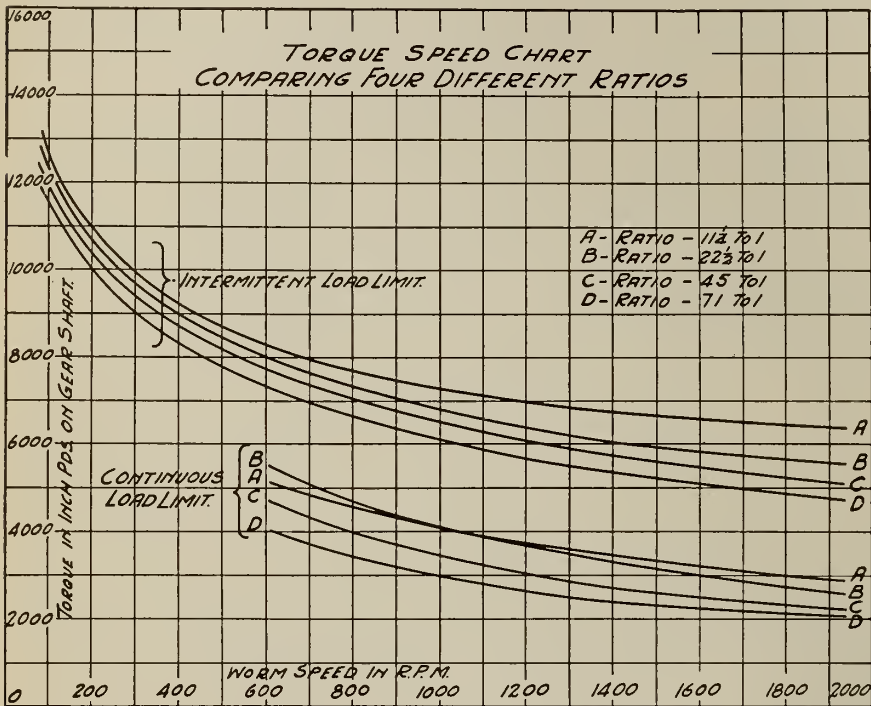

Fig. 6

To find the intermittent load limit implied a series of intermittent tests with cooling periods between. Cooling can be greatly accelerated by a blast of air from an ordinary electric fan directed against the outside of the case. Practical experience showed that the cooling periods could be entirely dispensed with if the fan was used continuously. The limiting condition, of mechanical failure, was found by visual inspection of the teeth of the gear, through the large open top of the case, after each test. The temperature curve drawn by the recording thermometer was found to be an invaluable guide. (See Fig. 4 which shows two typical runs.) Aside from the actual temperature, the shape of the curve gave immediate warning of abrasion. The normal curve is convex upward. Immediately abrasion occurs, the temperature rises rapidly and the curve turns concave upward. The time of reversal is exactly the time of failure. Thus, by watching the curve it is unnecessary to ruin the gear, as the slight surface abrasion can be smoothed out in the preliminary runs of the next test. If by chance the load selected happens to be right at the critical point where abrasion starts, then the curve may be wavy and horizontal, at least for a time, but it is liable to collapse into a failure curve with concave upward. Visible abrasion on the surface of the gear teeth always coincides with the change of type of curve. This is true throughout the speed range where abrasion is the limiting condition, but does not apply at low speeds where heat losses are small and tooth breakage is the limiting condition. It is satisfactory to know that these temperature curves, in series, were drawn from deductive reasoning a year before any had been made from tests.

In these tests to destruction for intermittent load limit, it was found that there was a practical limit to the oil bath temperature of about 300 degrees F. There appear to be several reasons for this. Above a recorded oil bath temperature of 300 degrees F. the local temperature right at the point of contact appears to approach dangerously near to (*a*) the point of preliminary breakdown of the oil, leading to carbonization, (*b*) the drawing of the temper of the worm slightly, but enough to permit it to wear, and (*c*) the "hot short" point of the bronze, or at least near enough to it to permit a crumbling sort of wear, if at high speed, or a breaking through tooth root or rim, if at low speed.

The results of the tests are presented below in groups, with the objectives and conditions of each stated at the head of each division. In general there were five speeds used, approximately 100, 300, 720, 1440 and 1800 r.p.m., the choice being partly indicated by induction motor speeds at 25 and at 60 cycles frequency. As the charts were plotted on a speed base it was immaterial exactly what the actual speed was, so long as the resultant torque figure was plotted on the actual speed ordinate. For a similar reason, torque instead of horse-power was used. Fig. 5 shows the kind of log sheet on which results were recorded. Fig. 4 is a typical recording thermometer dial chart. Figs. 6 and 7 show assembly charts on which the curves from several working charts are brought together and shown in their relation to each other, for comparison and analysis.

The general method of procedure in the load tests was to take one worm and gear and work on them till they were spoiled, varying the other conditions, rather than maintaining conditions and changing gears. It was found best to start at the highest speed and at the lowest load for that speed, i.e. at 1,800 rev. determine first the continuous load limit without fan cooling, and then the intermittent load limit with fan cooling. This ended with an abraded gear. Normally the abrasion of the gear would be slight and the worm would be uninjured. Shifting then to 1,440 rev., by changing the chain drive, the gear would be run in and polished at moderate load. This would then be increased by stages to determine the continuous load limit and then the intermittent load limit at that speed. Thus successively lower speeds would be used in turn. If the degree of abrasion was too much to polish up readily, but not enough to warrant taking out for re-hobbing, it was necessary to cold-

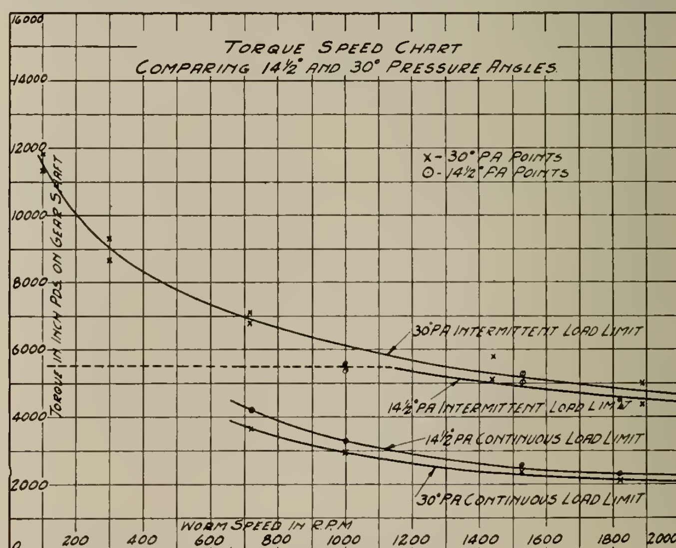

Fig. 7

Fig. 8.—Table of Oils Compared on Chart 9

Chart Curve No.	Description of Lubricant Referred to in Test on Chart Fig. 9	Viscosity Saybolt @ 210° F.	Pour Test Deg. F.	Baume Gravity Deg.	Flash (Open Tester)	Fire Test Deg. F.	Fatty Oils Per Cent.
1	600W. Steam Cylinder Oil	140	40	24½	540	600	5
2	A Good Steam Cylinder Oil	162	47	25	565	635	5
3	A Lighter Compounded Mineral Oil	90	— 5	20½	340	390	10*
4	Mineral Cylinder Stock, Distilled	150	25	18	450	480	0
5	Steam Refined Transmission Oil	150	55	22½	520	580	0
6	Castor Gear Oil	91	—20	16½	477	561	0
	*The 10% is vegetable oil, no animal fat.						

work the surface by dropping to a lower speed and applying a fairly heavy but safe load, in several increasing steps, using fan cooling to control the temperature. This same procedure of cold working was used after re-hobbing or when starting to use a new gear. It had no part in the test itself but was an essential preliminary. Otherwise there would be no consistency in the test results as between a new gear and one that had been through several other tests. This is in agreement with ordinary commercial practice on any bronze bearing where one is well advised to "go easy at first" till the job "gets a skin burnished on it."

Subdivision 1.—Power Capacity Tests

To find the continuous load limit, as defined by the 210 degrees F. limit line on the torque-speed chart.

Conditions: *Constants*—One case of 3½-inch centres; one oil, 600-W by Vacuum Oil Company; *Variables*—two pitches (one worm of .25 in. c.p. and three worms of .4 in.

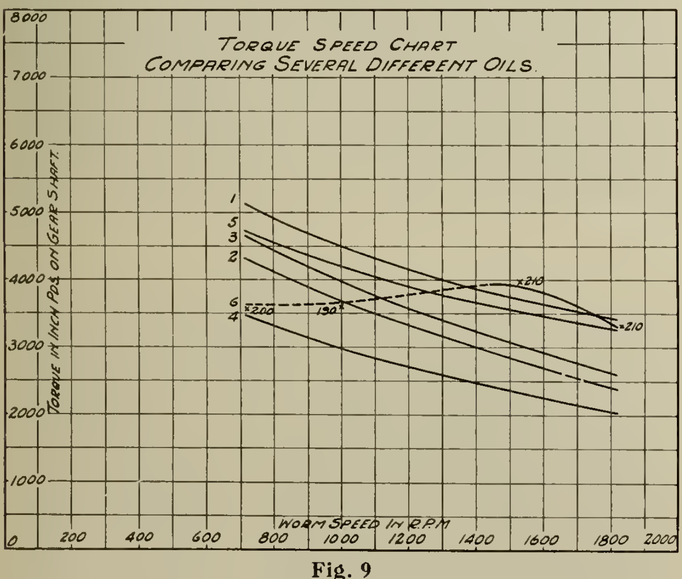

Fig. 9

c.p.); four ratios, single 71 to 1, single 45 to 1, double 22½ to 1, and quadruple 11¼ to 1; four speeds, 1,800, 1,440, 1,000 and 720 (a thermal limit has no significance at very low speeds); *Operation*—progressively increasing loads applied and temperature recorded; Series terminates with test load which will produce an oil bath temperature of 210 degrees F. with natural radiation from exterior of case. Results are shown in chart Fig. 6. Photograph, Fig. 10, shows the four worms.

Subdivision 2.—Power Capacity Tests

To find the short time or intermittent load limit, as defined by the highest load which would not cause failure by abrasion, permanent tooth deflection or breakage of the worm, the gear or both.

Conditions: *Constants*—one case of 3½-inch centres; one oil, 600-W by Vacuum Oil Company; *Variables*—two pitches, (one worm of .25 in. c.p. and three worms of .4 in. c.p.); four ratios, single 71 to 1, single 45 to 1, double 22½ to 1 and quadruple 11¼ to 1; five speeds, 1,800, 1,440, 720, 300 and 100 r.p.m; *Operation*—progressively increasing loads applied and temperature recorded; visual observation for abrasion each time load is increased; series terminates with test load which produces mechanical failure, with fan cooling on outside of case. The final (failing) and next previous (successful) torque loads are both plotted on chart to speed base. At high and medium speeds failure was always by abrasion, at low speeds by breakage. Results are shown in chart Fig. 6.

Photographs, Figs. 11 to 14, show four of the gears after being tested to destruction. In Fig. 11, the 71 tooth, .25-inch c.p. gear, a section of teeth sheared clear off at a tangent load of 4,300 pounds. Fig. 14, ratio 45 to 1, is selected to show one that failed by abrasion, though a flowing of the bronze at the ends of the teeth is also visible near the left edge of the picture. Fig. 13, ratio 22½ to 1, shows a combination of flowing of the metal along with bending of the teeth. The large amount of wear shown occurred on earlier tests previous to the final failure run. Fig. 12, ratio 11¼ to 1, shows how the whole rim may flow till angular cracks develop inwards from the bottom of each tooth space. The cracking and tilting of the teeth is very symmetrical around the gear, the failure appearing to be fatigue shear. The cracking is most extreme on the leaving edge of the gear, i.e. the side with the least pressure angle. The opposite edge, which has the greater pressure angle is characterized by an extreme flowing of the bronze.

Subdivision 3.—Power Capacity Tests

To make a comparison of two worm gear drives, one of 14½ degrees, the other of 30 degrees pressure angle but otherwise similar, the basis of comparison being their respective continuous load limits and intermittent load limits, using the same methods as in subdivisions 1 and 2.

Conditions: *Constants*—one case of 3½-inch centres; one oil, 600-W by Vacuum Oil Company; One pitch, .25 in. c.p. single thread; *Approximate Constants*—ratio 72, worm p.d. 1.467 in. for the 14½ degrees pressure angle; ratio 71, worm p.d. 1.52 in. for the 30 degrees pressure angle; *Variables*—two pressure angles, 14½ degrees and 30 degrees; six speeds, 1,800, 1,440, 1,000, 720, 300 and 100

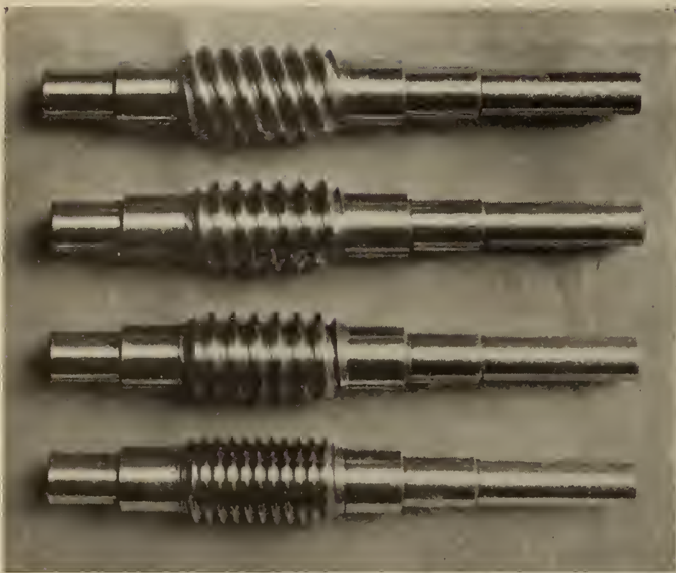

Fig. 10—The Four Worms, Tests of which are Recorded on Chart Fig. 6. The Lowest is the 30-degree Worm Referred to on Chart Fig. 7.

r.p.m.; *Operation*—progressively increasing loads applied and temperature recorded; same procedure as in Subdivisions 1 and 2. Results are shown in chart No. 7. The 30-degree worm and gear are shown in Figs. 10 and 11.

The 14½-degree gear runs slightly cooler at motor speeds and ordinary operating loads, i.e. it will carry slightly more load without exceeding 210 degrees F. The 14½-degree gear failed completely, by the folding over of the teeth, at a load about half that at which the 30-degree gear failed by shear. This 14½ degree failure occurred at 1,000 r.p.m. At higher speeds the 14½-degree gear failed by the usual abrasion but at a lower load than the abrasion point of the 30-degree gear. The lines fall so close that for moderate loads, and also for heavy loads at speeds above 1,200 r.p.m., there is no choice between the two pressure angles. For heavy loads at speeds below 1,200 r.p.m. it is obvious that the 30-degree gear is far superior. Also it should be noted that, short of the point of shearing off the teeth, any damage done to the 30-degree gear by a temporary overload is repairable by merely running-in till the worm polishes the gear again. On the other hand, the 14½-degree gear fails by a gradual bending of the teeth till they assume a ratchet form and lock the worm. Such damage is not repairable and the gear is a total loss from perhaps only a few minutes excessive load.

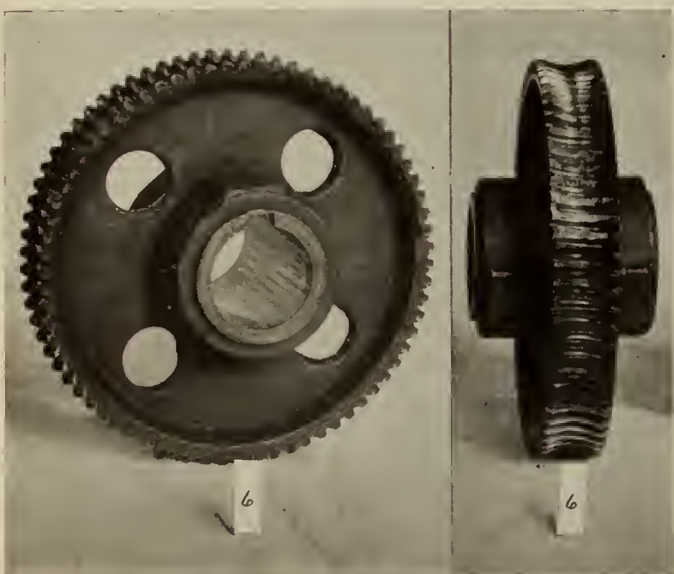

Fig. 11—Worm Gear after Test to Destruction, .25-inch c.p., 30-degree p.a. to Mate Single Thread Worm.

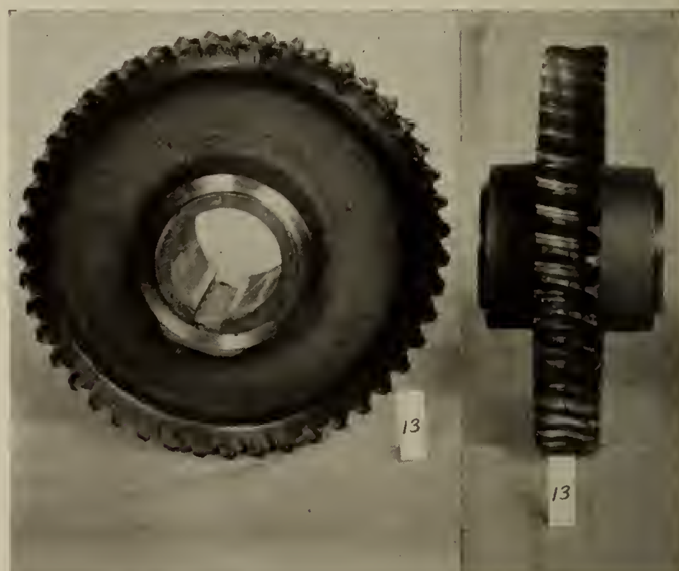

Fig. 13—Worm Gear after Test to Destruction, .4 inch c.p., 30-degree p.a. to Mate Double Thread Worm.

Fig. 12—Worm Gear after Test to Destruction, .4 inch c.p., 30-degree p.a. to Mate Quadruple Thread Worm.

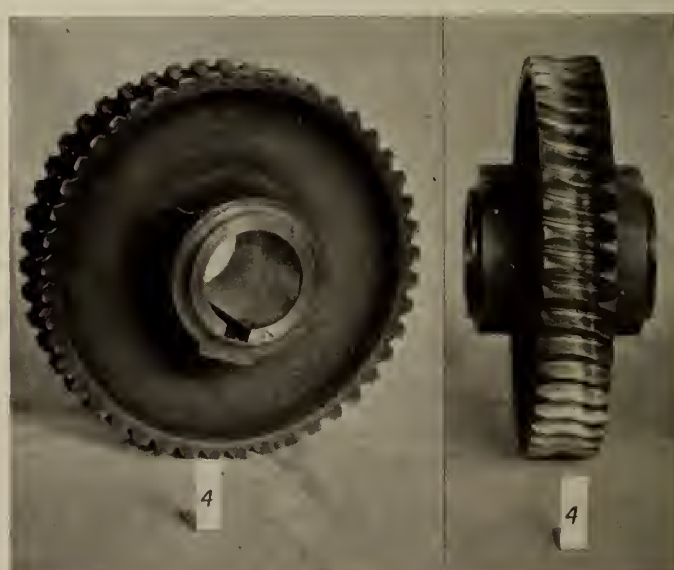

Fig. 14—Worm Gear after Test to Destruction, .4 inch c.p., 30-degree p.a. to Mate Single Thread Worm.

Subdivision 4.—Power Capacity Tests

For the comparison of various lubricating oils at speeds where abrasion is the limiting factor, omitting low speeds where tooth bending or gear breakage enters into the question, the basis of comparison being the 210 degrees F. continuous load limit line, determined as in subdivision 1 and plotted on the torque-speed chart. Conditions: *Constants*—One case of 3½-inch centres; one pitch, .4 in. c.p. double thread; one ratio, 22½ to 1; *Variables*—three speeds, 1,800, 1440 and 720; six different oils; *Operation*—progressively increasing loads applied and temperature recorded; load series terminates with the test load which will produce an oil bath temperature of 210 degrees F. with natural radiation from exterior of case.

Oil description listed on table Fig. 8. Results are shown in chart Fig. 9.

No. 2 oil fell below No. 1, probably by reason of its high viscosity .162 sec., which tended to increase the heating from fluid friction. No. 3 being a very much lighter oil was apparently about as far from the most desirable viscosity but in the other direction. The compounding used in this instance was a vegetable oil. No. 4 was a rather sticky asphalt base oil, and appeared to have a disproportionately high fluid friction. All others except No. 6 were paraffin base wholly or partly. No. 5 was a straight paraffin cylinder stock, steam refined, but not distilled over the top. It resembled No. 1 but had no compounding with animal or vegetable additions. No. 6, a patented mineral and castor blend, largely castor oil, gave a peculiar result. While it performed well at high speed, it would not carry enough load at the lower speeds to develop even a bath temperature of 210 degrees F. without collapse or failure of film lubrication, with rapidly rising temperature and abrasion. Therefore the part of line No. 6 shown dotted and marked with temperatures 200 and 190 degrees F. is really the mechanical or intermittent load limit line, while all full lines are thermal or continuous load limits.

A horse power rating formula cannot, of course, be developed from the data in this paper alone, because only one centre distance and two pitches were used, but when some further experimental work has been done on other variations of these factors, we hope to be able to build a satisfactory formula of truly rational type.

The Development of Special Portland Cements in Canada

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Chief Chemist, Canada Cement Company Limited, Montreal.

Paper presented before the Montreal Branch of The Engineering Institute of Canada, February 23rd, 1933.

SUMMARY.—This paper traces the development of rapid hardening cements, of which the first were high in alumina. These were useful but expensive, and their success inspired efforts to obtain a high early strength Portland cement. Cements of the latter type have now been produced successfully and the author describes the investigations and the methods of manufacture which have characterized Canadian practice. The paper also discusses methods of measuring the size of the minute particles in H. E. S. Portland cement for which extremely fine grinding is essential. This paper will be followed by a second, dealing with Canadian work on the development of an alkali-resistant cement.

Portland cement has been manufactured now for over one hundred years and as in other industries, during that time great changes have taken place in machinery and processes, and to some extent in chemical composition.

The Portland cement industry for many years depended principally upon haphazard experimentation and observations, but was fortunate in establishing very definite limits in chemical composition and process from the standpoint of quality and economy of production. In the last fifteen years cooperative effort in research of the associations of member companies in America, and elsewhere, has reached a high level and has investigated many problems both in the intelligent use of cement in concrete and in the chemical and metallurgical field. The identification of the mineralogical components in cement and their relative cementitious value has been established, and the study of the process of manufacturing clinker, and the hydration or setting and hardening of the individual components separately and collectively, and other research is in progress, with some phases of the investigations already completed.

Europe Develops a New Type of Hydraulic Cement

Shortly after the war, attention was directed to the new alumina cements which had been developed by the French and were used to some extent for the rapid construction of gun emplacements during the war because of their property of rapid hardening. In mixes of similar proportions to those used in Portland cement concrete, the aluminate cement concrete developed as much strength in one day as Portland cement would in a week or more. The alumina cements of Europe which were brought to the attention of Canadians in 1921 by C. M. Morssen, M.E.I.C., were made in electric furnaces by bringing to fusion a mixture of limestone and bauxite.

Although this type of cement is not exactly new, since a patent was granted to a German named Ludwig Roth in 1882 for making bauxite-cement and a British patent was granted to G. J. Snelus for a lime alumina cement 3 parts lime, 2 parts bauxite in 1888, the early attempts do not appear to have been very successful. The Bied process patented in 1908 was perhaps the first successful process. The yield was 10 to 35 tons or 60 to 200 barrels of cement per day from small vertical kilns 30 inches to 60 inches in diameter and 10 feet to 25 feet high, using coke as fuel. Electric furnaces were also used and rotary kilns with success when the mixture of bauxite and limestone was heated to complete fusion instead of holding it at the clinkering point as was first attempted in the rotary kiln.*

This new type of rapid hardening hydraulic cement excited much interest among engineers, chemists and others of the Portland cement trade and samples received in this country were examined and studied by chemical analysis and mechanical test for the purpose of a definite appraisal of their properties in comparison to the well known characteristics of Portland cements. To illustrate the difference in composition the following table has been compiled showing the analyses of several samples of each type of cement, Portland and alumina, received at the laboratories of the Canada Cement Company from various sources.

*E. C. Eckel.

Table I

	Typical Portland Cements 1921-1922					Alumina Cements 1922-1925				
	Whites English Per Cent	French Cement Per Cent	Alsens German Per Cent	Typical American Per Cent	Average Four Canadian Cements Per Cent	Chemical Symbol	Ciment Electrique Per Cent	Ciment Electrique Per Cent	Ciment Fondu Per Cent	Atlas Lumnite Per Cent
Silica SiO_2	23.22	23.00	21.74	21.69	22.05	SiO_2	7.04	9.37	8.31	8.82
Ferric Oxide Fe_2O_3	2.90	2.51	3.05	2.40	2.70	Fe_2O_3	2.94	0.29	11.10	14.09
Ferrous Oxide FeO	—	—	—	—	—	FeO	13.51	5.74	2.60	—
Alumina Al_2O_3	7.02	7.18	6.60	6.67	6.38	Al_2O_3	39.68	39.48	40.94	36.42
Calcium Oxide CaO	62.38	63.60	61.96	62.02	62.15	CaO	35.70	44.60	35.99	37.22
Magnesia MgO	1.48	1.04	1.43	3.44	2.88	MgO	0.76	0.35	0.71	0.72
Sulphuric Anhydride SO_3	1.35	0.45	1.70	1.75	1.69	SO_3	—	—	0.12	0.65
Loss on Ignition	1.56	1.17	3.02	1.20	1.42	Loss on Ignition	0.15	0.17	0.06	2.00
Total	99.91	99.95	99.50	99.17	99.27	Total	99.78	100.00	99.83	99.93

Table II

	English	French	German	American	Canadian
	Per cent	Per cent	Per cent	Per cent	Per cent
Calcium Sulphate ($CaSO_4$)	2.30	0.77	2.89	2.97	2.87
Tetra Calcium Alumino Ferrite ($4CaO.\ Al_2O_3.\ Fe_2O_3$)	8.81	7.62	9.27	7.29	8.20
Tricalcium Aluminate ($3CaO.\ Al_2O_3$)	13.70	14.79	12.32	13.62	12.35
Tricalcium Silicate ($3CaO.\ SiO_2$)	22.22	30.73	33.29	34.19	33.66
Dicalcium Silicate ($2CaO.\ SiO_2$)	49.84	42.83	37.28	36.46	37.89

Comments on the Comparative Composition of Portland and Alumina Cements

The above table of typical analyses of samples received between 1921-1925 will serve to show the contrast in chemical composition that the alumina cements presented to Portland cements representative of the time in Europe and America.

The alumina cements known as Ciment Electrique and Ciment Fondu were fused cements, the products of vertical electric furnaces. Lumnite was the alumina cement produced in rotary kilns by the Atlas Cement Company.

The approximate formula for alumina cements has been given in some patents as $5CaO.\ 3Al_2O_3+CaO.SiO_2+FeO.\ SiO_2$ for the cements made in the electrical furnaces. A large proportion of the iron content of the product from such furnaces was present in the ferrous form (FeO) or possibly as $FeO.Fe_2O_3$ and could be removed with a magnet. The iron in Lumnite a rotary kiln product however was all present in the ferric form (Fe_2O_3).

Recent studies of the compounds present in the alumina cements indicate that the ferric oxide (Fe_2O_3) probably occurs as $2CaO.\ Fe_2O_3$ and not as $CaO.\ Fe_2O_3$ and that in the presence of sufficient $CaO.\ Al_2O_3$ the double compound $4CaO.\ Al_2O_3.\ Fe_2O_3$ is formed. Calculations on this basis would indicate the probable presence of the compounds $3CaO.\ 5Al_2O_3$ and $CaO.\ Al_2O_3$ in some of the cements and $CaO.\ Al_2O_3$ and $5CaO.\ 3Al_2O_3$ in others depending upon the silica and ferric iron content and the relative amounts of lime and alumina present.

In the Portland cements analysed at that time however the alumina compound was probably the tricalcium aluminate $3CaO.\ Al_2O_3$, on account of the fact that plenty of lime was available in the mixture to form this compound at the temperatures prevailing in the hottest part of the kilns.

The Portland cements of Table I were all sound and of good quality, although somewhat lower in tensile and compressive strength at the early periods of test than the Portland cements of present day manufacture. It was assumed that the cements contained no free lime and the probable compound composition was calculated to have been as shown in Table II.

From the above it will be evident that the compounds present in the Portland cements were quite different from those present in the alumina cements and that the cementing properties of the alumina cements depended upon the

Table III

Comparison of Compressive Strength of Standard Sand Mortars made from Alumina Cement and Portland Cement In Pounds Per Square Inch

Age at Test	Alumina Cement	Portland Cement	Strength per cent	Alumina Cement	Portland Cement	Strength per cent
	Mix 1—3	Mix 1—3	Advantage to Alumina Cement	Mix 1—4	Mix 1—4	Advantage to Alumina Cement
1 Day	2,163	813	266	1,235	475	260
2 Days	2,907	1,397	208	1,813	863	210
3 Days	4,533	2,200	206			
7 Days	5,360	2,720	197	2,773	1,596	174
28 Days	5,065	4,440	114	3,330	2,523	132

calcium aluminates, while the cementing quality of the Portland cements was derived principally from the lime silicate compounds. It may be noted also that the Portland cements of ten years ago were in general lower in tricalcium silicate content and relatively higher in dicalcium silicate than those of today.

Comments on Alumina Cements

The market costs of the alumina cements were much greater than the Portland cements and hence they did not threaten very serious competition with Portland cement except in construction wherein time was the most important factor.

Many tests were made to determine the relative strength of the Portland and new alumina cements in mortar and concrete. The alumina cement samples obtained from various sources were not of course of equal quality or strength, but in general all excelled in the compressive strength in mortar or concrete developed at 1, 2, 3 and 7 days as compared to the Portland cement specimens of equal mix and age. An illustration of how the best of the alumina cements inspected compared in 1-3 and 1-4 mortar tests is given in Table III.

It will be noted that the alumina cement in 1-3 mortar attained its highest strength at seven days. The advantage in strength shown by the alumina cements gradually lessened with time and in fact the Portland cement mortars surpassed several of the alumina cements in mixes of equal proportions at two years and thereafter.

The following is a comparison of several alumina cements and Portland cements in concrete under similar conditions, for example, type, grading and proportions of aggregate; water content or consistency and moist curing at equal temperatures, each value being an average of several tests made in 1923-1924. (See Table IV.)

The test results in the above table also show that the strength developed by both types of cement was affected by a change in the temperature of curing as well as by other variations of test conditions.

Alumina Cements Inspired Efforts to Increase The Early Strength of Portland Cement Concrete

The discovery or development of successful processes for the manufacture of alumina cements in vertical and rotary kilns and in the electric furnace acted as a spur to those engaged in the Portland cement industry both in Europe and America and started intensive research and experimental work in a study of ways and means by which the development of higher early strength in Portland cement concrete might be accomplished. The discussion in this paper of this enterprise on the part of Portland cement manufacturers will be necessarily limited to a brief description of some of the work done in Canada towards the desired achievement.

Since the comparative cost of Portland cement was only one-quarter to one-half that of the alumina or fused cements, the first efforts towards a high early strength Portland cement concrete were made by experiments to determine the factors of most influence or advantage for the purpose.

Fig. 1—Experimental Road Opened to Heavy Traffic in Twenty-four Hours, Pointe Anne, September, 1925.

The use of calcium chloride as an accelerator was investigated. A considerable number of tests established the fact that two per cent by weight of the cement produced the maximum benefit. In rich mixtures it was found to produce an average gain in strength of 40 per cent to 50 per cent at twenty-four hours over similar concrete made without it.

The more important recommendations resulting from the research for the production of high early strength Portland cement concrete were as follows:—

1.—The use of rich mixes.

2.—The quantity of mixing water should be kept to the minimum required to produce plastic or workable concrete.

Table IV

Compressive Strength of 6-Inch by 12-Inch Concrete Cylinders In Pounds Per Square Inch

Kind of Cement	Mix by Volume	Water Cement Ratio	Cured at Normal Temperature				Cement and Mix	38 Degrees — 50 Degrees Cured at Low Temperature			
			1 Day	3 Days	7 Days	28 Days		1 Day	3 Days	7 Days	28 Days
Canada	1–4	.65	1068	2912	3419	4570	Canada 1–4	226	1941	3082	3885
French Electrique	1–4	.8	1709	4500	5207	5658					
Electrique	1–6						Canada 1–6	97	646	1743	2803
Quebec	1–2–4	100	580	2860	3324	3903					
Fondu	1–4	Relative consist.		7000	7280	8090*	Ciment Electrique 1-6	269	(2) Days 723	1812	2715
Average of 4 Brands Portland Cement		given as equal on Flow Table		1760	2850	4740*					

*These tests were made at the Portland Cement Association in Chicago using sand and pebbles graded to 1½ inch.

3.—Calcium chloride of good commercial purity should be used as an accelerator admixture added as a solution at the mixer.

4.—The aggregates used should be graded as coarse as conditions permit.

5.—The temperature of the concrete should be 70 degrees F. or higher when poured and concrete should be protected to maintain it at such temperatures for the first day without the loss of moisture or in other words should be kept moist.

Construction of Concrete Roads to Demonstrate Efficiency of Methods

To prove that these methods could be employed with success in accelerating the early strength of concrete and make it possible when expedient to put Portland cement concrete into early service three stretches of concrete road were constructed at Montreal, Belleville and Port Colborne. These were opened to traffic and heavy trucks ran over them twenty-four hours after pouring, and this despite the fact that two of the sections were constructed in October in moderately cold weather.

The richest mix used in the construction of the three sections of road was:—

1 part cement (Canada)
½—1 part clean natural sand
2 parts crushed stone.

and 2 per cent by weight of the cement or 1¾ pounds of calcium chloride per bag of cement.

The mix was made workable with a water content of 3 to 3¼ Imperial gallons per sack of cement.

The average temperatures of the weather were below 50 degrees F., and the minimum temperatures below freezing.

The following is a synopsis of the strength obtained with this mix on specimens moulded and stored beside the road until the time of the crushing test.

Table V

Pounds per Square Inch Compressive Strength

	24 Hrs.	*2 Days*	*7 Days*	*28 Days*
Montreal	2,175	3,620	4,655	5,232
Belleville	1,940	2,419	3,571	4,669
Port Colborne	1,451	2,675	4,526	5,678

Meanwhile, chemists had been studying the influence of variations in composition and improvements of process in the development of early strength.

The Development of New Type of Portland

Europe, particularly Switzerland, seems to have led in the development of the high early strength Portland cements, at least the earliest information of such a product came from Zurich and a little later in 1926 from Dr. Kuhl of Germany. These had a much higher strength at one and three days than the standard or normal Portlands.

In composition they were higher in alumina content and lower in silica. The percentage of Al_2O_3 found on analysis of the Kuhl sample was 9.18 per cent with ferric oxide 5.80 per cent and silica 16.8 per cent. Several cement companies in France and England also brought out a cement of greater early strength than their normal product, and in the United States several developed cements of similar characteristics. In Canada, there was as yet comparatively small demand for such cements, partly because the experimental work towards the production of high early strength concrete through the use of methods similar to those described previously in this paper had been successful when used for rush jobs, but after The Canada Cement Co. plant at Lakefield, Ontario, was rebuilt along more modern lines permitting perfect chemical control of composition, it seemed opportune to see what could be done in producing a cement which would compare with the high early strength cements of other countries.

Reason for Choice of Lakefield for Experiment

At Lakefield there is a deposit of very excellent cement rock which is in the form of a large plateau, the top surface being flat with very shallow overburden and about thirty-five feet above the level of the adjoining area. The rock belongs to the Black River geological formation and is composed of beds of fairly pure limestone ranging from 78 to 93 per cent in content of calcium carbonate and thinner layers of calcareous shale of 43 to 70 per cent calcium carbonate.

The strata lie almost horizontal and the proportions are such that the average of the full face is almost a perfect mix. In order to keep the mix uniform, blending silos or tanks are used in the plant operations. The mixed rock and shale is put through crushers, then dried in rotary driers and afterwards ground in ball mills and passed into storage tanks which are sampled automatically as they are filled. The chemist then draws from these in the proper proportions for the desired mix. The material is passed through measuring hoppers and discharged into a receiving hopper and conveyed to the tube mills where it is pulverized to a fineness of about 85 per cent passing the No. 200 sieve. The result is a raw mix feed for the kilns of very uniform chemical composition which produces an excellent quality of cement and an easily burned clinker.

The composition of the mix and cement for the ordinary product of the plant together with the average setting time, fineness and 1—3 tensile and compressive strength is given on Tables VI and VII.

Table VI

Chemical Analysis of Ordinary Raw Mix and Cement Produced At Plant No. 7

	Per Cent Raw Mix	Per Cent Cement
Silica (SiO_2)	15.14	21.62
Alumina (Al_2O_3), Ferric oxide (Fe_2O_3)	5.37	9.28
Lime (CaO)	42.42	63.47
Magnesia (MgO)	1.42	2.19
Sulphuric anhydride (SO_3)	—	1.63
Loss on ignition (Carbon dioxide, etc)	34.90	1.25
Hydraulic modulus $\frac{CaO}{SiO_2 + Al_2O_3 + Fe_2O_3}$	2.06	2.05

Typical Physical Tests

Fineness	*Sieve No. 100*	*Sieve No. 200*
Per cent passing	98.4	82.7

Setting Time:—
Initial Set—2 hrs. 50 mins.
Final Set —5 hrs. 0 min.

Table VII

Strength of 1-3 Standard Sand Mortar in Pounds per Square Inch

Tensile Strength				Compressive Strength			
3 Days	282	278	296	3 Days	2,430	2,266	2,416
7 Days	357	347	351	7 Days	3,580	3,400	3,550
28 Days	433	415	443	28 Days	4,150	4,683	4,516

By rejecting clayey material at the quarry it was possible to increase the lime content of the material delivered to the mill, and by careful blending to obtain a mix of the approximate composition desired for the first experiment in production of high early strength. The object of course was to produce a clinker of considerably higher content of tricalcium silicate than was contained in the routine product. The mix being more basic and lower in the fluxes, iron and alumina, was naturally more refractory and more difficult to clinker. It might be well to describe briefly here the changes brought about in burning the raw material to clinker in a cement kiln.

The raw meal or mix consists as stated in a finely ground mixture of clay constituents, silica, alumina, iron oxides principally and the carbonates of lime and magnesia. The carbon dioxide content of such a mix is usually from 34.5 to 35.5 per cent. There is in the case of the dry processed materials very little moisture, but in the wet process plants the water content of the mix or slurry may be from 30 to 40 per cent.

The material to be calcined and clinkered is fed into one end of the kiln, the fuel, slack coal or oil is blown into the opposite end of the kiln, so that as the kiln turns the cement material moves down towards the flame and into a progressively increasing heat.

Reactions in the Kiln

The temperature of the gases at the exit end of the kiln for dry process may be as high as 1,200 degrees or 1,600 degrees F. and of the front or firing end 2,600 degrees or 2,900 degrees F. The exit gas temperature of a wet process kiln is usually maintained at 550 degrees F. or lower.

The moisture or water of the mix is driven off first and as the material proceeds down the kiln the carbon dioxide is expelled when the temperature of dissociation has been reached. This temperature has been placed at 896 degrees C. (1,645 degrees F.) at 760 millimetres or 29.92 inches barometric. The dissociation temperature decreases as the pressure decreases and vice versa increases with the pressure.

The first reactions in the kiln, evaporation of water and decomposition of the carbonates are endothermic reactions requiring heat to bring them about. Of the various secondary reactions some are exothermic and some are endothermic.

When the dissociation of the carbonates is completed the oxides $CaO.\ MgO.\ Al_2O_3.\ Fe_2O_3.$ and SiO_2 remain as the principal components and reaction between these is carried on following the heat treatment required to bring about combination.

Ferric oxide and alumina having the lowest melting temperatures are the first to form combinations with the lime, and because they and magnesia lower the temperature of liquid formation they hasten the reactions between the lime and silica of the mixture, forming eutectic mixtures which result in liquid formation at temperatures (e.g. 1,300 degrees C.) below those required for mixtures of the equilibrium compounds.

Magnesia, while assisting in the formation of combinations of lime and silica through its fluxing action, does not appear in any of the four major combinations of the oxides which constitute the active part of cement according to the investigations carried on by the Portland Cement Association Fellowship under Dr. Bogue.

While the first reactions in the kiln between the oxides probably result in the initial formation of dicalcium ferrite $2CaO.\ Fe_2O_3$ and penta-calcium trialuminate $5CaO.\ 3Al_2O_3$, these compounds as the heat treatment continues take up more lime and are in the clinker identified in the ternary compound tetra-calcium alumina ferrite $4CaO.\ Al_2O_3.\ Fe_2O_3$. If more alumina is present in the mixture than the quantity required to unite with the ferric oxide available, it is found combined with lime in the binary compound tricalcium aluminate, and if the iron is in excess of the amount required for the ternary compound it may be found in the compound dicalcium ferrite. W. C. Hansen and L. T. Brownmiller and R. H. Bogue in their studies on the system calcium oxide—alumina—ferric oxide in 1927 were probably the first to identify the ternary compound tetra-calcium alumina ferrite in Portland cement and to determine its optical properties (biaxial and negative) and its melting point 1,320 degrees C.

Tricalcium Silicate the Most Important Compound for Early Strength

The most important of all the cementitious compounds in Portland cement is tricalcium silicate.* It appears to be formed by the interaction of dicalcium silicate in the solid state with a liquid supersaturated with respect to CaO. The action is slow because one of the reacting phases is a solid. A small quantity of CaO may be taken up rapidly in reaction with $2CaO.\ SiO_2$ if a large amount of the dicalcium silicate is present, but with decreasing rate, as the dicalcium silicate is decreased in the melt. In order therefore to obtain a high tricalcium silicate content a higher temperature is required or a longer exposure to the temperature used. The determination of free lime in the clinker will indicate if the reaction is complete or can be completed under the prevailing conditions of composition of the mix and heating capacity of the fuel and kiln.

There has been a great deal of research done in recent years by the Portland Cement Association on the effect of particle size distribution on properties of Portland cement and also on the valuation of the properties of the four compounds $3CaO.\ SiO_2$, $2CaO.\ SiO_2$, $3CaO.\ Al_2O_3$ and $4CaO.\ Al_2O_3.\ Fe_2O_3$.

The results of the latter investigation indicate that early strength is due entirely to the $3CaO.\ SiO_2$ tricalcium silicate and $3CaO.\ Al_2O_3$ tricalcium aluminate and that $2CaO.\ SiO_2$ (dicalcium silicate) has very little strength until the later ages, but from six months to two years the increase in strength of the $2CaO.\ SiO_2$ is about twice as great as the increase in strength of the $3CaO.\ SiO_2$.

One large cement company in the United States, in order to increase the tricalcium silicate content of their cement and thus add to its potential strength at early periods, grind their clinker and reburn it in another kiln adding additional lime if required. Other methods followed are to use great care in preparation of the mix, maintaining certain ratios such as the socalled hydraulic modulus and silica ratio within certain limits.

The raw materials available at the Lakefield and Montreal plants have made this latter method easily pos-

Table VIII

Showing Hypothetical Sieves Capable of Measuring Small Particle Sizes

Sieve No.	Size of Opening: Inches	Millimeters	Particle Size in Microns
100	.0054	.149	149
200	.0029	.074	74
325	.0017	.044	44
450	.0012	.031	31
630	.0008	.022	22
910	.0006	.015	15
1420	.0003	.009	9
2030	.0002	.006	6
3330	.00015	.004	4
4760	.00011	.003	3

*Bogue and Taylor.

sible, as was proved in the first experimental run at Lakefield in April 1929.

While the composition of the cement clinker must be as stated one of comparatively high tricalcium silicate content, that alone would not suffice to produce such high one day strengths as are required today for this type of special cement. The cement must be ground much finer than the normal or standard product in order to make available for hydration as great a proportion of the cement as possible. This necessitates double grinding in most cases and an additional quantity of gypsum must be added in order to regulate the set of the extra cement thus made available for hydration.

Fig. 2—Sedimentation Apparatus.

Finest Sieves No Longer Adequate

The measurement of fineness by sieves has been found quite inadequate for these high early strength cements. The 200 mesh sieve has an aperture of 74 microns diameter and diagonally particles of 95 or 100 micron size may pass.

In the present-day manufacture of cement even the 300 and 325 mesh sieves can not be considered sufficiently reliable, as those sieves do not give the true indications of the expected strength or of the actual work produced by the grinding machines.

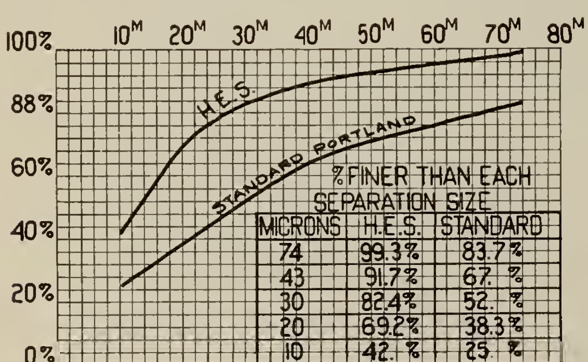


Fig. 3—Fineness in Microns as Determined by Air Analyser Method.

As a whole, the majority of cements, both Portland and high-early-strength cement, are composed of particles varying in sizes from 1 to 150 microns.†

†The micron is one-thousandth of a millimeter.

If we examine the particle distribution in a sample of Portland cement, we have the following approximate figures:—

	Per cent		Per cent
Finer than 150 microns	100	Finer than 20 microns	50
" " 75 "	90	" " 10 "	30
" " 45 "	78	" " 5 "	15
" " 30 "	65	" " 1 "	less than 2

For a properly ground high-early-strength cement we will find higher percentages of flour. For example, the percentage of particles finer than 75 microns (the 200 mesh size) will be 97 per cent, while correspondingly higher percentages will be found also for particles smaller than 45, 30, 20, 10, 5 and 2 microns.

If these two cements are compared as to fineness and only the 200 mesh sieve is used, we find that the screening test for the Portland cement only discloses the knowledge

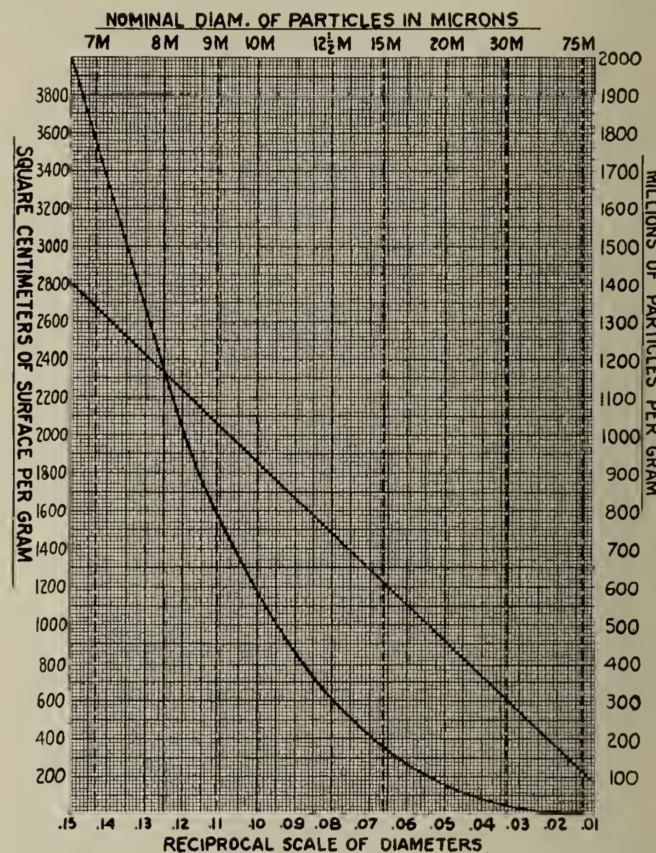


Fig. 4—Relation Between Fineness, Specific Surface and Number of Particles per Gram.

Diagram by E. W. Reed-Lewis.

to us that 10 per cent of the cement has particles of sizes between 150 and 75 microns. For the high early strength cement the screening on the 200 mesh sieve is of lesser value, as it gives us knowledge of only about 3 per cent of the cement.

If the two cements are compared as to fineness and the 325 mesh sieve is used, our knowledge obtained about the Portland cement takes in about 22 per cent of the cement, and only about 12 per cent of the high early strength cement. No information at all is obtained as regards the bulk of the cement, namely 78 and 88 per cent respectively.

Finer sieves than the 200 sieve are delicate and costly and the operation of sieving a most tedious one. Many have been working to devise some more accurate and satisfactory method of measuring the size distribution of very small particles.

The Air Analyzer

This is an instrument devised to separate a granular or pulverulent material, such as cement, according to the size or mass of the component particles. The separation is effected by fluid (air) currents and the size of the particles removed is dependent on the velocity of the current and the specific gravity of the material. This apparatus when used in conjunction with the microscope to measure

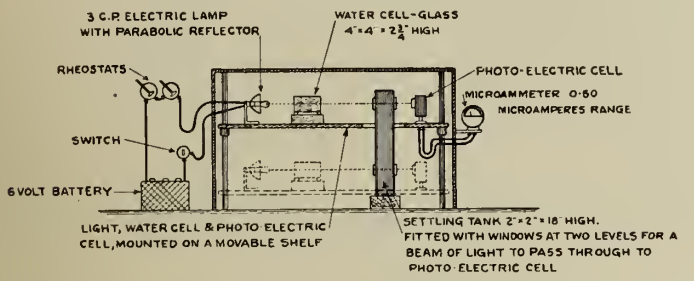


Fig. 5—Turbidity Meter.

the size of the particles removed, has been used for determining the fineness of cement and especially of that portion of the cement passing through the 200 mesh sieve. There are several on the market and certain research laboratories have built their own. They are rather expensive and other devices are being tried using the principal of sedimentation.

Sedimentation Apparatus

Experiments have also been made with a sedimentation apparatus developed by Mr. Reed-Lewis of the Supercement Company. It is designed to measure the relative sub-sieve fineness by the rate of settlement of the particles through a column of butanol (normal butyric alcohol).* It consists essentially of a burette of suitable dimensions supported in a vertical position filled to a definite height with butanol maintained at a constant temperature throughout the test. (Fig. 2.)

The test procedure is to agitate the butanol in the burette by bubbling air through it at a constant rate, introducing the air through the stopcock at the bottom of the burette; a one-gram sample of the cement to be tested is then introduced into the butanol through the top of the burette and the agitation by bubbling is continued for 15 minutes when the air is shut off and sedimentation commences.

At subsequent appropriate time intervals the cement that has come to rest at the bottom of the burette is drawn off through the stopcock. These fractions of the original sample are recovered in individual glazed porcelain crucibles, or small beakers. The small quantity of butanol drawn off with each fraction is evaporated by heating and the dry fractions are weighed.

The bubbling process produces a partial segregation or suspension, the smaller particles congregating towards the top of the burette, the coarser particles towards the bottom. After bubbling is stopped the segregation of particle sizes is accentuated since all particles then tend to follow Stokes' Law without disturbance.

The successive fractions of the cement sample drawn from the burette at intervals throughout the duration of the test are therefore composed of particles which are progressively smaller in size.

Table X

Record of Quality of Canada XXX H.E.S. Cement Plant No. 1.—Oct. 20 - Nov. 5, 1932.

Date Mfg'd	Soundness Boil Test	Fineness #200 Sieve	Setting Time		1-3 Tensile				1-3 Compression			
			Initial	Final	24 Hours	3 Days	7 Days	28 Days	24 Hours	3 Days	7 Days	28 Days
Oct. 20	OK	99.5	1° 12'	2° 40'	377	464	467	513	3697	5383	6423	7035
21	OK	99.4	1° 17'	2° 33'	382	447	518	512	3890	5825	6717	7760
22	OK	99.3	1° 15'	2° 50'	362	459	450	490	3733	5443	6700	6709
23	Sunday											
24	OK	99.2	1° 10'	2° 27'	384	458	525	555	3708	5250	6583	6946
25	OK	99.2	1° 06'	2° 16'	335	458	549	494	3633	5433	6833	8269
26	OK	99.2	1° 20'	2° 37'	296	443	488	513	3133	5183	6350	6719
27	OK	99.2	1° 20'	2° 46'	336	479	507	524	3267	5367	6667	7041
28	OK	99.2	1° 10'	2° 48'	343	458	534	515	3283	5340	6660	6666
29	OK	99.2	1° 17'	2° 42'	348	474	501	545	3600	5267	6533	7415
30	Sunday											
31	OK	99.1	1° 15'	2° 32'	351	465	497	522	3467	5457	6633	6684
Nov. 1	OK	99.2	1° 10'	3° 27'	367	426	539	565	3690	5483	6640	6945
2	OK	99.3	1° 05'	2° 45'	356	456	527	532	3700	5367	6500	7508
3	OK	99.3	1° 30'	3° 03'	340	452	515	531	3233	5350	6683	7265
4	OK	99.2	1° 22'	2° 25'	338	456	509	524	3100	5317	6670	7812
5	End of Run											
Average Test of Run		99.3			351	457	509	524	3510	5390	6614	7205

Turbidity Meter

The latest and most attractive apparatus for measurement of fineness in so far as speed of determination is concerned is the turbidity meter developed by the United States Bureau of Standards, in which the total surface area of the particles is measured rather than the proportions of certain particle sized material.

Briefly, with this apparatus fineness as represented by specific surface is measured by passing light of constant intensity through a suspension of the cement to be tested,

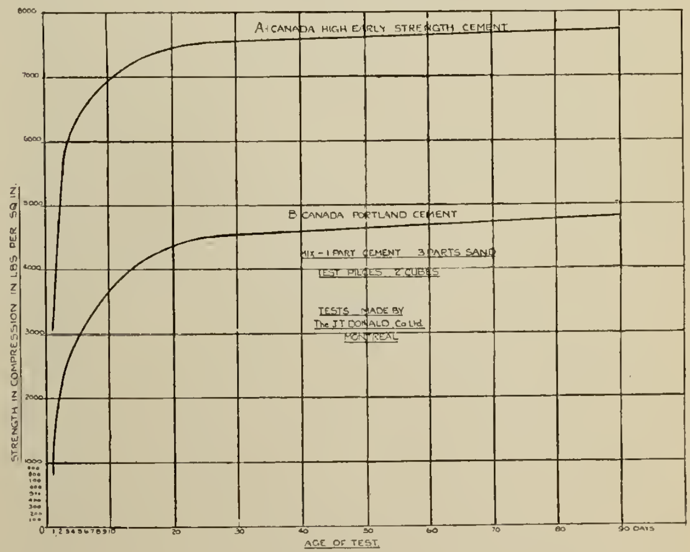


Fig. 6.

into a sensitive photo electric cell. The current generated in the cell is measured with a microammeter and the indicated reading is a measurement of the turbidity of the suspension. General considerations indicate that turbidity is a measure of the surface area of a suspension, and that a change in turbidity due to settling of the suspended material is a measure of the distribution of that surface area.

Table IX

Showing the Average Analysis and Cementitious Components of Canada XXX H.E.S. Cement Produced at Plants No. 1 and No. 7

Chemical Analysis	No. 1 Per cent	No. 7 Per cent	Cementitious Compounds	No. 1 Per cent	No. 7 Per cent
Silica (SiO_2)	19.26	20.00	C_4AF	8.29	7.90
Alumina (Al_2O_3)	5.96	6.60	C_3A	11.18	13.09
Iron Oxide (Fe_2O_3)	2.73	2.60	C_2S	6.45	16.11
Lime (CaO)	64.32	64.33	C_3S	64.75	54.74
Magnesia (MgO)	3.26	2.21	$CaSO_4$	3.89	4.11
Sulphuric Anhydride (SO_3)	2.29	2.42	MgO	3.26	2.21
Loss on Ignition	1.22	1.16	Loss Ign.	1.22	1.16
Total	99.04	99.32		99.04	99.32

C_4AF Symbol for Tetra calcium alumina ferrite
C_3A " " Tri calcium aluminate
C_2S " " Di calcium silicate
C_3S " " Tri calcium silicate
$CaSO_4$ " " Gypsum (anhydrous)

*The apparatus and methods of operation are described in the February 1933 number of "Concrete."

A study was made by the Portland Cement Association of the properties of cement fractions so graded that each fraction was made up of particles of a narrow range of size in which clinker from the stock pile of a commercial plant was ground in the laboratory ball mill to a 200 mesh fineness of about 85 per cent without addition of gypsum. The ground clinker was separated in an air separator giving products of varying size distribution within narrow size ranges.

Imperial Gallons per Bag of Cement 87½ Lbs.

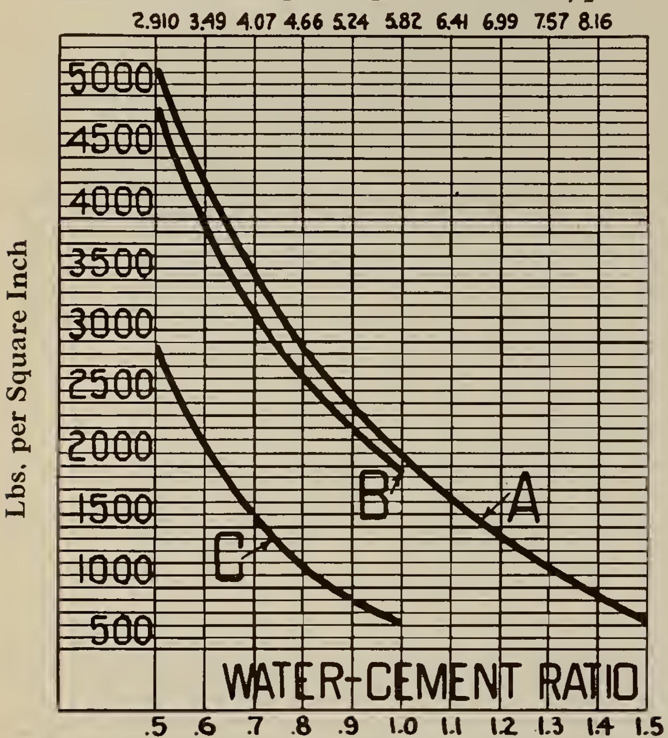


Fig. 7—Relative Compressive Strength of Concrete made with St'd. Portland Cement and Canada XXX H.E.S. Cement.
A—Standard Portland Cement at 28 days.
B—Canada XXX at 3 days.
C—Canada XXX at 1 day.

Experiments to Find Relative Value of the Various Particle Sizes

Each of the clinker fractions was divided into three portions. Cements for test purposes were produced by adding a different amount of gypsum to each portion, the range of quantities added being selected on the basis of the fineness of the fraction. Each of those cements was tested in 2-inch mortar cubes of 1—2.75 mix using mine run Ottawa sand at ages of 1, 3, 7 and 28 days. A constant water-cement ratio of 0.80 was used except in the case of the finest fraction which required a 1.20 water-cement ratio and a 1-2 mix for comparable consistency.

The finest fraction of the particles thus studied averaged 2.7 microns and ranged from 1.5 to 7.0 microns in size. It was quick setting (about fifteen minutes) and quick hardening. It was necessary to use gypsum contents far in excess of those required in the coarser fractions and even with 6 to 8 per cent gypsum the set took place in about 15 minutes. The one day strengths for this fraction were very high compared with those of the other fractions and of the whole clinker and the 28 day strengths were about the same as those obtained with the whole clinker.

The next fraction which averaged 10.3 microns in particle size (6M—26M) gave the highest 3, 7 and 28 day strengths obtained in this group of tests. However the one day strengths were far below those obtained with the finest fraction. Optimum strength was obtained with a gypsum content of 3.5 per cent.

The most significant results of this test or study is the fact that most of the strength is obtained from the cement particles finer than about 40 microns in size.

Commercial Production of High Early Strength Cement Started

As initial experiments in the spring of 1929 proved that high early strength Portland cement could be produced at the Lakefield plant, it was decided to manufacture a quantity sufficient to satisfy any possible demand from the market in eastern Canada, and operations were accordingly commenced in October 1931. The run was quite successful in producing a good uniform product, uniform in chemical composition, perfectly sound and possessing high early tensile and compressive strength and regular setting properties; the initial set being approximately 1 hour and 40 minutes and final set 2 hours and 50 minutes, as compared to 2 hours and 30 minutes initial set and 4 hours and 30 minutes final set for the regular product from the Lakefield mill.

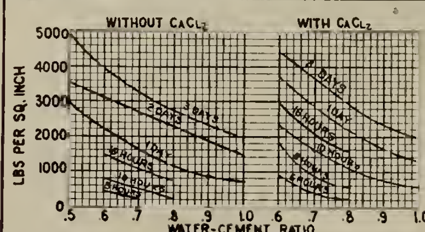
In the fall of 1932 after a few preliminary experiments the production of a similar product was begun at Montreal and an equally good cement of the high early strength pattern was turned out. The composition and properties of this cement are shown in Tables IX and X and Figs. 6, 7 and 8.

Summary of Methods Adopted for Manufacture

In general the methods employed in developing the high early strength product at the Lakefield and Montreal plants were similar, namely:—

1. Secured at each plant the most favourable physical as well as chemical condition and composition of the raw mixture.
2. Operated the kilns so as to secure optimum conditions of burning.
3. Thoroughly cooled the clinker previous to grinding it.
4. Ground the clinker in the usual way by kominuter and tube mill and returned product from the first tube mill grinding to tube mills for repeated grinding, thus increasing the percentage of impalpable powder. An additional per cent of gypsum was added before the final grinding to regulate the set of the extra cementitious flour thus made available.

	WITHOUT $CaCl_2$						WITH 2% $CaCl_2$			
WATER-CEMENT RATIO	.5	.6	.7	.8	.9	1.0	.6	.8	.9	1.0
IMP. GALLONS OF WATER TO 1 CANADIAN SACK	$2\frac{4}{5}$	$3\frac{1}{2}$	4	$4\frac{2}{3}$	$5\frac{1}{4}$	$5\frac{7}{8}$	$3\frac{1}{2}$	$4\frac{2}{3}$	$5\frac{1}{4}$	$5\frac{7}{8}$
SLUMP	3"	3"	3½"	4"	2"	1½"	1½"	5½"	6"	6"
CEMENT	1	1	1	1	1	1	1	1	1	1
SAND	.71	1.14	1.43	2	2.28	2.57	1.43	2	2.28	2.57
STONE	1.28	2.28	2.85	3.43	4	4	2.28	3.43	4	4
TEMP. OF MIX WATER	70° F.	72° F.	70° F.	70° F.	70° F.	70° F.	70° F.	70° F.	70° F.	70° F.
TEMP. OF AIR	68-74°	68-74°	70-74°	62-72°	64-72°	69-72°	67-74°	68-74°	68-74°	70-73°
TEMP. OF STORAGE WATER	70-74°	68-72°	68-72°	66-72°	69-72°	70-72°	68-72°	70-72°	70-71°	71-72°
DATE POURED	20/2	19/2	18/2	17/2	16/2	15/2	25/2	26/2	27/2	29/2



SIEVE ANALYSIS-PERCENT RETAINED

SIEVE No	SAND	CEMENT	
8	5.0		
14	22.6		
28	70.8		
48	96.0		
100	98.8		
200	99.7	97.2	
325		87.4	

GRAVEL ALL PASSING ¾ SIEVE AND RETAINED ON No 4 SIEVE

Fig. 8—Compressive Strength of Concrete made with Canada XXX H. E. S. Cement Plant 7.—February and March 1932.

The materials at the Montreal plant were of slightly lower alumina content and the mix was designed to produce a higher tricalcium silicate content in the finished cement to offset the diminished early strength due to the lower tricalcium aluminate.

Uses for High Early Strength Cements

The economic advantage of high early strength cement for many construction jobs may be questioned, but in so far as speed of hardening enters into the choice of cement for any given use, it fulfills the requirements.

In the class of urgent or emergency work might be placed jobs involving cutting off water flow from wells, mine shafts or other tunnels, dams, foundations: emergency work in floods or other disasters: the laying of concrete between tides or under other marine difficulties: the laying of concrete between frosts: and all military uses of concrete in the theatre of operations as in front line work. In the case of its use for such work as the early completion of roads or pavements in congested city streets or other areas and where the saving of time is directly reflected in the cost of the work or in the payments which the contractor receives, as affected by bonuses or penalties, it is an economical product, as it results in a saving of time, money and human patience.

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E. W. Reed-Lewis:—Determining Sub-Sieve Fineness of Portland Cement, "Concrete", February 1933.

Discussion on "Relations of Aeronautical Research to General Engineering"

Paper by Squadron Leader A. Ferrier, A.M.E.I.C, A.F.R.Ae.S.(1)

Mr. M. J. Berlyn(2)

Mr. Berlyn desired to ask the author for an explanation of his statement that "It was found that the mixing of lubricating oil with a fuel containing an anti-detonant resulted in a virtual destruction of the anti-knock properties."

Several manufacturers of displacement-type superchargers, and a prominent English automobile racing driver had stated that it is essential that oil be mixed with the fuel in order to prevent seizure of the blower. There were few, if any commercial engines which depend so completely on anti-detonant fuels as do racing automobile jobs, almost all of which, in Europe, use displacement superchargers of the eccentric vane or Roots type.

Mr. Berlyn did not see how these facts could be reconciled with the author's statement regarding the virtual destruction of anti-detonant properties by the mixture of lubricating oil with the fuel.

Professor Ellwood Wilson, M.E.I.C.(3)

Professor Wilson remarked that the author had presented an interesting and timely paper bringing out very well some of the engineering problems which are engaging the attention of aeronautical engineers concerned with research. His review of the work being done in England, the United States and Canada was complete, and it was only to be regretted that more attention is not being given by our research men to problems, which owing to our geographical location are practically peculiar to Canada.

Government research departments in carrying out their function to aid directly in building up arts and industries, also helped in bringing out fundamental principles. The work which had been done and which was being done by the United States Bureau of Standards was a case in point, as regards their investigations on radio guidance for aeroplanes and their latest work on crash proof and bullet proof gasoline tanks.

Mention might be made of one or two problems which needed attention. The most pressing was an absolutely accurate and sensitive altimeter, which will enable a pilot to know his distance from the ground closely so that in flying in mountainous country he may avoid the hills, and so that in making landings on glassy water or snow covered ground or lakes he can keep from flying right into them. With a really accurate altimeter, when flying in fog, he would be enabled to come down low to get his bearings without danger of crashing. In Canada a combination wheel-ski landing gear was badly needed; one had been designed but, so far as Professor Wilson knew, had not proved entirely practical.

He believed that from the operating standpoint, visibility was an outstanding problem and anyone who would design a practical aeroplane in which the engine or engines are behind, above or below the pilot so as not to come down and flatten him out when he crashes, would contribute greatly to the art of flying. Aerial photography offered so much to the civil, hydraulic, mining and forestry engineers and would be so much aided by clear vision ahead, that any advance along this line would be of great importance.

There was also the question of cheapening alcohol so that it can be used as fuel and the designing of an aeroplane engine to burn it.

T. W. Hardy(4)

Mr. Hardy observed that in these days of specialization, with its attendant danger of lack of knowledge and appreciation of the facts and principles of other lines of endeavour, the co-operation of specialists working in different fields is absolutely essential if real progress is to be made. This was especially true in regard to the question of the selection or development of materials for specific applications, since any failure of the designer to recognize the limitations and difficulties of the fabricator on the one hand and the metallurgist on the other, would almost certainly lead to an inferior product. Fortunately, this necessity for co-operation had become generally recognized, and there could be no doubt that the substantial advances that have been made in the fields of automotive and aeronautical engineering are the results of such co-operative efforts by specialists in different fields. Thus the demands of the automotive engineer had provided the stimulus for many of the recent developments in the manufacture and heat treatment of alloy steels, and it would appear from Squadron-Leader Ferrier's paper, that the aeronautical engineer, the metallurgist and the fabricator, building upon the firm foundation established in the automotive field, are combining their energies and specialized knowledge in the development of new materials, designs and shop practices more specifically suited to the needs of aeronautics.

J. J. Green, A.R.C.Sc., Ph.D., B.Sc., D.I.C.(5)

While congratulating the author on his interesting and stimulating paper on a subject that embraced so wide a field, Dr. Green did not agree with his suggestion that practically all aeronautical research since 1919 has had for its object improvement under one or other of the heads, safety, economy and reliability. This might possibly be true of most "applied research" but a wealth of work had

(1) Paper presented before the Annual General Professional Meeting of The Engineering Institute of Canada, and published in the April, 1933, issue of The Journal.

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(3) Professor of Sylviculture, Cornell University, Ithaca, N.Y.

(4) Metallurgical Engineer, Division of Ore Dressing and Metallurgy, Mines Branch, Ottawa, Ont.

(5) National Research Council, Ottawa, Ont.

been done under the title "pure research" that had no direct application to aeronautics, (to be quite frank much of it never would), and for that reason it could not be classified under any of the author's three heads. Such work, when fostered by the aeronautical world, was undertaken with a desire to learn more about the fundamentals of the subject, possibly in the misguided hope that the exploration of these avenues of research might bring to light new phenomena which, if applicable, may entirely revolutionize existing methods of flight. The interest with which the aerodynamics of rotating cylinders was studied about the year 1924 in the hope of utilizing their lifting potentialities was typical. Work on the boundary layer was now receiving great attention, because viscous drag, form drag and the breakdown in lift of wings at stalling attitudes, all originated there. This work was typical of the class of research to which he wished to refer,—very little of it could ever be applied to aeroplanes and yet it gave knowledge of underlying principles and should for this reason be stimulated.

Dr. Green had noticed that the author had placed "the expansion of fundamental mathematical theory of fluid motion" under his heading of safety but ventured to doubt any justification he may advance for that classification.

The accumulated research work applied to the production of higher powers from aircraft engines could not be classified in his three categories and likewise the great steps made to achieve high performance from aircraft should be under a new heading, the question of economy not being paramount or even relevant in the majority of such work.

He regretted that in a paper of this kind no mention was made of the valuable research work being done, primarily at the Royal Aircraft Establishment, on noise and its elimination. Here was a subject of the deepest interest to engineers in all branches where machinery plays an important part. Noise had so grown to be recognized as one of the necessary inconveniences of the mechanized age that little is done to reduce it and this showed a wrong attitude of mind. The scientific study of noise in England is yielding fruitful results and considering its benefits to personnel and that elusive quantity human efficiency, it should be brought to the attention of engineers generally.

Coming to the section on aerodynamics, the author explained the adoption of methods for rendering air flow visible by saying that the analogy between liquids and gaseous fluids is not perfect. This was hardly true. The word analogy was unfortunate in that it implied only a superficial similarity between two otherwise different phenomena, when in reality the same laws governed both. So long as the speed in gaseous fluid was such that compressibility is not encountered to any extent, the flows in both types of fluid were identical at the same Reynolds number, and certainly any slight changes in flow due to difference of Reynolds number, or even to moderate compressibility effects, would not be exhibited by visual methods of observing flow, so that water would be as satisfactory as air. Dr. Green believed that the development of technique in rendering air flow visible was tried because in the end it would be more convenient, simple, rapid and cheaper than using a water tank. Both air and water as used were subject to the drawback resulting from serious discrepancy between model and full scale, and for that reason results obtained can only be qualitative.

He would like to ask the author for a reference to the work on exploration of the wake behind bodies using a sensitive thermocouple and whether or not he was referring to the hot wire microphone as used at the National Physical Laboratory.

In the section on materials, the author had not laid sufficient emphasis on the very great stimulus and pressure the demands made by aeronautics have had on a variety of old and new industries.

In dealing with the light alloys which might be valuable to the general engineer, he was surprised that the author had expanded so much on duralumin, which is not only widely known but widely used, while omitting all mention of the light alloys of magnesium such as "electron" which are not widely known outside aeronautical circles and yet may become very important to the general engineer, more so than a material such as "alclad" to which the author had drawn attention.

In concluding, Dr. Green found himself in disagreement with the author's suggestion for a central publishing pool for all scientific research. In the work of the National Research Council difficulty often arose from having to seek for research records among a mass of reports on widely dissimilar topics and it was felt that segregation of the various subjects would be more helpful.

Group-Captain E. W. Stedman, M.E.I.C.[6]

Group-Captain Stedman remarked that if the author had omitted anything it was because there is such a mass of material that he could not cover everything. However, there were one or two topics which, in his opinion, might be added. For instance, the rayon silk industry was practically a direct development of the cellulose acetate industry, which started for the manufacture of aeroplane dopes.

The development in aircraft engines had, of course, a very wide influence on all automobile work, but it was particularly significant that the engines used in motor cars and motor boats for record purposes are now generally aircraft engines.

Another important development was just being realized, that is, long distance aerial photography. Recently photographs from the air had been taken over distances unheard of before. That had been the result of infra red photography which is likely to have important development for other purposes and is urged on by means of aviation.

The author had not referred to the examination of the crystal structure of materials by X-rays, a method developed for aviation purposes, which has been of great assistance in metallurgy. It appeared likely that X-rays will be used to determine exactly what will produce oiliness in a good lubricant. With no particular difference in specification, some oils are good lubricants while others are not. Research indicates that X-rays will help in solving many problems of this sort.

With reference to the method of driving the supercharger from the crankshaft through a train of gears and centrifugal clutch to the blower, he would ask if the clutch was on the crankshaft end or the blower end of the train of gears.

Dr. J. H. Parkin, M.E.I.C.[7]

Dr. Parkin desired to compliment the author, not only on his courage in attempting such a broad paper, but also on the very capable manner in which he had dealt with it.

Aeronautical research, in its broadest sense, included the design and construction, operation and maintenance of all types of aircraft—airways and airports—and therefore embraced most branches of engineering, including many phases of chemistry. Reactions affected the realms of architecture and medicine.

F. H. Peters, M.E.I.C.[8]

Mr. Peters drew attention to the difficulties arising from noise and vibration particularly in cabin planes, where conversation was often almost impossible.

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[6] Chief Aeronautical Engineer, R.C.A.F., Department of National Defence, Ottawa, Ont.

[7] Assistant Director, Division of Physics, National Research Council, Ottawa, Ont.

[8] Surveyor General, Department of the Interior, Ottawa, Ont.

LIEUT.-COL. W. A. STEEL, A.M.E.I.C.[9]

Although not in a position to discuss the paper in general, Colonel Steel would also refer to the question of eliminating sound in connection with the cabin-type machine.

While in England he had been investigating the studios of the British Broadcasting Corporation and the Royal Aircraft Establishment in connection with the study of broadcasting. It might be asked what broadcasting had to do with aviation. He had been impressed with the value of the research which had been accomplished along that line in connection with broadcasting, where extraneous noise would affect the quality of output. Methods had been developed of measuring and preventing noise which would no doubt be of service in connection with aircraft.

P. L. KUHRING, A.M.E.I.C.[10]

Mr. Kuhring desired to refer to the point brought up by Mr. Berlyn as to the loss of anti-detonant quality. There was an adverse effect on iron carbonyl dope, and he would like to know if any information was available in the same line on the effects of upper cylinder lubrication.

K. F. TUPPER[11]

Mr. Tupper believed that hydraulic engineers could learn something from the design of wind-tunnels, in connection with elbow losses.

Many engineers knew of the reduction in elbow losses by use of the splitter, but were not familiar with the wind tunnel corner that has a bank of vanes. This method was first employed by Professor Prandtl of Gottingen and is now incorporated in every modern wind tunnel. The usual elbow loss is one per cent of the velocity head, or two per cent with bad elbows, but with the vane corner, the loss can be reduced to about one-tenth of that amount. He believed that in penstock bends, these vane corners could be very profitably employed.

DR. J. H. PARKIN, M.E.I.C.

Dr. Parkin stated that the "vane" design for corners and passages had caused a certain amount of interest in general engineering, and inquiries from large electrical manufacturers with respect to ventilating ducts in motors, and also from hydraulic engineers for design of equipment had already been made.

SQUADRON-LEADER A. FERRIER, A.M.E.I.C.[12]

Replying to Mr. Berlyn's remarks questioning whether the mixing of lubricating oil with a fuel containing an anti-detonant resulted in a virtual destruction of the anti-knock properties, the author admitted that the statement in his paper was somewhat too general. In the investigation referred to it was found that a number of typical lubricating oils had an adverse effect on the anti-knock properties conferred by iron or nickel carbonyl, whereas the effect with ethyl fluid or benzol was much less pronounced. The effect varied with the type of lubricating oil and with the induction temperature.

Possibly in the particular case cited by Mr. Berlyn most of the oil is retained in the blower, which after all is the place where it is destined to work.

The question raised by Professor Ellwood Wilson in regard to the need for an absolutely accurate and sensitive altimeter, was of real importance, and was receiving attention. Promising work was now being carried out on the so called Sonic altimeter and the echo detection of obstacles and ground from an aeroplane. It had been stated recently that a pilot who flew blind, had successfully made use of a Sonic altimeter for landing.

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(10) Assistant Engineer, River St. Lawrence Ship Channel, Department of Marine and Fisheries, Ottawa, Ont.

(11) National Research Council, Ottawa, Ont.

(12) Aeronautical Engineer, Department of National Defence, Ottawa, Ont.

The latest form of ski-wheel landing gear had proved successful, although it had not yet been through extensive service trials and there would probably be teething troubles. It was now only a matter of mechanical development and improvement.

Dealing with the question of visibility—that was largely a matter of cost. Aeroplanes could be built with any desired arrangement of engines if the funds were available.

With reference to the question of cheapening alcohol so that it can be used as fuel, the author pointed out that while the present aeroplane speed record was gained with alcohol fuel, the difficulty arose that the volume of alcohol is great, and consequently for a given range a large amount of tankage is needed. In the last Schneider Cup races gasoline fuel was used, because there was not enough tankage to feed the engine on alcohol for the distance required; for the speed record they had to cover less distance, and therefore changed over to alcohol fuel for the sake of the extra power they could get.

In reply to Group-Captain Stedman's question concerning the clutch, the author stated that the location of this protective device was largely a matter of choice and convenience. In the French Jupiter engine the main drive gear was not directly connected to the crankshaft, but was carried round by means of a series of compression springs lodged between six pairs of lugs, one set of which was integral with a hub on the crankshaft, and the other with the gear. In addition to this a centrifugal clutch was incorporated in each of the three large intermediate gears which mesh with the blower spindle. In a well known American engine, a centrifugal clutch was incorporated about half way through the train, while in the Armstrong Siddeley the location of the clutches was similar to that in the Jupiter, though there was no spring coupling.

Replying to Mr. Peters, and, in part, to Colonel Steel, concerning the omission of any mention of research on vibration and noise in aeroplanes, the author admitted the omission, but would point out the difficulty of doing anything to reduce noise without adding weight. As a result of a great deal of research, it was now possible to eliminate practically all the engine noises, but the airscrew and structure noises unfortunately still remained.

As to Dr. Green's remarks, the author could not agree with the contention that there is anything much under "research" which was not destined ultimately to effect an improvement under one of the three categories, namely safety, economy and reliability.

If fundamental research was being done which could not with some imagination be classified under one of these headings, then it could not be justified economically and should certainly not be charged against public funds.

The very works that Dr. Green cited as examples to support his statement were by no means remote in their application to practical problems of today.

The sensitive thermocouple for the exploration of the wake was referred to on page 27 of the 1931-32 Report of the Aeronautical Research Committee.

Dr. Green misunderstood the author's plea for the publication of scientific reports in a uniform manner in a single series. The segregation of subjects was quite possible in a single series, and was exactly what the author recommended. At the present time, a complete survey of any one minor subject required reference to reports published under many different series even in one country.

Mr. Kuhring's question had been sufficiently answered in the author's reply to Mr. Berlyn, except as to the upper cylinder lubrication.

Mr. Tupper's suggested applications for aeronautical research were valuable, because he had touched on a point which could not fail to help engineers in designing hydraulic machines of all kinds.

THE
ENGINEERING JOURNAL
THE JOURNAL OF
THE ENGINEERING INSTITUTE
OF CANADA

VOLUME XVI MAY 1933 No. 5

Fifteen Years of The Journal

With this issue The Engineering Journal enters upon the sixteenth year of its existence. At the Annual Meeting in Montreal, on January 23rd, 1918, a resolution was adopted which transformed The Canadian Society of Civil Engineers into The Engineering Institute of Canada. The change of name and of organization which then took place had far reaching effects. The decision to reorganize was taken at a time when four years of war had made it difficult to predict the future, but time has shown that the development of The Institute was in the hands of men of vision, and the results have justified their courage.

One of the principal features in the new regime was to be the establishment of a monthly periodical to serve as a means of communication with all of the members, and to provide for the publication of professional papers presented at Institute and Branch meetings. Formerly the annual or semi-annual volumes of Transactions had been the only medium available for the circulation of such papers, and without intending to discontinue the issue of Transactions, it was felt that a periodical of more personal appeal was needed.

The necessary steps were taken without delay, and the first number of The Journal appeared in May 1918. Fraser S. Keith, M.E.I.C., was the editor. Associate editors were nominated from the branches, and a board of management, headed by President H. H. Vaughan, M.E.I.C., watched over the new arrival. There were few teething troubles, and the infant's growth was vigorous from the first. The plans laid down were sound, as has been shown by the fact that practically all of the leading features included in the first number will be found to characterize The Engineering Journal to-day.

It is interesting to look over the first number of The Journal and note the messages of encouragement and counsel contributed by prominent members and officers of The Institute, some of whom are, unfortunately, no longer with us. One of these, written in 1918, might have been composed to-day. Councillor H. R. Safford, M.E.I.C., said: "We seem to be passing through a period when the entire world is being stressed to nearly its elastic limit. Social, industrial and political structures are being tested severely by stresses for which they do not appear to have been designed, and it is apparent that the formulae previously used were inadequate and erroneous, because they failed to embody many heretofore unknown factors and they gave false values to many known factors."

The second number contained expressions of appreciation from members which indicated that the make-up and contents of The Journal were meeting with general approval, and that The Institute was solidly behind the new venture. That support has continued during the years that have since elapsed, and The Journal has established for itself a definite position among Canadian engineering publications. It differs from the majority of these in being the organ of a nation-wide association whose members contribute the technical articles it contains. Dealing, as these do, with all branches of engineering work, they serve as a record of the varied spheres of activity of our members.

One of the main purposes of The Journal, the knitting together of The Institute's widespread membership, has undoubtedly been achieved. Many members turn first to the Branch news and the personal section in order to gather news of the recent doings of the various branches, and to catch references to professional acquaintances in other branches. Reports of the discussions and the decisions of the Council, and official communications from Council to the membership at large, also form an important part of The Journal make-up.

As regards our advertising pages, these not only provide a large proportion of the sinews of war, but in themselves are valuable to our members as a source of technical information regarding advances in engineering equipment. They tell us what to buy or specify; where to buy it, and what it will do or build. They give the advertiser an opportunity of placing authoritative information regarding his products before a large body of readers, all of whom are technically trained in some branch of engineering. It will thus be obvious that without the support of our advertisers The Journal could never have served our members as it has done.

A criticism occasionally received comes from members whose interest is confined to some highly specialized branch of engineering work, and is usually to the effect that The Journal has recently contained practically nothing on this or that special topic, the subject named, of course, depending on the writer's own particular branch of work. With regard to complaints of this kind, it should be remembered that a journal which endeavours to give equal prominence to all the main branches of engineering cannot possibly fill the requirements of a man who wants the detailed results of all the latest investigations in some special sub-division of professional work. What the technical contents of The Journal can do, is to afford a cross-section of the work of our members; that is to say, a fairly comprehensive account of the achievements of Canadian engineers. The extent to which this aim has been fulfilled may be easily judged by a glance at the index for each year; as an example we may note the classification of the technical papers published in full in The Journal during the four years 1926 to 1929. Of these there were 153, of which 33 dealt with mechanical engineering topics, including aviation; 38 had to do with civil engineering and construction; 32 were of interest to electrical engineers; 21 treated of mining and metallurgical or chemical subjects, and the remaining 29 can be classed as "various." In addition to these, the Branch news sections contained abstracts of a large number of interesting papers presented at branch meetings.

At the Plenary Meeting of Council in 1929, attention was directed to the publications of The Institute, including The Journal, and as a result a special committee was appointed to report on the subject. This committee, besides making inquiries on its own account, sent questionnaires to the various branch executive committees, so framed that the replies would give an idea of the relative importance assigned by members to various features in The Journal. From them it was satisfactory to learn that the existing policy was generally endorsed and that the four divisions of The Journal regarded as of major or considerable interest were professional papers, advertising pages, activities of Council, and Branch news, in the order named. This special committee attached to its report a number of recommendations for improvement in The Journal, practically all of which would involve additional expenditure for which provision could not be made at that time, and which has become even more unattainable since. The committee recommended, for example, as a most desirable feature, the publication in each issue of abstracts of selected articles in current engineering literature, both European and American, reviewing engineering developments elsewhere. Other proposals were made looking to the more adequate expression of Branch views and activities. Unfortunately since that time conditions have made it necessary to limit, not to increase, the amount of material printed in The Journal.

It would have been a sign of inertia rather than of active interest on the part of Institute members if criticism of The Journal and its contents had not been forthcoming from time to time. Much of this criticism has been very welcome to the editorial staff, both as suggesting possible improvements and indicating possible lines of new activity. Many of the changes or new features proposed were ruled out by financial limitations; some have been adopted with advantage; a few were not practicable.

In this connection, however, there are one or two suggestions as regards The Journal to which attention might be directed with advantage. The first arises from a proposal noted in our editorial columns in March 1932. Most of the original papers received for publication in The Journal have to do with engineering works or industrial projects of considerable importance. Comparatively few deal with work which is carried out on a less extensive scale or with subsidiary divisions of the larger schemes. Work of this character, though of minor importance as regards cost, often possesses unusual features of technical interest, or has to be done under severe limitations, or calls for the solution of problems of detail which are none the less difficult. Papers or articles containing information on such points would be of interest to a large number of our younger members, and to many in less responsible positions on larger work. Good material of this kind would be welcomed, and would add to the value of The Journal's pages.

Another feature in which improvement is possible relates to discussions on papers published in The Journal. If more of our members who are qualified to do so by training or experience would make a point of preparing and contributing written discussions on the papers which we publish, particularly those presented at Institute meetings, they would be rendering a valuable service to The Institute. A considered discussion, especially if put in writing, often brings out important points which would otherwise escape the author's attention. It is our custom, whenever possible, to send out preprints ahead of an annual or professional meeting, and discussion is requested upon them. There seems no reason, however, why discussion by correspondence should not follow every paper of importance which is printed in The Journal, whether it has been presented at an Institute or a branch meeting.

It is in directions like these that our members can give practical effect to their desire to support The Journal. If they will contribute letters or articles on phases of work which would interest their fellow members; if they will make a point of mentioning The Journal in corresponding with advertisers, and if they will act on the principle that the papers and discussions in The Journal should constitute a record of all important Canadian engineering work, The Journal's successful career during the past fifteen years will continue, and its usefulness will be further developed.

Message from Past-President H. H. Vaughan, M.E.I.C.

Fifteen years ago the writer had the honour of introducing The Journal of The Engineering Institute of Canada to its owners. The first issue followed shortly after an important development in the life history of The Institute. Early in 1918 the name was changed from The Canadian Society of Civil Engineers to the one it now bears, and new by-laws were adopted decentralizing all professional activities and establishing Headquarters in Montreal as an administration centre only.

The first issue of The Journal recorded the proceedings of the first General Professional Meeting of The Institute held at Toronto, which was most successful in spite of the terrible conditions existing at the time. The programme for the meeting had one definite object, the discussion of the fuel and power situation, and it is interesting to note that the economies put into effect by the railways and the Canadian War Board on account of the scarcity of fuel were even more stringent than those now dictated for financial reasons. The carefully prepared report on the conclusion of the meeting, while containing suggestions of undoubted value, can hardly be said to have borne any definite results, as with the conclusion of the War the urgency for conserving our natural resources went the way of many other anticipated reforms.

H. H. VAUGHAN, M.E.I.C.

During these fifteen years I believe it can safely be claimed that The Journal has fulfilled the expectations of its promoters, and has been of real value to The Institute. That it alone could have built up The Institute to the extent hoped for when the organization was changed in 1918 could not be expected under the conditions, but it has undoubtedly been of great service in keeping the widely spread membership informed of each others doings and ideas. It has also been of service as a medium for publishing papers and discussions, perhaps not in as convenient form as in well prepared Transactions, but decidedly better than

Transactions which could not be published regularly on account of lack of funds.

The Journal has been practically self-supporting and it must be gratifying to its founders to see how carefully its character has been preserved as the journal of a professional society. The inclusion of an advertising section was always regarded as a necessity, and the forecast that its circulation among several thousand of the leading engineers of the country would insure its being considered a good advertising medium has been fully realized. It has, however, always maintained a standing apart from a trade or technical publication, and has adhered to its own particular function as The Journal of The Engineering Institute.

Message from Past-President J. M. R. Fairbairn, M.E.I.C.

For its age, The Engineering Journal has achieved a notable standing with all the membership of The Engineering Institute. Entering upon its sixteenth year, those who have followed its progress from the beginning are, I am sure, unanimous in their appreciation of the excellent manner in which it has filled its own particular field; to broadcast the news in general of the engineering profession throughout this country, to record the activities

J. M. R. FAIRBAIRN, M.E.I.C.

of the various branches of The Institute and to publish the more important papers read before The Institute. Not without value also is the Employment Service Bureau, and as an advertising medium for covering the users of engineering and construction supplies The Journal is most useful.

Having been when started a leader in its field, The Journal has served as a model for similar publications elsewhere, and has now established itself in such a position that its parent, The Engineering Institute, should not only be very proud of its past, but should watch with increasing gratification and interest its continuing development.

Message from Past-President S. G. Porter, M.E.I.C.

The Engineering Journal has served the engineering profession of Canada for fifteen years. Its birth marked the beginning of a new period in the history and progress of the profession in Canada, the two outstanding events being, first, the re-organization and broadening of the Canadian Society of Civil Engineers, bringing all branches of the engineering profession into The Engineering Institute, and secondly, legislation which has brought into existence the Associations of Professional Engineers in the various provinces.

We are now facing another duty to the profession, and that is the co-ordinating of the activities of our various organizations so as to unify and solidify the profession, and so increase its influence and usefulness. While we are marking time in construction and industry, let us overhaul our own machinery and be the better prepared to assume the larger responsibility which a perplexed business and

S. G. PORTER, M.E.I.C.

social order seems ready to assign to us. It is hoped that the next few years will witness the accomplishment of the programme of co-ordination and see the engineering profession in Canada assume a position of much greater influence and importance than it has filled in the past.

Message from Fraser S. Keith, M.E.I.C.

The occasion of the fifteenth anniversary of the establishment of The Engineering Journal recalls many memories associated with its inception.

One of the fourteen points of the Committee on Society Affairs, which was adopted when the Canadian Society of Civil Engineers became The Engineering Institute of Canada was to the effect that the members should have an

FRASER S. KEITH, M.E.I.C.

intercommunicating medium published at regular intervals, which whether owned by the Society or not, was to be under its control. The Committee, consisting of several past presidents, studied the problem during the period of expansion when new branches were being established and the various proposals of the committee were being put into effect.

Amongst the proposals considered were:—

To purchase an existing publication to be owned by leading members of the profession and to be the organ of The Institute.

To set up a privately owned publication, also to be the organization's organ.

To accept offers made by publishers to publish a magazine owned and controlled by them but under the editorial dictatorship of The Institute.

To establish a Journal of The Institute entirely owned and controlled.

The fact that the secretary of the day had had journalistic experience made it possible to adopt the last proposal without incurring a large capital expenditure. Opposition to this policy was experienced from certain outside quarters, but the hearty support it received from the members soon indicated that The Journal was to be a fundamental part of our organization's policy. Its existence has had an important bearing on the success of The Institute during the years that followed.

Meeting of Council

A meeting of Council was held at Headquarters on Tuesday, March 21st, 1933, at eight o'clock p.m. with, President O. O. Lefebvre, M.E.I.C., in the chair, and eight other members of Council present.

Council approved of the participation of The Engineering Institute of Canada in the work of the National Construction Council of Canada which is being formed, and appointed J. B. Carswell, M.E.I.C., as the official delegate of The Institute thereon, with A. H. Harkness, M.E.I.C., as a substitute if at any time Mr. Carswell is unable to act.

It was unanimously resolved that the thanks and appreciation of The Institute be conveyed to the Committee on Development, which has now been discharged, following which Mr. Busfield, chairman of the Committee of Council re the Committee on Development, stated that his committee was proceeding to review all the reports and recommendations on the subject with the ultimate object of submitting a report to the Plenary Meeting of Council. It was further decided that a resume of the committee's work should be published in The Journal from time to time.

The membership of The Institute's Committee on Membership, as submitted by Mr. Tennant, was approved as follows:

D. C. Tennant, M.E.I.C., Chairman
A. Frigon, M.E.I.C.
F. S. B. Heward, A.M.E.I.C.
C. K. McLeod, A.M.E.I.C.

The Institute's Committee on Unemployment was re-appointed as follows:

D. C. Tennant, M.E.I.C., Chairman
A. Duperron, M.E.I.C.
R. J. Durley, M.E.I.C.

A letter was presented from the Secretary of the Montreal Branch advising that that Branch wished to call its newly formed Radio Section "The Radio and Wire Communication Section," and the Secretary was directed to communicate with the Secretary of the Institution of Electrical Engineers with reference to this proposed change.

Eighteen resignations were accepted, thirty-seven members were placed on the Suspended List, and a number of special cases were dealt with.

A number of applications for admission and for transfer were considered, and the following elections and transfers were effected:

Elections		*Transfers*	
Member	1	Junior to Assoc. Member	4
Assoc. Members	2	Student to Junior	1
Junior	1		
Students admitted	19		

The Council rose at ten forty-five p.m.

Progress Report re Committee on Development

The Committee of Council has carefully studied the opinions that have been expressed regarding the qualifications for corporate membership in The Institute, and it is evident to the Committee that the consensus of opinion leans to the suggestions that (*a*) there should be no lowering of the standards for admission, (*b*) that the Council should have discretion to recognize membership in a professional association, (*c*) that membership in a professional association should not be accepted, ipso facto, for membership in The Institute, and (*d*) that membership in a professional association need not be essential for membership in The Institute.

With these principles in mind, and based on the fundamental requirement that technical qualifications must be a function of the three factors age, education and experience, the following definition is being considered for the requirements for corporate membership as a substitute for the recommendations in the Interim Report of the Committee on Development.

"To be eligible as a Member a candidate shall have the following qualifications:—

"1. He shall be at least twenty-seven years of age.

"2. He shall have a thorough knowledge of the theory of the science of engineering. In determining a candidate's eligibility under this clause, the following will be considered:—

(*a*) Graduation from a school of engineering recognized by the Council will be sufficient proof of theoretical qualifications.

(*b*) Registration as a professional engineer in any of the Provincial Associations in Canada or equivalent membership in other engineering bodies of a like nature, may, at the discretion of the Council be accepted as sufficient proof of theoretical qualifications.

(*c*) If a candidate lacks the qualifications stated in either (*a*) or (*b*), the adequacy of his theoretical knowledge will be judged by the applicant submitting to an examination, which may be waived at the discretion of Council if the evidence obtained from his sponsors or from other competent sources is satisfactory. In any case it must be definitely established that the candidate possesses a mastery of the theory of the science of engineering.

"3. In addition to theoretical qualifications, he shall have held a responsible engineering position for at least four years. An appointment as professor or assistant (or associate) professor of engineering at a school of engineering recognized by the Council will be considered as a responsible engineering position."

The Committee of Council is continuing its deliberations.

April 24th, 1933. J. L. B.

March Journals Required

Members are requested to return to the Headquarters of The Institute, at 2050 Mansfield Street, Montreal, any copies of the March, 1933, issue of The Engineering Journal which they may possess and for which they have no further use. An allowance of 25 cents to cover the cost of postage, etc., will be made on each copy received.

OBITUARIES

Alonzo Clarence Selig, M.E.I.C.

Widespread regret will be felt at the death of Alonzo Clarence Selig, M.E.I.C., which occurred at Moncton on March 10th., 1933.

Mr. Selig was born at Lunenburg, N.S., on August 14th, 1863. Entering the field of railway engineering at the age of fifteen his entire professional career of more than half a century was spent in the service of the Government Railway System. On June 11th, 1878, he entered the service of the old Intercolonial Railway as junior in the engineering department. In 1888 he was appointed office assistant and in 1898 assistant engineer in charge of office under the chief engineer. From 1912 to 1915 he held the position of chief architect, following which, he was made assistant district engineer. On the re-organization of the railways into the Canadian National System he was appointed first assistant engineer for the Atlantic Region. He retired in March 1932.

Mr. Selig was of a genial and kindly disposition and was held in high regard by the hundreds whom he delighted to call friends, both in the Maritime Provinces and elsewhere, all of whom will learn of his passing with genuine regret.

Mr. Selig became a Member of The Institute on April 18th, 1922. At the time of his death he was a Life Member, and a member of the Executive Committee of Moncton Branch.

George Hart Waring, A.M.E.I.C.

Members of The Institute will learn with regret of the death at Saint John, N.B. on April 5th, 1933, of George Hart Waring, A.M.E.I.C.

Mr. Waring was born at Saint John, N.B. on January 19th, 1873.

After serving his apprenticeship in his father's marine engineering workshops in the Saint John Iron Works, then conducted under the firm name of Waring and White, he went to sea for some years, and from 1897 to 1904 was a chief engineer with the Standard Oil Company's fleet of tank vessels in the Japanese trade. In the latter year Mr. Waring became assistant, and later general manager, of the Union Foundry and Machinery Works Ltd., Saint John. He afterwards undertook the superintendency of the harbour ferry service at Saint John. Following his retirement from civic employ in 1929, Mr. Waring became manager of the Saint John Iron Works Ltd., which plant had become connected with the activities of the Saint John Dry Dock and Shipbuilding Company. For some years Mr. Waring held responsible appointments as engineer-surveyor to British and American marine classification bureaux. More recently he was also identified with the Nashwaak Pulp and Paper Company, and his last occupational work was as resident engineer with the succeeding enterprise in that plant, the Port Royal Pulp and Paper Company.

Mr. Waring became an Associate Member of The Institute on August 24th, 1920, and was an active member of the Saint John Branch.

Philip Ridsdale Warren, M.E.I.C.

Philip Ridsdale Warren, M.E.I.C., for many years connected with the engineering works carried out by Sir Alexander Gibb and Partners, died in London, England, on March 7th, 1933.

Colonel Warren was born in London on September 7th, 1874 and was educated at Malvern College and the Applied Science Department of University College, London.

In 1893-1894 he was an articled pupil to B. Moreland and Sons, mechanical engineers, London, and from 1894 to 1900 served an apprenticeship with and was afterwards assistant engineer to Sir John Wolfe Barry, F.R.S., President of the Institution of Civil Engineers. He was assistant engineer on the construction of the Tower bridge, and of the Barry docks in South Wales, later being engineer in charge of construction of the Barry dry dock. From 1900 to 1911 Colonel Warren was with the firm of Coode, Son and Matthews on the design and subsequently on the construction of harbour and dock works in the Malay Peninsula at Penang, Singapore, Malacca and Kuantan. From 1907 to 1911 he was chief engineer in charge of the construction of the dock works at Singapore, including a wet dock of 35 acres and a deep sea wharf a mile in length. From 1911 to 1914 Colonel Warren was in charge of various harbour and engineering works at Saint John, N.B., Sydney, N.S., Quebec, and elsewhere in Canada, and from 1914 to 1918, served with the Royal Engineers in France, having constructed the channel ferry terminus at Cherbourg and railway depots at Oissel, Yvetot, Lery and Havre. In 1919 he was assistant Director General of Transport in France, with the rank of lieutenant-colonel, and in charge of the reconstruction of the Belgian ports of Ostend and Zeebrugge. In 1920-1921, Colonel Warren was in charge for the British Admiralty, under the terms of the Peace Treaty, of the demolition of the fortifications and naval harbour of Heligoland. Following this, Colonel Warren was until 1923 head of a mission, for Sir Alexander Gibb and Partners, to Brazil, to prepare the engineering details of a scheme for the development of iron mines, including 350 miles of railway and the building of a port at Santa Cruz. From 1924 to 1925 he was in charge of a hydro-electric scheme in Newfoundland for the development of 100,000 h.p. and the construction of a 400-ton paper mill, and in 1926-1927 was engaged on water works construction in China. In 1928 he headed an engineering mission to Greece in connection with reclamation and development projects. In 1929 Colonel Warren became deputy member on the Colombian National Council of Ways of Communications for Sir Alexander Gibb, G.B.E., C.B., and representative in Colombia of the firm of Sir Alexander Gibb and Partners, consulting engineers to the Republic of Colombia. In this position he was technical adviser to the Colombian government on all hydraulic engineering matters, and succeeded to a remarkable degree in winning the confidence equally of colleagues, officials and members of the government, a marked testimony to his tact and fairness. It is certain that Colonel Warren's work of these last four years has contributed greatly to the prestige of his country and countrymen in Colombia.

Colonel Warren was a member of the Institution of Civil Engineers and of the American Society of Civil Engineers. For War and post-War services he was made an O.B.E. and received the Belgian Order of the Crown.

Colonel Warren became a Member of The Engineering Institute of Canada on April 13th, 1912.

Maritime Professional Meeting, July, 1933

The Halifax, Cape Breton, Moncton and Saint John Branches of The Engineering Institute of Canada and the Nova Scotia Association of Professional Engineers are planning a three-day summer meeting at White Point Beach, near Liverpool, N.S., to take place on Thursday, Friday and Saturday, July 13th, 14th and 15th, 1933. Members of the New Brunswick Association of Professional Engineers will also participate. Further particulars will be announced later.

Papers are being arranged on highways and power development and utilization, and the plant of the Mersey Paper Company will be visited.

The place and time selected are ideal, and a large number of members of The Institute and the Associations are sure to attend the gathering, in this way promoting co-operation and good feeling between The Institute Branches in the Maritime Provinces and the Associations of Professional Engineers.

RECENT ADDITIONS TO THE LIBRARY

Proceedings, Transactions, Etc.

American Institute of Electrical Engineers: Quarterly Transactions December 1932 and March 1933.
American Institute of Consulting Engineers: Proceedings of Annual Meeting, 1933.
Institution of Water Engineers: Transactions Vol. 37, 1932.
American Society of Civil Engineers: Proceedings, March 1933.
American Society of Mechanical Engineers: Record and Index of Transactions, December, 1932.
Institution of Engineers Australia: Selected Papers from The Journal, Volume 2, 1930.

Reports, Etc.

Department of Mines, Mines Branch, Canada:
Anhydrite in Canada, L. H. Cole and R. A. Rogers.
Department of Interior, Geodetic Survey, Canada:
Altitudes in Saskatchewan, R. H. Montgomery.
Publication No. 34, Triangulation in Quebec, J. E. R. Ross.
Department of Interior, Forest Service:
Circular No. 36, Leaching Tests on Water Soluble Wood-Preservatives.
Circular No. 37, Red Stain in Jack Pine.
Bulletin 82, Mechanical Properties of Canadian Woods.
Air Ministry, Aeronautical Research Committee, Great Britain:
Reports and Memoranda:
No. 1493: Stability on the Water of a Seaplane in the Planing Conditions.
No. 1494: Airflow about Aeroplanes shown by Wool-Tufts.
No. 1483: Periodic Flow Behind an Airscrew.
No. 1476: Stressless Corrosion followed by Fatigue Test to Destruction on Aluminium Crystal.
No. 1495: Improvement of Airscrew Body Performance by Radical Vanes.
No. 1496: Acceleration of an Aeroplane upon Entering a Vertical Gust.
Department of Interior, Canada:
Publications of the Dominion Observatory, Vol. 10, No. 16, Bibliography of Seismology.

Technical Books, etc., Received

Does Industry Need a National Standardization Agency: *American Standards Association.*
Prices, by George F. Warren and Frank A. Pearson, (*John Wiley and Son, Inc.*)
Low Cost Roads and Bridges, by Victor J. Brown and Carleton N. Conner, (*Gillette Publishing Company, Chicago, Ill.*)

BOOK REVIEWS

Low Cost Roads and Bridges

By Victor J. Brown and Carleton N. Conner. Gillette Publishing Company, Chicago, Ill., 1933, cloth, 6¼ by 9¼ in., 536 pp., photos., tables.

Reviewed by Professor R. DeL. French, M.E.I.C.*

Any new technical book is, in the nature of things, bound to be in the main a compilation of what has already appeared in print. Few authors, however, admit it so frankly as do Messrs. Brown and Conner—"The authors' problem was one of selection, correlation and synthesis, rather than research, experiment and analysis." Such frankness predisposes the reader favourably to their book, but this should be well received for its own sake.

In ten well-arranged chapters the authors have covered the fundamentals of highway design, economics and planning, grading, surface treatment, low-cost paving materials and their testing, inspection and maintenance. An additional chapter discusses highway bridges. Although the book is not overloaded with illustrations, there are enough to make clear the text.

Heavy-traffic arteries warrant enough expenditure so that it is relatively easy to decide upon the treatment they shall receive, but what to do with the many times greater mileage of roads on which traffic is often so light as to be almost non-existent, is not so easy to decide. It is with this type of highway that the book is concerned, written for the county engineer and others like him, whose most difficult problems are those just mentioned.

In a work of this kind, one would not expect to find any discussion of the more expensive types of surfacing—sheet asphalt, brick, stone block, etc.,—nor does it appear. The treatment of the lower types, however, is entirely adequate. The authors have not hesitated to enlist the co-operation of a number of specialists, which, if detracting somewhat from their own glory, adds much to the value of their book.

A thorough-going discussion of low-cost highways has long been needed; the authors are to be congratulated upon their work, which will surely find a ready sale to those who have to do with highway affairs, even though this reviewer feels that the publishers could have done a better job. There are too many obvious typographical errors, and some of the illustrations could be improved.

*Professor of Highway and Municipal Engineering, McGill University, Montreal.

Canadian Trade Index-1933

The ninth annual issue of the Canadian Trade Index has been received and in addition to the many well-known and excellent features of this book, the 1933 edition has the feature of a 60-page Special Export Section provided by the Department of Trade and Commerce of the Dominion government. Experienced exporting manufacturers have contributed articles outlining five main methods of doing export business.

The publication of this book, the only one of its kind in Canada, containing as it does the names of members and non-members alike, is one of the many general services rendered by the Canadian Manufacturers' Association to the manufacturing community and the business public at large. The continuance of old and new features will prove most valuable in keeping Canadian users fully informed respecting goods produced in Canada and in putting importers in other countries expeditiously and efficiently in touch with Canadian sources of supply.

BULLETINS

Refrigeration equipment—A four-page booklet has been received from The Aluminol Products Corp., Cleveland, Ohio, describing and illustrating a new type of cast units designed to replace the ordinary pipe coil used in refrigerating installations.

Copper Bearing Steel—Cargo Fleet Ironworks, Middlesbrough, England have issued a thirty-two-page booklet describing Carfleco Noncorr copper bearing steel manufactured by that firm. This includes specifications, typical tests of various descriptions and uses. This firm also manufactures steel sheet piling. British Steel Piling Co. Ltd., London, England and Canadian Sheet Piling Co. Ltd., Montreal.

Grabs—A four-page folder has been received from Messrs. Busfield, McLeod Limited, Montreal, illustrating various types of grabs manufactured by Priestman Brothers Ltd., London, England.

Under Water Metal Cutting—A twenty-page booklet has been received from Under-Water Cutters Limited, London, England, containing a description of the equipment used and procedure followed in cutting metal under water by means of the oxy-hydrogen submarine blow-pipe.

The Severn Barrage Scheme

At a time when post-war optimism ruled our affairs the Ministry of Transport promulgated a scheme for utilising the tidal power of the Severn in a document, which, as we then said, read suspiciously like a company prospectus.

After a period of oblivion, caused either by this reception or by the fact that politicians had found something else to engage their activities, the scheme was rejuvenated during the first Labour Government's tenure of office. Lord Snowden then announced that 95,000*l*. was to be spent on an investigation which was to determine whether a suitable site for the barrage was available, and whether the geographical, hydrographical and economic circumstances would enable it to be constructed. A Committee was appointed by the Lord President of the Council.

Almost immediately after its appointment, the committee reported that a *prima facie* case for the scheme had been made out, and were granted funds, so that a hydrographic survey might be carried out at English Stones,* the point on the river, of the three suggested, which appeared to be the best site for a barrage.

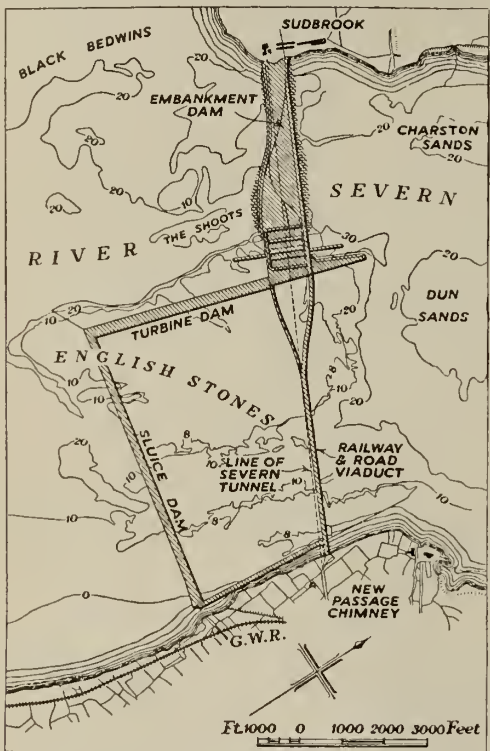
It was accordingly recommended that a complete tidal power scheme should be prepared; and this has since been done by the consulting engineers, under the detailed supervision of an expert sub-Committee, of which Sir John Snell is the chairman and Professor Gibson and Sir Basil Mott among the members. This sub-Committee recently concluded its labours and a final report, which has been published by H. M. Stationery Office, London,† has, as a result, been submitted by the main body.

The latest geological investigations confirm the earlier view that the best site for the barrage is at English Stones, and Professor Gibson is now able to recommend a type of barrage structure, which will conform to the natural conditions in the estuary. The same authority and Mr. Shirley Hawkins have also independently estimated that the output per tide would be 4,680,000 kw.-hr. at spring tides, 3,190,000 kw.-hr. at mean tides, and 1,300,000 kw.-hr. at neap tides. As there are 706 tides per annum, the total potential output each year would, therefore, be 2,252,000,000 kw.-hr., of which about 45,000,000 kw.-hr. would be required for operating the sluice gates and other plant, leaving 2,207,000,000 kw.-hr. for delivery to the grid. It is assumed that to generate this power, 72 turbines with a maximum output of 17,000 brake horse-power would be installed, thus marking a distinct advance over the 1,300 kw. units originally suggested by the Ministry of Transport. Only 67 of these units would be required at any one time.

It is stated that the constructional period would last for about 15 years, and that the works would include a turbine dam 4,550 ft. long and a sluice dam 6,825 ft. long. The Shoots Channel, which is about 1,200 ft. wide, and runs along the northern edge of the English Stones,

*English Stones lies just down stream of the line of the Severn Tunnel.—Ed. E.
†Severn Barrage Committee—Report of Expert Co-ordinating Sub-Committee.

would also have to be blocked and an embankment dam 4,000 ft. long constructed in it. A railway on embankments leading up to the barrage viaducts, locks, an impounding basin, transmission towers and a control station are also included in the project, the estimated total cost of which is 29,325,000*l*. Of this, 8,991,000*l*. is divided between the roadway authorities, the Great Western Railway Company and the authority responsible for operating the locks and regulating the impounding basin, leaving 20,334,000*l*. for the barrage and power scheme proper. It is proposed that this sum should be raised by a loan with a government guarantee, the total amount required with compound interest at 4 per cent. during the constructional period of 15 years, being 25,457,500*l*. The repayment periods, which would begin on the completion of construction, are assumed to be the same as those normally adopted for government projects, and would vary, from 75 years for the permanent civil engineering work, to 20 years for the electrical machinery. On this basis it is estimated that it would be possible to deliver electricity to the transmission lines at the cost of about 0.18*d*. per kw.-hr. It is not easy to criticise this assumption since, as we have already stated, the technical data on which it is based are not yet available. In view of the composition of the Committee by which it is put forward, it may, however, be accepted.—*Engineering.*



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Annual Meeting of the Association of Professional Engineers of Alberta

The annual meeting of the Association of Professional Engineers of Alberta was held in Calgary, on March 25th, about thirty members gathering from all parts of the province. The meeting was presided over by R. J. Gibb, M.E.I.C., engineer of the city of Edmonton.

Ald. P. Turner Bone, M.E.I.C., welcomed the Association to the city on behalf of the mayor and council.

An actual increase in membership was reported in spite of the difficult economic situation, but an increase in dues outstanding was noted. The council have budgeted for a deficit during the coming year, and expenditures are to be considerably reduced.

Dean R. S. L. Wilson, M.E.I.C., of the University of Alberta reported on the efforts being made to obtain cooperation and ultimate Federal unification of the associations of the various provinces. He thought a loosely held committee through which views might be expressed and acted upon was the best form at present, having the ultimate objective of a more closely coordinated Federal association, perhaps in conjunction with The Engineering Institute of Canada in the distant future.

It was decided to hold the annual meeting for 1934 in Edmonton.

J. D. Baker, Edmonton, was elected president, and J. B. DeHart, Lethbridge, vice-president for the ensuing year.

Members of The Engineering Institute of Canada were invited to the dinner held at the Renfrew Club in the evening, about seventy members of both organizations and friends being present.

The first speaker, J. H. Ross, A.M.E.I.C., took as his topic "The Engineer in the Public Life of Tomorrow" outlining the inherent qualifications and handicaps of the engineer in connection with public affairs.

Mr. Gordon Leighton, editor of the Calgary Albertan, chose "Where do we go from Here" as his subject, but first defined "Here" as the world crisis which he further defined as the sum total of all the national and individual crises which we are experiencing.

S. G. Porter, M.E.I.C., past-president of The Engineering Institute of Canada expressed his gratification at the progress being made towards some form of coordination of the various professional associations. He congratulated H. S. Trowsdale, A.M.E.I.C., and the local Branch on his election as a vice-president of The Engineering Institute.

Annual Meeting of the Corporation of Professional Engineers of Quebec

On Wednesday, March 29th, the annual meeting of the Corporation of Professional Engineers of Quebec was held at the Headquarters of The Engineering Institute of Canada, Mansfield Street, Montreal.

Dr. A. R. Decary, M.E.I.C., superintendent engineer for the province of Quebec at the Department of Public Works of Canada, was re-elected for the fourteenth time as President of the Corporation.

The Secretary-Treasurer, S. F. Rutherford, A.M.E.I.C., read the reports from Council, the Treasurer, and the different committees of the Corporation for the past year; all these reports show a great deal of activity within the Corporation which is doing efficient work in the way of protecting its members.

The members present took part in the discussion of several questions of general interest to the engineering profession. It has been reported that the Lieutenant-Governor in Council had given its approval to the Tariff of Fees, the Code Professional Ethics, and the By-Law on Seal.

The Secretary read the report of the scrutineers, and the following members were declared elected: for the District of Montreal, Messrs. O. Lefebvre, M.E.I.C., J. M. Robertson, M.E.I.C., and Geo. K. McDougall, M.E.I.C.; for the District of Quebec, Mr. Hector Cimon, M.E.I.C.

At the close of the meeting the Council met and elected officers as follows: President, Dr. A. R. Decary; Vice-President, Col. C. N. Monsarrat, M.E.I.C.; Secretary-Treasurer, Mr. S. F. Rutherford. The other members of Council are: Dr. O. Lefebvre, and Messrs. J. M. Robertson, Geo. K. McDougall, A. B. Normandin, A.M.E.I.C., and Hector Cimon. Mr. Adhémar Mailhiot was re-elected as Registrar of the Corporation.

Oil-Engine Troubles

In a paper contributed to a meeting of eleven technical societies, recently, and organised by the Institution of Automobile Engineers, Mr. H. R. Ricardo, F.R.S., discussed some imperfectly explained troubles experienced with petrol and Diesel engines. Amongst these are the comparatively frequent but somewhat erratic failures of the white-metal in big-end bearings. After a certain period of service, small cracks appear in the white-metal lining the top half of the bearing, directly in line with the connecting rod. These cracks spread rapidly and multiply until the whole surface becomes a complete mosaic, pieces of which ultimately become detached and attempt to climb over their neighbours. It is stated that about 60 per cent. of oil-engine builders, both at home and abroad, have experienced troubles of this kind, whilst other makers enjoy comparative immunity. Apparently neither speed or lubrication is an important factor. As remedies, Mr. Ricardo suggests, where possible, the use of built shafts and floating bearings. These, he states, are immune since they are constantly turning and the blow, due to the explosion, is not always repeated on the same spot. White-metal linings should, he states, have a thickness of the order of 10 mils to 20 mils, and be mounted on thin steel shells. In his paper, Mr. Ricardo also suggests that the heavy wear of oil-engine liners often experienced is mainly due to chemical action, and is thus corrosion rather than erosion. The wear averages, he states, some 3 mm. to 4 mm. per 1,000 hours run in the case of petrol engines, but is generally some 75 per cent. greater in airless-injection oil engines. The amount appears to be nearly independent of the speed of revolution, but may vary with the pressure and with the fuel used. In general, it takes the form of deep grooves near the top of the piston travel, tapering off to a minimum at mid-stroke level. In sleeve-valve engines, the wear is only about one-tenth as great in engines with stationary liners. The total loss of metal from the liner is many times the loss from the piston rings, which seems inconsistent with the view that erosion is the main factor responsible. Moreover, the wear is not reduced, but is actually increased, if the liners are made of case-hardened metal or nitrided steel. Since marine Diesel engines suffer as severely as their fellows in land service, the damage cannot be attributed to dust carried in on the suction stroke. Mr. Ricardo notes further, that the rate of wear is greatly increased by the use of fuels having high ignition temperatures. He suggests that the phenomenon is connected with the fact that when a flame is suddenly chilled by contact with a relatively cold surface, combustion is checked and partial products formed, which are strong oxidising agents. * * * * * * —*Engineering.*

BRANCH NEWS

Calgary Branch

J. Dow, M.E.I.C., Secretary-Treasurer.
W. H. Broughton, A.M.E.I.C., Branch News Editor.

About forty members and friends gathered at the Board of Trade rooms on the Evening of Thursday, February 8th with F. M. Steel, M.E.I.C., in the chair to hear an address on "Forestry" by H. G. Reynolds, Esq., R.P.E. (B.C.), a member of the Canadian Society of Forest Engineers.

Forestry

Forestry as a science is of comparatively recent date, Hartig and Cotta being the first two men to exert an influence which is with us today.

It may be divided into four classes, namely: Forest Management, Forest Protection, Grazing and Records.

Under the heading of management come—Silviculture, Dendrology, Forest Mensuration, Timber Cruising, Surveying, Reconnaissance, Land Classification, etc.

Forest protection embraces actual fire fighting, protection organization, lookout systems, construction and maintenance of roads, trails, telephone lines, radio stations, aeroplane and land patrols, care and storage of protection equipment, etc.

Grazing deals with range lands and forest fodder, determining the number and class of grazing animals best suited for each particular location and insures against the overstocking of range lands and the destruction of the tiny seedling in the forest from excessive trampling and browsing.

The object of forestry is to discover and apply the management principles. Forestry being distinct from aboriculture which deals with the individual tree, the individual tree being of interest to the forester only as they stand together over large areas.

The silvicultural characteristics of the different trees were explained, the various requirements of different species for moisture, warmth, cold, light, etc. Their reproduction powers, by seed or sprout. The seven stages of the growth of a tree were explained from the beginning of the tiny seedling until the decay of the veteran.

The strip method of timber cruising was then taken up and explained by diagrams. The methods of carrying the elevations and plotting the topography were discussed, also the width of the strip and method of computing the estimate.

Conditions which influenced a forest fire were then explained, some of the more important being, moisture content of the material, wind, steepness of the slope, draught created by the fire itself, volume of heat and the relative humidity in the air.

The different kinds of fires were then explained, namely: Duff fires, Ground fires, and Crown fires,—Duff fires being those which burn under the ground, Ground fires being those which on the surface of the ground and Crown fires which are confined to the crowns of the trees and through falling embers set the ground fire.

The four methods of attack usually adopted to cover these fires are: the direct method, twofoot method, parallel and indirect methods.

A hearty vote of thanks for his interesting address was accorded Mr. Reynolds on a motion by Messrs. M. H. Marshall, M.E.I.C., and J. J. Hanna, A.M.E.I.C.

Annual Meeting

The usual coterie of stalwarts assembled at the Board of Trade Rooms on the afternoon of Saturday, March 11th to administer the customary commendation or blame to officials and chairmen of committees in accordance with the manner in which duties had been performed.

The Secretary-Treasurer's report showed the need for making our expenditures fit our income, thus being in accord with the majority of treasurers' reports heard in these strenuous days.

The following reports were read and adopted:

Credentials	by B. L. Thorne, M.E.I.C.
Programme	by M. W. Jennings, A.M.E.I.C.
Attendance	by W. H. Broughton, A.M.E.I.C.
Branch News-Editor	by W. H. Broughton, A.M.E.I.C.
Publicity	by G. H. Thompson, A.M.E.I.C.
Policy	by R. C. Harris, M.E.I.C.
Prize	by M. H. Marshall, M.E.I.C.
Reception	by B. L. Thorne, M.E.I.C.

It was felt by the majority that the Annual Ball has sufficient advertising value to warrant the expenditure. R. S. Trowsdale, A.M.E.I.C., threw out a suggestion to the incoming programme committee to inaugurate some ventures during the coming winter that will produce a little revenue.

Considerable discussion followed the reading of the report of the Applications and Credentials committee and a motion was passed with the object of having the incoming committee critically examine its method of handling applications and changing it if deemed desirable.

R. J. Stringer Affil.E.I.C. and F. N. Rhodes, A.M.E.I.C. (scrutineers) reported the result of the Ballot as follows:

Chairman	H. J. McLean, A.M.E.I.C.
Vice-Chairman	G. P. F. Boese, A.M.E.I.C.
Secretary-Treasurer	J. Dow, M.E.I.C.
Executive (Elected)	F. G. Bird, A.M.E.I.C.
	A. Griffin, M.E.I.C.
	R. MacKay, A.M.E.I.C.
(*Ex Officio*)	F. M. Steel, M.E.I.C.
	S. G. Porter, M.E.I.C.
	B. Russell, M.E.I.C.
	H. W. Tooker, A.M.E.I.C.

The Chairman, F. M. Steel, M.E.I.C., thanked the officers, convenors of committees, and particularly the Secretary-Treasurer for the very hearty support accorded him during his term of office and bespoke the same support for his successor.

In the absence of the newly elected chairman the vice-chairman, G. P. F. Boese, M.E.I.C., then took the chair and Mr. Steel presented the retiring Secretary-Treasurer with a beautiful little Kodak which was fittingly and feelingly acknowledged.

Visits to industrial plants, and probably to the annual golf meeting during the coming summer were promised by the incoming executive.

Kingston Branch

L. F. Grant, M.E.I.C., Secretary-Treasurer.

The Kingston Branch held its regular meeting and dinner at the Badminton Club on Thursday March 23rd. Following the dinner an illustrated talk on "Recent Developments of the Diesel Engine" was given by Lieut.-Col. E. J. Schmidlin, R.C.E., M.E.I.C., chairman of the Branch, of which the following is a synopsis.

Diesel Engines

Most engineers are familiar with the principle of the Diesel engine which is that of spontaneous ignition of the charge, in the high temperature caused by compression.

The original method of injecting the fuel was by means of compressed air; consequently the early Diesel engines were all designed for low speeds, as this method of injection is difficult to control satisfactorily under high speed conditions. The result was to produce a comparatively large and heavy machine, which was suitable for stationary and marine purposes.

The first improvement was to substitute pump injection for compressed air, but this was applied only to the smaller units, and left the question of slow speed and excessive weight unsolved for the larger machines.

The use of the so-called semi-Diesel principle, in which a highly heated area provides the igniting effect, gave a lighter and cheaper construction, but operation and efficiency were not very satisfactory. Semi-Diesels are no longer being manufactured on a large scale.

One of the difficulties in combustion at high speeds being combustion lag, a pre-combustion chamber was introduced with satisfactory results, and made it possible to run the engine at speeds up to 2,500 r.p.m. Another problem is to meter the fuel, and this has been more or less successfully met by careful and improved design of the pump. Better mixing of air and fuel in the combustion chamber has been obtained by providing turbulence of the air charge by proper shape of piston head, air inlet passage etc.

In practice a Diesel requires for complete combustion about thirty per cent more air than that theoretically necessary, thus descreasing the available power per cubic inch of cylinder correspondingly. A satisfactory solution of this difficulty has not been found. In regard to supercharging, it is questionable whether the advantages gained will outweigh the resulting greater wear to the engine parts, but operating results are encouraging.

Diesel power is now extensively installed in flour mills, ice-making plants and saw-mills, and there has been a very rapid development in its application to small craft such as tugs yachts and ferry-boats, for which it offers great advantages.

Other uses have been in locomotives, excavating machinery, tractors, road rollers, buses and motor-trucks, but in the private passenger car the Diesel installation has been negligible. A good deal of experimentation has been carried out for aviation purposes, and the R 100 was Diesel-powered.

At the conclusion of the address the large number of questions which Colonel Schmidlin was called upon to answer indicated the interest of his audience.

Lethbridge Branch

E. A. Lawrence, S.E.I.C., Secretary-Treasurer.
R. B. McKenzie, S.E.I.C., Branch News Editor.

The Annual Meeting of the Lethbridge Branch, Engineering Institute of Canada, took place in the Marquis Hotel, at 6.30 p.m. Saturday evening, March 4th, 1933. The speaker for the evening was W. D. Armstrong, A.M.E.I.C., plant superintendent of the Canada Cement Company Limited, Exshaw, Alberta. During the dinner, Geo. Brown's orchestra presented a programme. Mr. Meech, after a few complimentary remarks, introduced the speaker. The chairman, Wm. Meldrum, A.M.E.I.C., reviewed the work of the past year and then transferred his duties to the incoming chairman, J. Haimes, A.M.E.I.C.

The Manufacture of Cement

In opening his address, Mr. Armstrong mentioned that at present Portland Cement is one of the most widely used materials for building purposes, but it has been in general use for only a short period. In its earlier forms it has been used long before the dawn of recorded history. Later man began to use lime mortar, and still later to add partially burned gypsum to it. This material was used in the construction of the pyramids.

The cement industry proper may be said to date from the latter part of the 18th century, as a result of a discovery by John Smeaton, an English engineer.

While this was the beginning of the Portland cement industry, in a small way, it remained almost at a standstill from its beginning in 1824 till 1885 when Ronson, an Englishman, developed the rotary kiln.

From this the speaker went on to discuss the five factors responsible for the development of the industry to its present stage. 1. The systematic application of the mixture, the use of each kind of raw material having the necessary ingredient. 2. The development of efficient grinding machinery. 3. The development of the rotary kiln, and the development of pulverized coal as fuel. 4. The development of standard specifications, permitting the manufacture from widely differing materials, insuring a reliable product. 5. The systematic study of the best uses of concrete and the best methods of making it.

Mr. Armstrong mentioned the fact that we still use the same materials as were used one hundred years ago, although we can state more definitely now the constituents in the lime, silica and aluminum. Fortunately for us, he said, these materials are quite widely distributed throughout nature. Limestone can be found in nearly all localities. Silica and aluminum can also be found in large quantities. The problem resolves itself to finding these main constituents as close together as possible. The market should also be as near at hand as possible. An electrical power supply is preferable. An average sized mill will produce about four thousand barrels of cement daily.

The process of manufacture of cement, the speaker said, consists briefly of four distinct steps. 1. The reduction of the rock and shale to a very finely divided condition. 2. Mixing the two materials intimately in proper proportions. 3. The formation of cement clinker by heating to the required temperature. 4. Grinding the clinker to a very fine powder. There are two general methods of handling raw materials, the wet and the dry processes, both of which have their advantages. The nature of the raw materials, etc., determines which method will be used.

In its final form the cement will pass through a mesh of 40,000 to the square inch. It is interesting to note that a sieve of this nature will hold water.

The cement is then stored in bulk, no change taking place due to storage. When ready for shipment it is put in bags by machinery. Complete chemical testing laboratories are kept at each kiln. A check is taken of the material every hour. In the cement are four major constituents upon one of which the gypsum acts as a catalyst.

After his address, a film was shown descriptive of the manufacture of cement, taking in all the processes. The projector was operated through the courtesy of Mr. C. Watson. G. N. Houston, M.E.I.C., in expressing his appreciation of the speaker's address, moved a hearty vote of thanks on behalf of the Branch.

London Branch

W. R. Smith, A.M.E.I.C., Secretary-Treasurer.
Jno. R. Rostron, A.M.E.I.C., Branch News Editor

The regular monthly meeting of the London Branch was held on December 15th, in the London Public Utilities board room, the speaker being W. C. Miller, B.Sc., M.E.I.C., city engineer of St. Thomas, Ont., and his subject, the "Purification of Public Water Supplies."

The minutes of the last meeting were read by the Secretary and passed unanimously. The chairman, D. M. Bright, A.M.E.I.C., introduced the speaker.

Last June the members of the Branch were taken by Mr. Miller on an inspection trip over the St. Thomas water works and his paper was a sequal to this visit.

Purification of Public Water Supplies

Mr. Miller stated that the purpose of his paper was to present a resume of the outstanding features in the modern practice of water purification.

It is the problem of the sanitary engineer to produce a clear, colourless, odorless, tasteless water and in addition it should be for all practical purposes, sterile.

As time goes on the general public will become awakened to the cost involved in using soap, soda, flakes, powders, etc., and will demand that they be supplied with soft water. It is conservatively estimated that in St. Thomas alone 90,000 pounds of soap, etc., is used annually more than would be necessary if three-quarters of the present hardness of the water were removed.

The work of treating water divides itself into the following main divisions: 1—preliminary sedimentation; 2—mixing and coagulation; 3—sedimentation after coagulation; 4—filtration; 5—aeration; 6—chlorination and ammoniation.

Mr. Miller gave detailed information regarding each one of the above divisions, stating for instance that preliminary sedimentation is incidental to a water supply storage basin, and in some cases serves to remove any granular suspension.

There were about thirty members and guests present, all interested in the subject and a very interesting discussion followed.

A hearty vote of thanks to the speaker was moved by E. V. Buchanan, M.E.I.C., manager of the Public Utilities Commission, London, Ont., seconded by W. G. Ure, A.M.E.I.C., city engineer, Woodstock, Ont., and carried unanimously.

Economy in Public Finance

The regular monthly meeting was held on March 15th, 1933 in the City Hall auditorium, the guest speaker being Major Gordon Ingram and his subject "Economy in 'Public Finance'."

The Chairman of the Branch, V. A. McKillop, A.M.E.I.C., presided and opened the meeting with a few preliminary remarks to the effect that in these days it was necessary for engineers to take up the study of economic and social problems, hence the subject chosen for this meeting.

Colonel I. Leonard, M.E.I.C., gave the Branch some information regarding the proceedings of the Council of the Association of Professional Engineers of Ontario. He said that they had given up the idea of trying to obtain special legislation, for the present anyway as it had been discovered that there was already a clause in the existing Act which gave considerable power and might prove adequate for the protection of the Professional Engineer in Ontario. It was proposed therefore to try it out by prosecuting, at the first opportunity, any person who was practising as an engineer without proper qualifications.

Major Ingram opened by describing the function of the committees, national, provincial and municipal, which had been formed to investigate, and it was hoped to remedy, the vastly increased expenditure of public bodies and consequent taxation. It was a year ago last fall that the local committee attached to the Chamber of Commerce had been formed and considerable progress had been made. In the first place all governing bodies, Federal, provincial and municipal strove to carry out the wishes of the people and it was in the doing of this that they had overstepped the mark.

The ultimate object, therefore, of the committees referred to was not so much to present their findings directly to the spending bodies but rather to put them before the public to educate them to the obvious fact that if they called for service and got it they would have to pay for it.

Mr. Sanford Evans of Winnipeg was compiling data mostly for the Committee on Federal Expenditure, while Dr. Britain was performing a like duty for the Provincial Committee. Professor Riley of the Western University was helping the local municipal committee.

The speaker had a number of Mr. Sanford Evans' charts, which he exhibited to the meeting.

Referring to the increased expenditure of the governments he cited the cost to the public of the taking over of the Grand Trunk Railway also the financing of public utilities, as being two important factors.

E. V. Buchanan, M.E.I.C., said that in his twenty-three years' experience as manager of the local Public Utilities Commission, he did not remember any deputation ever coming to the board meeting of the Commission with a request to curtail expenditures, on the other hand there had been scores of them asking for increased services. None of these deputations however ever gave a thought to the question of who pays.

Regarding the Board of Education's position, a cut of something like 20 per cent was suggested but as 60 per cent were fixed charges, it only left 40 per cent for salaries and if 20 per cent of the whole amount was cut off, it amounted to practically 50 per cent off the salaries, which was too much.

Many people criticized the Ontario Hydro Commission for developing too great a surplus of power, but he pointed out that this surplus only amounted to 30 per cent while the surplus in the United States was 57 per cent.

He was not criticising the local committee in any way but he wanted to know what was to be done about the rapidly increasing taxation.

Major Ingram in reply stated that their object was to show the public that they were largely responsible as the governments and municipal bodies tried to give them what they asked for and therefore the people themselves were really the governers. The primary object of the local committee was to show this angle to the public and let them see that the calling for further expenditure and consequent increased taxation, had got to stop.

W. C. Miller, M.E.I.C., C. Talbot, A.M.E.I.C., and S. Baker, (City Clerk), also took part in the discussion.

W. G. Ure, A.M.E.I.C., proposed a vote of thanks to the speaker which was seconded by J. A. Vance, A.M.E.I.C.

About forty members and guests were present.

Ottawa Branch

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

Great Lakes Waterways Development

"The Development of the Great Lakes Waterways System and Harbours thereon in Canadian Territory" was the subject of an address by Lt.-Col. H. J. Lamb, D.S.O., M.E.I.C., supervising district engineer for the Province of Ontario, Department of Public Works, before the Ottawa Branch at their noon luncheon, March 9th. Group Captain E. W. Stedman, M.E.I.C., chairman, presided and in addition head table guests included: Hon. H. A. Stewart; Hon. A. H. Macdonell; Hon. A. Duranleau; Major-Gen. H. A. Panet; Colonel A. E. Dubuc, M.E.I.C.; A. Speakman, M.P.; Doctor Chas. Camsell, M.E.I.C.; J. B. Hunter; K. M. Cameron, M.E.I.C.; R. deB. Corriveau, M.E.I.C.; J. E. St. Laurent, M.E.I.C.; D. W. McLachlan, M.E.I.C.; C. McL. Pitts, A.M.E.I.C.; J. G. Macphail, M.E.I.C. and W. E. MacDonald, A.M.E.I.C.

Lt.-Col. Lamb traced the development of this great system of international waterways touching briefly upon the following: International boundary line establishment; construction of canals and locks at Niagara Falls and St. Mary's Falls; charting the system and establishment of aids to navigation; improvement of connecting channels throughout the system; and construction of harbours for traffic and for refuge. His address was illustrated with lantern slides.

The first steamboat on the Great Lakes system, stated the speaker, was the "Frontenac" built in 1816 at Ernestown, 18 miles from Kingston. She was a 700-ton schooner equipped with British engines. In 1931, the fleet engaged exclusively in commercial traffic of the Great Lakes comprised 923 vessels with a gross tonnage of 3,405,000 tons. Of these 923 vessels, 601 were of United States registry and 322, or 35 per cent, of Canadian registry. The Canadian gross tonnage was 754,195 tons. Of these 923 vessels, 833 were available for moving the commerce either in bulk, package or tank, and figuring on the basis of a 19-foot draught they had a combined carrying capacity of 4,500,770 gross tons. The remaining ninety vessels were comprised of passenger-freight ships, car ferries, passenger and motor ferries, tugs, etc.

A modern large lake freighter, stated Lt.-Col. Lamb, is probably the most economical freight carrier ever designed. With it coal is carried from Lake Erie to Lake Superior ports, a distance of about 900 to 1000 miles, at a rate as low as 35 cents a ton; also the iron ore of the Mesabi range is carried from Lake Superior to Lake Erie ports at the low rate of 86 cents a ton or approximately one and one-tenth miles per ton-mile. This is probably the main factor in the supremacy of the steel industry in the United States. A twelve-thousand ton carrier is usually loaded with ore in from one and one-quarter to one and one-half hours including moving, and unloaded in less than three hours. The carrying charges actually become lower as the length of the ship is increased. Thus the cost of operation of the modern 600-footer is little more than a 450-footer.

Lt.-Col. Lamb gave some details with regard to the work performed in improving the channels and in providing harbours throughout the system. Where the important work lies in international waters (as the major portion of it does) the terms of the treaty of 1909 between Great Britain and the United States concerning such waters have to be strictly adhered to.

Highs and Lows

At the noon luncheon of the Ottawa Branch on March 23rd, there were present a large number of McGill University graduates and delegates to the Canadian section of the American Water Works Association, then in annual session at the Chateau Laurier. The guest speaker was Dean A. S. Eve, Department of Physics and Dean of the graduate faculty, McGill University. The title of his address was "Highs and Lows."

Group-Captain E. W. Stedman, M.E.I.C., chairman of the local Branch, presided. Except for three members of the Canadian Section of the American Water Works Association, guests at the head table were graduates of McGill University. In addition to the chairman and the speaker, there were: Senator G. V. White; Honourable J. H. King; Maj.-Gen. A. G. L. McNaughton, M.E.I.C.; Dr. T. H. Leggett; Dr. H. Barton; Dr. G. S. McCarthy; Dr. P. D. Ross; Dr. R. W. Boyle, M.E.I.C.; F. E. Bronson, M.E.I.C.; G. G. Gale, M.E.I.C.; K. M. Cameron, M.E.I.C.; R. deB. Corriveau, M.E.I.C.; C. McL. Pitts, A.M.E.I.C., R. C. Berry; W. E. MacDonald, A.M.E.I.C., president; A. U. Sanderson, A.M.E.I.C., president-elect; and Dr. A. E. Berry, A.M.E.I.C., secretary-treasurer of the Canadian section of the American Water Works Association.

Dean Eve's address dealt first of all with the "highs and lows" of nature, evidenced in weather phenomena of all kinds, and then went on to compare these fluctuations with those of the boom times and depressions that have characterized mankind's civilization.

"There were at least six depressions during the past century," stated the speaker. "In 1837, for instance, values melted so that in North Carolina farms could be bought for only 2 per cent of their supposed worth, New York was like a dead city, and from a half to two-thirds of the clerks and salesmen in Philadelphia were without work."

Other periods of panic and depression followed with remarkable regularity. "Can panics or depressions, and booms be predicted?" asked the speaker, "and can they be controlled? Or must society continue to be devasted by wild fluctuations in trade, commerce and finance?"

For answer, Dean Eve took the stand that "when the causes are due to human action, then the results can be controlled by man's intelligent intervention, if not unduly delayed." He suggested that four things could be done: educate the children and young men and women to realize that war is terrible and wasteful; create a strong public opinion in favour of punishment as a deterrent for those who raid the public by illegal or unethical methods; instill into the people the principle of honest dealing in all matters of government and business; and come to a general realization that all our problems are international and that the nations must work together in the promotion of peace.

In summing these points up the speaker gave out the suggestion: "Should there not be a Minister of Science, with a small but able staff advising in all scientific and engineering problems, with their interlocking financial and economic questions, inquiring into the ripeness of plans, advancing some, retarding others, and looking further into the future than the fleeting catchwords of impulsive schemes at present allow?" The minister, thought the speaker, should not necessarily be a scientific man but he should be able to interpret the wisdom of his permanent civil servants, who would be men of intelligence and probity, whose sole aim would be the benefit of the country at large.

"If other countries had such ministers and such staffs," concluded the speaker, "it might be possible to achieve by their co-operation, a larger intelligence than the world now possesses in the direction of international affairs."

Peterborough Branch

W. F. Auld, Jr.E.I.C., Secretary
W. T. Fanjoy, Jr.E.I.C., Branch News Editor

Developments in Topographical Mapping

In an informal talk to members of Peterborough Branch, March 23rd, on the subject of developments in topographical mapping, J. W. Pierce, past president of the Dominion Land Surveyors, said that the technique of aerial photography had been rapidly and extensively advanced early in the war. The necessity of obtaining accurate information of the enemy's position pressed the airplane into use as an auxiliary and virtually the eye of the engineers.

When Canada's airmen returned from overseas, the government decided to employ some of them in connection with the resurvey of the Ontario-Manitoba boundary. Hydroplanes of the pusher type were equipped with large cameras in the front cockpit, and photographs were taken at an elevation of approximately 5,000 feet. Mr. Pierce illustrated his explanation of the method followed by the pilots and surveyors who were under his direction. From known and measured control or base lines photographs with the camera set toward the horizon were made of a territory from six to eight hundred square miles in an hour's flying. The photographs were then imposed on "grids," equally spaced lines, in the office of the Surveyor-General, and by this process the map-makers at Ottawa were able to fill in on their old maps spaces that had previously been blank, and also to present accurately detailed topographical information that was invaluable to Mr. Pierce's surveying party.

Errors on old maps were corrected, and the work of defining the Ontario-Manitoba boundary from the Lake of the Woods to Hudson's Bay was greatly facilitated. In this respect the experience of the air force during the war was turned to the advantage of one phase of peace time engineering.

Mr. Pierce also told of the amazement of different settlement Indians at their first sight of a Johnson outboard motor. His photographs, thrown on the screen, showing views of the boundary sections of the province from the vicinity of Lake Winnipeg to Hudson Bay were of genuine interest, and were highly appreciated by the members of the Branch.

Students and Juniors Night

The Annual Students' and Juniors' night, April 6th, embraced three speakers, in the persons of E. J. Davies, Jr.E.I.C., a member of the staff of Peterborough Vocational School, who spoke on "Building the Backbone of the Nation," J. L. McKeever, S.E.I.C., of the engineering staff of Canadian General Electric Company, who took as his subject: "Determinism in Natural Science," and W. F. Auld, Jr.E.I.C., also a member of the Engineering Department of Canadian General Electric Company, who discussed "A National and International Problem."

The Student and Junior Meeting has been a regular feature of the Branch activities since 1926, when the idea was first put forth by B. L. Barns, A.M.E.I.C., then chairman of the Branch.

Building the Backbone of the Nation

"If factory heads would come to us when they have openings for young men in the various trades of their plants, I am sure that we could furnish them with students from our school that will make a success of the work that may be required of them," Mr. Davies stated. He explained that the purpose of the vocational school was to give the boys and girls an opportunity to find the jobs for which they are best suited and at which they will be happy and take pleasure in accomplishing.

Proof was furnished of the strides the students make in the school in the various industrial arts despite the comparatively short time that they spend at them in the school working day. Mr. Davies stressed the eagerness which the boys take to the practical work of the school, pointing out that many of the boys remain at the work benches long after 4 o'clock in order to gain fullest advantage of the equipment in the work shops and complete the job that has been assigned to them.

He showed conclusively the advantages and assistance the training at the school is to the boy in helping him to adjust himself to shop conditions and in finding the vocation at which he will best excel.

Determinism in Natural Science

Mr. McKeever, in his address, showed that before the age of science the mind of man could see no cause for various happenings in nature. These happenings were ascribed to the whims of gods, godesses and spirits. Later, however, as his mind developed he saw that for each event there was a cause and the same cause was always followed by the same event. This is called the Law of Causality.

With the beginning of the twentieth century a gradual change in point of view took place and it was left for Max Planck to formulate a new idea known as the Quantum Theory, whereby light was conceived as consisting of bundles of photons known as quanta. Later it was found, however, that dividing a beam of light, when this light was reduced to a single photon, these particles might follow either of two paths without apparent cause except for the purely mathematical laws of chance and probability.

Similarly with radium, the process of disintegration of radium into atoms of lead and helium goes on very slowly but the point to be noted is that there seems to be no particular reason for any one atom to disintegrate before another.

The above are only two examples of indeterminacy but they serve to show how the idea of Causality has been undermined and partly replaced by the mathematics of chance and probability.

A National and International Problem

In a humorous address W. F. Auld pointed out the dangers and evils of the increase in "public speakeasiness." He urged that the average citizen who is compelled upon nearly every occasion to endure hearing a flood of oratory should arise and put a stop to their own suffering by stamping out the spread of the germ of speakeasiness. If a speaker has no thought to utter no matter how well he expresses it, it remains nothing after it is spoken.

Saint John Branch

G. H. Thurber, A.M.E.I.C., Secretary-Treasurer.
G. C. Clark, S.E.I.C., Branch News Editor

A meeting of the Saint John Branch of The Engineering Institute of Canada was held at the Admiral Beatty hotel on March 23, 1933, the speaker being John N. Flood, A.M.E.I.C., on the subject "Some Features of a Town Planning Scheme for Saint John." A. A. Turnbull, A.M.E.I.C., chairman of the Branch, presided. The meeting was open to the public and the wide interest taken was evidenced by the large attendance. The paper presented by Mr. Flood was broadcast over Radio Station CFBO.

Town Planning Scheme for Saint John

Mr. Flood traced the history of the town planning movement since its inception in 1915, through the preliminary stages resulting in legislation in 1919, and final approval by the provincial government in 1931. References were made to Canadian and American cities employing similar schemes, showing methods used and some of the results obtained. Comparisons were made to show in general how similar investigations could be conducted in Saint John to determine faults in traffic conditions and suggest future remedial measures. The need for this type of work was illustrated by photos showing present arterial thoroughfares in Saint John. Mr. Flood presented many examples to show how existing and future traffic conditions could be improved by widening streets or by new construction in some instances and constructing viaducts in others. It was shown how a viaduct 1,600 feet in length would open up a vast tract of land north of the city for development, and would provide a short route to the municipal airport.

With reference to buildings, changes could only be made slowly, without large expenditures, in the city proper, the speaker stated, hence the present applications of the scheme were being directed toward outlying areas now under development. A large number of charts were shown giving population changes in different sections of the city and adjoining parishes over a long period. These charts showed a definite trend of population loss in the central districts and a corresponding increase in outside areas.

A series of graphs were shown giving the increase in school population over a long period, and the necessity of providing adequate playground areas for children was dealt with at some length. Large scale maps and charts were shown to indicate areas in adjoining districts that could be readily developed as parks when conditions warranted, if the proper action was taken now. Reference was also made to the desirable development of historic points in the city and vicinity.

At the close of the address a hearty vote of thanks was moved by G. G. Murdoch, M.E.I.C., and seconded by Alex. Gray, M.E.I.C. Among those taking part in the brief discussion following the paper were A. R. Crookshank, M.E.I.C., J. L. Feeney and F. P. Vaughan, M.E.I.C.

Saskatchewan Branch

Stewart Young, A.M.E.I.C., Secretary-Treasurer.

The sixteenth annual meeting of the Saskatchewan Branch of The Engineering Institute of Canada was held on Friday evening, March 24th, 1933, in the Hotel Champlain, Regina, J. D. Peters, A.M.E.I.C., presiding.

The meeting was preceded by a dinner at which thirty-two were present.

The Secretary advised the Branch of an intended visit by the president of The Institute, O. O. Lefebvre, M.E.I.C., to Saskatchewan; Saskatoon on April 6th and Regina on April 20th.

The reports of standing committees were then presented and adopted.

A. C. Garner, M.E.I.C., then presented an Institute badge to D. A. R. McCannel, M.E.I.C., past-chairman, 1931, and Mr. McCannel thanked the meeting.

The entertainment included songs by Messrs. Jenkins and Laird, and several moving pictures of Saskatchewan scenery were shown, H. C. Ellis, of the Bureau of Publications being in charge of the lantern.

The scrutineers, H. A. Jones, A.M.E.I.C., and L. W. Llewellyn, Jr.E.I.C., made the following report on the ballot:

Chairman	P. C. Perry, A.M.E.I.C.
Vice-Chairman	R. A. Spencer, A.M.E.I.C.
Secretary-Treasurer	Stewart Young, A.M.E.I.C.
Executive Committee	A. P. Linton, A.M.E.I.C.
	H. R. MacKenzie, A.M.E.I.C.
	A. M. MacGillivray, A.M.E.I.C.
Nominating Committee	H. J. A. Bird, A.M.E.I.C.
	H. S. Carpenter, M.E.I.C.
	S. R. Muirhead, A.M.E.I.C.
	C. J. MacKenzie, M.E.I.C.
	L. A. Thornton, M.E.I.C.

These were declared by the chairman to be duly elected.

Mr. Perry, in taking over the chairmanship, expressed appreciation of the work of J. D. Peters, as chairman, during the past year, making special reference to the fact that Mr. Peters had made special effort to be present at all meetings of the Branch during his term of office, having in each case travelled by car, sometimes under trying conditions, from Moose Jaw.

Messrs. R. W. Allen, A.M.E.I.C., and S. R. Muirhead were elected auditors.

Mr. Perry then gave a report on the recent Annual Meeting at Ottawa, stating that, inasmuch as the west is entering on a period of great changes that would affect the organization, the Executive would need the co-operation and support of the individual Branch members.

Of outstanding interest at the Annual Meeting was the report of the Committee on Development. After outlining the history of the activities of this Committee, Mr. Perry proceeded to place before the meeting, as briefly as possible, the present status of the movement to co-ordinate the activities of The Engineering Institute of Canada with the several Provincial Associations of Professional Engineers. He pointed out that there were many difficulties in the way. On the one hand there is a body of engineers of the opinion that The Engineering Institute should function entirely apart from the Professional Associations. On the other hand there are those of the opinion that The Institute should function as a co-ordinated organization of Professional Associations. After introducing the subject in this manner, Mr. Perry called on Mr. D. A. R. McCannel.

After expressing his appreciation of the way in which Mr. Perry had placed before the Annual Meeting in Ottawa an outline of conditions in Saskatchewan, Mr. McCannel proceeded to discuss the subject in detail.

Due, in part, to the falling off of membership in several branches of The Institute, there is a feeling that the activities of The Institute should be more closely related with those of the Professional Associations. In particular, Mr. McCannel pointed out that the Professional Associations in Canada were in the first instance fostered by The Institute.

In referring to a meeting in Montreal of representatives of the eight provincial Professional Associations, Mr. McCannell drew attention to the fact that each representative also was a member of The Institute. This meeting, after discussing all angles of the question, concluded that the first step towards co-ordination was the setting up of a Dominion Council of eight. He then placed before the meeting the recommendations of the committee of eight to the representative Professional Associations, pointing out that these associations need an organization such as The Institute to give to the engineer a broader outlook. There is a tendency to view the profession from the point of view of the individual, forgetting that by the raising of the status of the profession the status of the individual member also is raised. Moreover, The Engineering Institute of Canada offers a better contact with fellow engineers than the purely provincial organizations and, being a larger body, offers the greater opportunity to raise the status of the engineering profession in Canada. In concluding his remarks Mr. McCannel felt that, inasmuch as co-ordination at present is more or less out of the picture, engineers should, in the meantime, support both organizations and particularly The Engineering Institute of Canada.

In the discussion which followed the following members took part: H. R. MacKenzie, J. C. Meade, A.M.E.I.C., A. P. Linton, A. C. Garner.

Arising out of the discussion the following resolution was passed:

Moved by A. C. Garner, seconded by A. P. Linton, that council appoint a committee to study all angles of the question and co-operate with the Associations of Professional Engineers in an endeavour to arrive at a solution of the problem of co-ordination.

Sault Ste. Marie Branch

G. H. E. Dennison, A.M.E.I.C., Secretary-Treasurer.

The Sault Ste. Marie Branch held their March meeting at the local mills of the Abitibi Power and Paper Company, where they were the guests at dinner of Mr. C. O. Sisler, mill manager. Following the dinner and business meeting, the members were addressed by Mr. C. B. Davies, B.Sc., superintendent of the sulphite mill who had prepared a very interesting paper on the manufacture of sulphite pulp and some of the more recent technical developments of the process and materials used.

MANUFACTURE OF SULPHITE PULP

Mr. Davies opened his talk with a reference to the various uses of sulphite, in celanes, celophane, bond book and writing papers and in newsprint. He outlined the essential elements in the manufacturing of paper and passed on to a detailed description of the sulphite process, following through the different operations and illustrating his talk with flow sheets, diagrams and samples of the partly finished product.

At this point an opportunity was afforded the members of going out to the mill to see the different operations performed, visiting the wood room, digester house and screen room and the wet press room.

After reassembling Mr. Davies described some of the newer cooking processes, first the chemi-pulp system in which one digester is used as an accumulator to which the raw acid is pumped and where it is heated and strengthened by the relief gases and acid from the digesters under steam, thus saving at least 20 per cent of the steam consumption usually lost through the necessity of cooling relief to obtain satisfactory absorption at atmospheric pressure; next indirect steaming was discussed; by using a pump and circulating the liquor external of the digester through a heat exchanger the condensate instead of going to dilute the cooking acid can be returned to the boiler house with a corresponding saving in relief losses. Estimates of savings through the application of such engineering principles to the industry were quoted by Mr. Davies and shown to be substantial. The corrosive nature of the cooking acids have been responsible for some delay in developing the sulphite process to a high point of efficiency, consequently acid resisting alloys, and particularly the new chrome-nickel steels have received much attention and were dealt with by Mr. Davies at some length. Samples of valve parts and fittings which had been in service were shown and the cause of some of the failures discussed.

The analyses of some of the most successful chrome-nickel steels were given and the necessity of heat treatment was stressed. In concluding Mr. Davies ventured the opinion that with the perfection of these steels the industry faces a new era of development.

A hearty vote of thanks to Mr. Davies for his splendid paper, and to Mr. Sisler for his hospitality was expressed on motion of Messrs. H. F. Bennett, A.M.E.I.C., and A. E. Pickering, M.E.I.C.

Vancouver Branch

A. I. E. Gordon, Jr.E.I.C., Secretary-Treasurer.

THE NEW CARRALL STREET GAS PLANT

The February meeting of the Vancouver Branch was held on Monday, February 20th, in the auditorium of the Medical Dental Building, when Mr. John Kirkhope, operating superintendent of Gas Chambers and Coke Ovens Ltd., London, England, described the new Carrall street plant of the B. C. Electric Power and Gas Company Ltd. This meeting was a sequel to the visit of the Branch to the plant on February 10th.

Representing an investment of $1,500,000.00 the new plant is six acres in extent with 375 feet of wharf frontage on False Creek. It has an annual consumption of 70,000 tons of British Columbia coal and will produce over 30,000 tons of high-grade coke annually. It is producing 3,000,000 cubic feet of 465 B.t.u. gas per day, from 170 tons of coal.

The plant consists of twenty-four intermittent vertical chamber ovens fired by producer gas made in a fully mechanical self steam raising producer plant, equipped with waste-heat boilers and fed with coke. It is the only installation in Canada employing the intermittent vertical chamber ovens which originated in Germany in recent years, and has many advantages over the older types. All qualities and grades of coal can be utilized, no expensive handling machinery is required.

The steps in the gas-making process are as follows. Slack coal is unloaded by a crane from scows into blending bunkers of 250-ton capacity and then travels by belt conveyor to overhead storage bunkers, whence it is few by gravity to the ovens. The charge lies quiescent for sixteen hours, but at the end of ten hours steam is introduced producing water gas and keeping the B.t.u. content down to 465. Foul gas is exhausted by machinery through water-cooled condensers and scrubbers and then forced through tar extractors, rotary scrubbers, purifiers and the station meter to the waterless gas-holder and thence to the mains. Coke is discharged at the bottom of the ovens after sixteen hours into a coke bus and quenched with water from a tower before being cut to suitable sizes and stored for fuel.

Discussion lasted about half an hour. A vote of thanks to the speaker was moved by A. S. Wootton, M.E.I.C., and seconded by W. H. Powell, M.E.I.C.

INSPECTION OF IOCO OIL REFINERY

On Saturday afternoon, March 4th, forty-five members and friends of the Branch motored to Imperial Oil Company's Ioco refinery. On arrival they were welcomed by Mr. A. D. Grant, superintendent, assigned to groups in charge of technical guides and conducted over the plant.

The original refinery, built about twenty years ago, has been enlarged as demand required until now it occupies a rectangular clearing on the forest-clad north shore of Burrard Inlet about 1½ miles deep with a mile water frontage. Crude oil is pumped from tankers over the crest of a hill to fireproof storage tanks at the rear of the property, and is pumped back later to the cracking or distilling plants situated on the crest of the hill. The former consists of two units and the latter of nearly a dozen large oil-fired stills. Gasoline is the premium product, but several hundred by-products are obtained. About 7 per cent of the total crude received is burned as fuel to provide heat in the cracking and distilling plant, or in the steam plant consisting of five large Kidwell water tube-boilers.

The quality of the product is controlled by analysis in a well-equipped laboratory, and a sample of all shipments leaving the plant is retained.

The inspection required about two hours and before leaving P. H. Buchan, A.M.E.I.C., chairman of the Branch, thanked Mr. Grant on behalf of the members for the many courtesies extended.

Winnipeg Branch

E. W. M. James, A.M.E.I.C., Secretary-Treasurer.
E. V. Caton, M.E.I.C., Branch News Editor.

At a meeting of the Winnipeg Branch held on March 16th, 1933, a paper was given by Professor A. E. Macdonald, M.Sc., A.M.E.I.C., associate professor of civil engineering, University of Manitoba, on "Granular Materials in Deep Bins."

GRANULAR MATERIALS IN DEEP BINS

"As from time to time certain members of the engineering profession are called upon to design bins and related structures for the storage and treatment of such materials as grain, sand, gravel, coal, stone, cinders, cement, clinker and minerals.

"Timber, steel, brick, tile, special blocks and monolithic concrete have been used in the construction of storage bins. Of these, since 1900, reinforced concrete has been the most generally employed due to its adaptability to resist stresses occurring in the structure, its fireproof qualities, protection against dampness and vermin, and, since moving or sliding forms have come into general use, its speed of construction.

"Friction and interlocking action, together with the friction on the bin wall surfaces, causes the filling to wedge or arch against the bin walls and in deep bins, after a depth of about 3 diameters has been reached, the weight of filling above is carried entirely by the bin walls. The character of the material and nature of the bin walls will determine this ratio between depth of filling and diameter beyond which the addition of material does not increase either the vertical or the lateral intensity of pressure in the filling at the bottom of the bin.

"In the year 1895, H. A. Janssen, of Bremen, deduced a theoretical analysis of pressures due to granular materials in deep bins and derived a general formula for pressures, the validity of which has been proven by numerous investigators.

"Circular bins built in single units offer little difficulty in design since tension is the only stress in the walls, except the vertical stress due to the filling on the walls and the weight of the latter. It is customary however to construct bins of a large storage plant in clusters and this immediately causes complications in design. These bins may be 13 to 30 feet in diameter and from 50 to 120 feet in height. The effort is usually to increase storage capacity, or variety, with the minimum addition of walls.

"Practical experience in the design and construction of reinforced concrete bin clusters, for storing grain, would indicate that the stresses (from filling) in bins up to 23 to 24 feet in diameter, with usual wall thicknesses of 6 to 7 inches, are not excessive, provided the bins are in contact and rigidly connected."

The author ultimately developed an original formula for design of these bins which when applied to structures which had failed indicated very definitely the reason for such failure.

A hearty motion of thanks was tendered Professor Macdonald and he was requested to have the paper put in such form that it could be submitted to the Publications Committee of The Institute for printing in The Journal.

The business of the meeting consisted in discussing a letter from Headquarters re membership and the Executive reported that a committee consisting of:—

J. P. Fraser, A.M.E.I.C.
J. W. Porter, M.E.I.C.
R. H. Andrews, A.M.E.I.C.
A. W. Fosness, M.E.I.C.

had been appointed to take charge of this work.

The chairman also reported that he had attended a meeting which had been called in Winnipeg in connection with a National Construction Council, and recommended that two representatives be appointed to represent the Branch in connection with the activities of the Winnipeg Branch of the National Construction Council. After considerable discussion a motion was passed that further information should be obtained from Headquarters of The Institute before any definite action was taken by the local Branch.

The Garlock Packing Company of Canada, Ltd., Montreal, announces Garlock lubricating paste compound No. 2 for steam and water packings and Garlock lubricating paste compound No. 3 for packings working against gasoline and oils. Garlock lubricating pastes are packaged in standard 12-ounce, 24-ounce and 5-pound cans, and are also furnished in larger special containers of any size.

Preliminary Notice

of Applications for Admission and for Transfer

April 26th, 1933

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, 1933.

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

NANCARROW—GILBERT EDWARD, of 14 London St. No., Hamilton, Ont., Born at Devonport, England, Oct. 30th, 1897; Educ., 1912-15, Devonport Dockyard Upper School. First Class Stationary Engineer's Cert. (Prov. of Ontario); 1912-18, machinist ap'tice, Devonport Naval Dockyard; 1919-28, at sea. Holds 1st Class B.O.T. Marine Engr's. Cert.; 1928-33, with the International Harvester Co. Ltd., Hamilton, Ont., in charge of shift at power house, and acting as asst. to chief operating engr. Apr. 1933, appointed chief operating engr. of power plant at Hamilton Works.

References: A. R. Hannaford, V. S. Thompson, A. Love, H. B. Stuart, E. D. W. Courtice.

MILLER—JOHN LEONARD, of 2160 Orchard Ave., Niagara Falls, Ont., Born at Nottingham, England, Oct. 10th, 1890; Educ., 1908-11, Univ. of Nottingham, Univ. of London (Part time). Passed exam. for Assoc. Member Inst. M.E. 1921. Elected A.M. 1922; 1908-11, ap'ticeship, Smith Bros & Co. Ltd., Nottingham, mfgrs. of engines and boilers; 1911-12, asst. works mgr. with above company; 1912-14, mgr., hand crane dept., Herbert Morris Ltd., Loughborough, England; 1914-18, on active service with Royal Engrs., Major, M.C.; 1919-23, field engr. (North of England district), Herbert Morris Ltd., Loughborough. Responsibility for all plans and supervision of erections; 1923-33, mgr., Herbert Morris Crane & Hoist Co., Niagara Falls, Ont. Entire responsibility for design, manufacture, assembly and erections.

References: H. G. Acres, E. A. Allcut, T. Kipp, C. B. Hamilton, Jr., F. E. Sterns.

MOSLEY—HAROLD GORDON, of 119 Main St., Glace Bay, N.S., Born at Glace Bay, March 16th, 1904; Educ., Glace Bay High School. I.C.S. Diploma in Surveying and Mapping; 1920-22, dftsman., mining engrg. dept., 1922-26, chainman and rodman, same dept., 1926-28, instr'man., mine and surface surveys, Dominion Coal Co. Ltd.; 1929-30, struct'l. steel dftsman., Dominion Bridge Co. Ltd., Montreal; 1930 to date, asst. town engr., Town of Glace Bay, N.S.

References: S. C. Mifflen, A. L. Hay, W. M. Sutherland, J. R. Morrison, K. H. Marsh.

MUIR—WILLIAM GORDON, of Halifax, N.S., Born at Shelburne, N.S., Aug. 9th, 1908; Educ., B.Sc., (Mining), N.S. Tech. Coll., 1931; 1925-30 (Summers), land surveying work; 1931 to date, field engr., Alexander Murray & Co. Ltd., Halifax, N.S.

References: F. R. Faulkner, S. Ball, H. F. Laurence, G. H. Burchill, E. L. Baillie.

SIMPSON—ALBERT EDWARD, of 2201 Dorchester St. West, Montreal, Que., Born at Winnipeg, Man., Feb. 7th, 1898; Educ., B.Sc. (Civil), McGill Univ., 1923; 1919 (summer), C.N.R. bridge dept., Winnipeg, inspr., reinforced concrete culvert constrn.; May 1921 to Sept. 1922, gen. dfting and some timber trestle design (office); 1923-26, Nfld. Power and Paper Co., Corner Brook, Nfld., engrg. office, dfting and design, installn. of equipment in mill. Asst. to supt. of groundwood, mainly on mtce. and repair; 1926-27, sales representative for aerial surveys contracts for state of Florida with Fairchild Aerial Surveys Co. of New York; 1927-28, in charge of field work and mapping, surveys division, Canadian Airways Ltd., Three Rivers, Que.; 1929-32, in charge of field work and aerial engrg., surveys division, and from Sept. 1932 to date, supt., aerial surveys laboratory, Canadian Airways Limited, Montreal.

References: W. Walkden, E. Wilson, J. Stadler, R. H. Mulock, R. L. Weldon, C. R. Lindsey, C. N. Mitchell, R. DeL. French, E. S. Holloway.

FOR TRANSFER FROM THE CLASS OF STUDENT

FORRISTAL—GERALD JOSEPH, of London, Ont., Born at London, Ont., Nov. 24th, 1902; Educ., 1922-26, University of Western Ontario, chemistry and physics; 1926-29, asst. mech. engr. and efficiency expert, and from 1929 to date, mech. engr. and efficiency expert, London and Petrolia Barrel Co. Ltd., London, Ont. (*St. 1927.*)

References: D. M. Bright, W. M. Veitch, R. W. Garrett, W. R. Smith.

STARR—CHARLES HARRY, of 17 Mount Ave., London, W.5, England., Born at Port William, N.S., Sept. 3rd, 1905; Educ., 1926-29, Acadia Univ.; at present preparing to write graduateship exams. of the Inst. E.E. in Nov. 1933; actively engaged in amateur experimental radio work since 1919 (before the days of broadcasting); Summers; 1925, wireless operator, Great Lakes Divn., Canadian Marconi Co.; 1926, development and test Engrg. on tungar type battery chargers and small transformers for Packard Electric Co., St. Catharines; 1927, wireless officer, Hudson's Strait Expedition; 1928, radio receiver development engrg. work with transmission engrg. dept., Northern Electric Co. Ltd.; June 1929 to Sept. 1931, engrg. work on telephone central office equipment, radio-broadcast transmitter and speech input equipment, large permanent public address and music reproducing equipments, etc., with telephone systems eng. dept., transmission engrg. dept., and research products engrg. dept., Northern Electric Co. Ltd.; Jan. 1932 to date, attached to the engrg. dept., Electric and Musical Industries Ltd., Hayes, Middlesex, England, engaged on engrg. work in connection with design and manufacture of radio receivers and gramophones, and gramophone recording in various engrg. and mfg. depts. (*St. 1929.*)

References: H. J. Vennes, F. G. O'Brien, J. H. Thompson, C. P. Edwards, A. Sutherland, G. H. Burchill.

Three Years' Work

In three successive years the British aircraft industry has collected three most coveted records. In 1931, the world's speed record, which had been set up two years before by Great Britain was broken by a Vickers seaplane and a Rolls-Royce engine. Last year, the new altitude record was made by a Vickers aeroplane and a Bristol engine. In February, 1933, the distance record was raised by 329 miles by a Fairey aeroplane and a Napier engine. These represent sets of quite different problems satisfactorily solved. The speed record was closely allied with the high performance during brief periods which finds its most useful expression in the interceptor fighter. The height record, too, had its association with the production of fighter aircraft, but it went beyond the present needs of the fighter and suggested the ultimate realization of flying in the stratosphere. The distance record was concerned with weight-carrying and endurance such as may be expected to affect commercial aviation more than military aviation. Those who look to the aeroplane for regular ocean services will see great promise in this feat.

—*The Times Trade and Engineering Supplement.*

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

Situation Vacant

Civil Service of Canada

22694—SENIOR DRAUGHTSMAN in the Penitentiary Branch of the Department of Justice, at Ottawa, salary $1,800 per annum, less deduction of 10 per cent as authorized for the year 1933-34. This position is at present of a temporary nature but should it be made permanent, the person appointed to the temporary position will receive, if satisfactory, the permanent appointment, in which case the initial salary of $1,800 may be increased upon recommendation for efficient service at the rate of $120 per annum, until a maximum of $2,160 has been reached. While there is but one position vacant at the present time, it is possible that one or more additional appointments may be required in the near future.

Duties.—To draw plans and prepare drawings of engineering structures; in particular, under direction, to design and draw plans of proposed buildings; to prepare working and detailed drawings of reinforced concrete, structural steel, and other construction work connected with Penitentiaries generally, and to perform other related work as required.

Qualifications.—Education equivalent to high school graduation; either graduation from a school of applied science of recognized standing with four years of experience in an architect's or engineering construction office, or six years of experience in an architect's or engineering construction office; knowledge of structural steel, reinforced concrete and mechanical design; ability to work up plans and details from rough sketches. While a definite age limit has not been fixed, age may be a determining factor when making a selection.

GENERAL DIRECTIONS

Application forms properly filled in must be filed with the Civil Service Commission, Ottawa, **not later than May 25, 1933.** Application forms may be obtained from the offices of the Employment Service of Canada, from the Postmasters at Prince Rupert, Vancouver, Victoria, Edmonton, Calgary, Regina, Saskatoon, Winnipeg, Quebec, Fredericton, Saint John, Charlottetown and Halifax, from the Secretary of the Civil Service Commission and the Secretary of The Engineering Institute of Canada, Montreal.

Candidates must be British subjects and have resided in Canada for at least five years.

Situations Wanted

ELECTRICAL AND RADIO ENGINEER, B.Sc., '28. Experience in the design and testing of broadcast radio receivers, including latest superheterodyne practice, and capable of constructing apparatus for testing same. Also familiar with telephone and telephone repeater engineering. Thorough experience in design, and construction and inspection of municipal power conduits. Apply to Box No. 12-W.

MECHANICAL ENGINEER, Canadian, with technical training and executive experience in both Canadian and American industries, particularly plant layout, equipment, planning and production control methods, is open for employment with company desirous of improving manufacturing methods, lowering costs and preparing for business expansion. Apply to Box No. 35-W.

MECHANICAL ENGINEER, A.M.E.I.C. Married. Experience in machine shops, erection and maintenance of industrial plant mechanical and structural design. Reads German, French, Dutch and Spanish. Seeks any suitable position. Apply to Box No. 84-W.

YOUNG ENGINEER, B.A., B.SC., A.M.E.I.C., R.P.E., Ont. Competent draughtsman and surveyor. Eight years experience including design, superintendence and layout of pulp and paper mills, hydro-electric projects and general construction. Limited experience in mechanical design and industrial plant maintenance. Apply to Box No. 150-W.

PURCHASING ENGINEER, graduate mechanical engineer, Canadian, married, 34 years of age, with 13 years' experience in the industrial field, including design, construction and operation, 8 years of which had to do with the development of specifications and ordering of equipment and materials for plant extensions and maintenance; one year engaged on sale of surplus construction equipment. Full details upon request. Apply to Box No. 161-W.

STRUCTURAL ENGINEER, B.A.SC., '15, A.M.E.I.C., R.P.E., (Ont.) Married. Experience in structural steel and concrete includes ten years design, five years sales, two years shop practice and erection, and one year advertising. Available at two weeks notice. Apply to Box No. 193-W.

Situations Wanted

CIVIL ENGINEER, age 44, open for employment anywhere, experience covers about 20 years' active work, including 7 years on municipal engineering, 2 years as Town Manager, 3 years on railway construction, 3 years on the staff of a provincial highway department, 2 years as contractor's superintendent on pavement construction. Apply to Box No. 216-W.

REINFORCED CONCRETE ENGINEER, B.SC., P.E.Q., eight years experience in construction design of industrial buildings, office buildings, apartment houses, etc. Age 30. Married. Apply to Box No. 257-W.

MECHANICAL ENGINEER, B.SC., McGill 1919, A.M.E.I.C., P.E.Q., 12 years experience oil refinery and power plant design, factory maintenance, steam generation and distribution problems, heating and ventilation, etc. Available at once. Location immaterial. Apply to Box No. 265-W.

ELECTRICAL ENGINEER, B.SC., '28, Canadian. Age 25. Experience includes two summers with power company; thirteen months test course with C.G.E. Co.; telephone engineering, and the past thirty months with a large power company in operation and maintenance engineering. Location immaterial and available immediately. Sales or industrial engineering desirable. Apply to Box No. 266-W.

Saskatchewan Branch

The Unemployment Committee of the Saskatchewan Branch of The Institute was formed in the fall of 1932. The first work undertaken was to circularize the members of the Branch in order to secure the names of those who were unemployed.

To such as reported themselves as out of employment, special forms were sent requesting a complete record of experience and educational qualifications. From the information supplied, a circular was prepared, giving a brief summary of the training and experience of those unemployed. This was forwarded to a list of prospective employers of engineers, compiled by the members of the committee, in the towns and cities throughout Saskatchewan. Each unemployed engineer was then supplied with a list of those employers to whom the summary of his education and experience had already been forwarded. The unemployed engineer was further advised that each individual or firm on the list of prospective employers had been requested by the committee to give consideration to the employment of members of the Branch should it be necessary to increase their engineering staff.

The unemployment situation among members in the province of Saskatchewan is reported as not particularly acute, and no doubt this is partially due to the systematic efforts of the Branch Unemployment Committee.

PLANE-TABLE TOPOGRAPHER, B.SC., in C.E. Thoroughly experienced in modern field mapping methods including ground control for aerial surveys. Fast and efficient in surveys for construction, hydro-electric and geological investigations. Apply to Box No. 431-W.

ELECTRICAL ENGINEER, B.SC., A.M.E.I.C., AM.A.I.E.E., age 30, single. Eight years experience H.E. and steam power plants, substations, etc., shop layouts, steel and concrete design. Location immaterial. Available immediately. Apply to Box No. 435-W.

CIVIL ENGINEER, B.A.SC., A.M.E.I.C., JR.A.S.C.E., age 28, married. Experience: construction, design, cost estimating on hydro-electric and storage work, also railway. Desires work in engineering, industrial or commercial fields. Available at once. Apply to Box No. 447-W.

CIVIL ENGINEER, B.SC., A.M.E.I.C., with six years experience in paper mill and hydro-electric work, desires position in western Canada. Capable of handling reinforced concrete and steel design, paper mill equipment and piping layout, estimates, field surveys, or acting as resident engineer on construction. Now on west coast and available at once. Apply to Box No. 482-W.

MECHANICAL ENGINEER, B.SC. Age 28, married. Four and a half years on industrial plant maintenance and construction, including shop production work and pulp and paper mill control. Also two and a half years on structural steel and reinforced concrete design. Located in Toronto. Available at once. Apply to Box No. 521-W.

Situations Wanted

CIVIL ENGINEER, Canadian, married, twenty-five years' technical and executive experience, specialized knowledge of industrial housing problems and the administration of industrial towns, also town planning and municipal engineering, desires new connection. Available on reasonable notice. Personal interview sought. Apply to Box No. 544-W.

ELECTRICAL ENGINEER, A.M.E.I.C., University graduate 1924. Experience includes one year test course and five years on design of induction motors with large manufacturer of electrical apparatus. Four summers as instrumentman on highway construction. Several years experience in accounting previous to attending university. Available at once. Apply to Box No. 564-W.

MECHANICAL ENGINEER, A.M.E.I.C., with twenty years experience on mechanical and structural design, desires connection. Available at once. Apply to Box No. 571-W.

MECHANICAL ENGINEER, B.A.SC., '30, desires position to gain experience, and which offers opportunity for advancement. Experience in pulp and paper mill and one year in mechanical department of large electrical company. Location immaterial. Available immediately Apply to Box No. 577-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.

MECHANICAL ENGINEER, Canadian, technically trained; eighteen years experience as foreman, superintendent and engineer in manufacturing, repair work of all kinds, maintenance and special machinery building. Location immaterial. Available at once. Apply to Box No. 601-W.

CHEMICAL ENGINEER, S.E.I.C., B.SC., University of Alberta, '30. Age 31. Single. Six seasons' practical laboratory experience, three as chief chemist and three as assistant chemist in cement plant; one year's p.g. work in physical chemistry; three years' experience teaching. Desires position in any industry with chemical control. Available immediately. Apply to Box No. 609-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.

CIVIL ENGINEER, A.M.E.I.C., R.P.E., Ontario; three years construction engineer on industrial plants; fourteen years in charge of construction of hydraulic power developments, tower lines, sub-stations, etc.; four years as executive in charge of construction and development of harbours, including railways, docks, warehouses, hydraulic dredging, land reclamation, etc. Apply to Box No. 647-W.

MECHANICAL ENGINEER, A.M.E.I.C., Canadian, technically trained; six years drawing office. Office experience, including general design and plant layout. Also two years general shop work, including machine, pattern and foundry experience, desires position with industrial firm in capacity of production engineer or estimator. Available on short notice. Apply to Box No. 676-W.

ELECTRICAL ENGINEER, B.SC., '29, JR.E.I.C. Age 26. Undergraduate experience in surveying and concrete foundations; also four months with Canadian General Electric Co. Thirty-three months in engineering office of a large electrical manufacturing company since graduation. Good experience in layouts, switching diagrams, specifications and pricing. Best of references. Available immediately. Apply to Box No. 693-W.

MECHANICAL ENGINEER, B.SC., '27, JR.E.I.C. Four years maintenance of high speed Diesel engines units, 200 to 1,300 h.p. Also maintenance of D.C. and A.C. electrical systems and machinery. Draughting experience. Westinghouse apprenticeship course. Practical mechanical and electrical engineer with a special study of high speed Diesel engine design, application and operation. Location in western or eastern Canada immaterial. Apply to Box No. 703-W.

COMBUSTION ENGINEER, R.P.E., Manitoba. A.M.E.I.C. Wide experience with all classes of fuels. Expert designer and draughtsman on modern steam power plants. Experienced in publicity work. Well known throughout the west. Location, Winnipeg or the west. Available at once. Apply to Box No. 713-W.

YOUNG ENGINEER, B.A.SC., (Univ. Toronto '27), JR.E.I.C. Four years practical experience, buildings, bridges, roadways, as inspector and instrumentman. Available at once. Present location, Montreal. Apply to Box No. 714-W.

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

Situations Wanted

MECHANICAL ENGINEER, age 41, married. Eleven years designing experience witb project of outstanding magnitude. Machinery layouts, checking, estimating and inspecting. Twelve years previous engineering, including draugbting, machine shop and two years chemical laboratory. Highest references. Apply to Box No. 723-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.

DESIGNING ENGINEER, M.Sc. (McGill Univ.), D.L.S., A.M.E.I.C., P.E.Q. Experience in design and construction of water power plants, transmission lines, field investigations of storage, hydraulic calculations and reports. Also paper mill construction, railways, highways, and in design and construction of bridges and buildings. Available at once. Apply to Box No. 729-W.

MECHANICAL ENGINEER, S.E.I.C., B.A.Sc., Univ. of B C. '30. Single, age 24. Sixteen months with tbe 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.

CIVIL ENGINEER, M.Sc., 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.

ELECTRICAL AND RADIO ENGINEER, B.Sc. '31, S.E.I.C. Age 25. Nine months experience on installation of power and lighting equipment. Eight months on extensive survey layouts. Two summers installing telephone equipment. Specialized in radio servicing and mercbandising. Available at once. Location immaterial. Apply to Box No. 740-W.

CIVIL ENGINEER, graduate '29. Married One year building construction, one year bydro-electric construction in South America, fourteen months resident engineer on road construction. Working knowledge of Spanisb Apply to Box No. 744-W.

SALES ENGINEER, B.Sc., McGill, 1923, A.M.E.I.C. Age 33. Married. Extensive experience in building construction. Thoroughly familiar with steel building products; last five years in charge of structural and reinforcing steel sales for company in New York state. Available at once. Located in Canada. Apply to Box No. 749-W.

DESIGNING ENGINEER, graduate Univ. Toronto '26. Thoroughly cxperienced in the design of a broad range of structures, desires responsible position. Apply to Box No. 761-W.

MECHANICAL ENGINEER, graduate, '23, A.M.E.I.C., P.E.Q., age 32, married. (English and Frencb.) Two years shop, foundry and draugbting experience; one year mechanical supt. on construction; six years designing draughtsman in consulting engineers' offices (mechanical equipment of buildings, heating, sanitation, ventilation, power plant equipment, etc.). Present location Montreal. Available immediately. Montreal or Toronto preferred. Apply to Box No. 766-W.

CIVIL ENGINEER, S.E.I.C., B.Sc. Queen's Univ. '29. Age 25. Married. Three years experience as construction supt. and estimator for contracting firm. Experience includes general building, bridges, sewer work, concrete, boiler settings, sand blasting of bridges and spray painting. Available at once. Apply to Box No. 767-W.

WORKS ENGINEER, A.M.E.I.C. Twenty-four years experience, responsible for the design and building of extensions to mill buildings, specifying and installing of equipment and maintenance of plant of large manufacturing company. Good references. Will take position abroad. Apply to Box No. 768-W.

ELECTRICAL ENGINEER, B.Sc. (McGill Univ. '29), S.E.I.C. Married. Experience in pulp and paper mill mecbanical maintenance, estimates and costs and machine shop practice. Desires position with industrial or manufacturing concern. Location immaterial. Available on short notice. References. Apply to Box No. 770-W.

ELECTRICAL ENGINEER, Queen's Univ. '24, Jr.E.I.C., age 32, married. Experience includes, student Test Course, Can. Gen. Elec. Co., four years dial system telephone engineering witb large manufacturing company. Available at once. Apply to Box No. 772-W.

CIVIL ENGINEER, B.Sc., '25, Jr.E.I.C., P.E.Q., married. Desires position, preferably witb construction firm. Experience includes railway, monument and mill building construction. Available immediately. Apply to Box No. 780-W.

DRAUGHTSMAN, experience in civil engineering, forestry engineering, land surveying and house construction. Good references. Apply to Box No. 781-W.

SALES REPRESENTATIVE. Electrical engineer with ten years experience in power field interested in representing established firm for electrical or mechanical product in Montreal territory. Excellent connections. Apply to Box No. 795-W.

Situations Wanted

CIVIL ENGINEER, S.E.I.C., graduate '30, age 23, single. Experience includes mining surveys, assistant on highway location and construction, and assistant on large construction work. Steel and concrete layout and design. Apply to Box No. 809-W.

CIVIL ENGINEER, college graduate, age 27, single. Experience includes surveying, draughting concrete construction and design, street paving both asphalt and concrete. Available at once; will consider anything and go anywbere. Apply to Box No. 816-W.

CIVIL ENGINEER, B.E. (Sask. Univ. '32), S.E.I.C. Single. Experience in city street improvements; sewer and water extensions. Good draughtsman. References. Available at once. Location immaterial. Apply to Box No. 818-W.

CIVIL ENGINEER, S.E.I.C., B.Sc. (Queen's '32), age 21. Three summers surveying in northern Quebec. Interested in hydraulics and reinforced concrete. Available at once. Location immaterial. Apply to Box No. 822-W.

CIVIL ENGINEER, B.Sc., A.M.E.I.C., witb fifteen years experience mostly in pulp and paper mill work, reinforced concrete and structural steel design, field surveys, layout of mechanical equipment, piping. Available at once. Apply to Box No. 825-W.

ELECTRICAL ENGINEER, S.E.I.C., grad. '29, age 24, married; experience includes one year Students Test Course, sixteen months in distribution transformer design and eight months as assistant foreman in charge of industrial control and switchgear tests. Location immaterial. Available at once. Apply to Box No. 828-W.

SALES ENGINEER, M.E.I.C., graduate civil engineer with twenty years experience in tbe structural, sales, and municipal engineering fields, and as manager of engineering sales office. Available at once. Apply to Box No. 830-W.

CIVIL ENGINEER, B.A.Sc., D.L.S., O.L.S., A.M.E.I.C., age 46, married. Twelve years experience in charge of legal field surveys. Owns own surveying equipment. Eight years on technical, administrative, and editorial office work. Experienced in writing. Desires position on survey work, assisting in or in charge of preparation of house organ, on staff of technical or semi-technical magazine, or on publicity, editorial or administrative office work. Available at once. Will consider any salary, and any location. Apply to Box No. 831-W.

AERONAUTICAL ENGINEER, B.Sc. (McGill), M.Sc. (Mass. Inst. Tech.). Canadian. Age 26, recent graduate. Capable of aeroplane design and stress analysis. Apply to Box No. 838-W.

CIVIL ENGINEER, M.Sc., R.P.E. (Sask.). Age 27. Experience in location and drainage surveys, higbways and paving, bridge design and construction city and municipal developments, power and telephone construction work. Available on short notice. Apply to Box No. 839-W.

CIVIL ENGINEER, S.E.I.C., B.Sc. '32 (Univ. of N.B.). Age 25, married. Two years experience in power line construction and maintenance; one year of highway construction; one summer surveying for power plant site, location and spur railway line construction. Available at once. Location immaterial. Apply to Box No. 840-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.

CIVIL ENGINEER, B.Sc. (Alta. '31), S.E.I.C., age 24. Experience, three summers on railroad maintenance, and seven months on higbway location as instrumentman. Willing to do anything, anywhere, but would prefer connection with designing or construction firm on structural works. Available immediately. Apply to Box No. 846-W.

MECHANICAL ENGINEER, Jr.E.I.C., tecbnical graduate, bilingual, age 30. Two years as designing heating draugbtsman witb one of the largest firms of its kind on this continent bandling heating materials; three years designing draugbtsman in consulting engineers' office, mecbanical equipment of buildings, beating, ventilation, sanitation, power plant equipment, writing of specifications, etc. Present location Montreal. Available at once. Apply to Box No. 850-W.

BRIDGE AND STRUCTURAL ENGINEER, A.M.E.I.C., McGill. Twenty-five years' experience on bridge and structural staffs. Until recently employed. Familiar witb all late designs, construction, and practices in all Canadian fabricating plants. Desirous of employment in any responsible position, sales, fabrication or construction. Apply to Box No. 851-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. Tbree years experience in railway construction and land surveying. Apply to Box No. 856-W.

MECHANICAL ENGINEER, B.Sc. '32, S.E.I.C. Good draughtsman. Undergraduate experience:—One year moulding shop practice; two years pipe fitting and sbeet metal work; one year draugbting and tracing on paper mill layout; six months machine sbop practice; and eigbt months fuel investigation and power heating plant testing. Desires position offering experience in steam power plants or heating and ventilating design. Will go anywhere. Apply to Box No. 858-W.

Situations Wanted

MECHANICAL ENGINEER, age 31, graduate Sheffield (England) 1921; apprenticeship with firm manufacturing steam turbine generators and auxiliaries and subsequent experience in design, erection, operation and inspection of same. Marine experience B.O.T. certificate thoroughly conversant with Canadian plants and equipment. Available on sbort notice. Any location. Box No. 860-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 sbops, 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.

ENGINEER, McGill Sci. '21-'25, S.E.I.C., aerial mapping, stereoscopic contour work; lumber classification; highway, railway and transmission line locations; estimates; water storage investigations, etc. Five years ground surveys; tbree years aerial mapping. Bilingual. Available on sbort notice. Apply to Box No. 872-W.

CONSTRUCTION ENGINEER (Toronto Univ. of '07). Experience includes hydro-electric, municipal and railroad work. Available immediately. Location immaterial. Apply to Box No. 886-W.

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

CIVIL ENGINEER, B.Sc., Montreal 1930, age 26, single, French and English, desires position technical or non-technical in engineering, industrial or commercial fields, sales or promotion work. Experience includes three years in municipal engineering on paving, sewage, waterworks, filter plant equipment, layout of buildings, etc. Available immediately. Apply to Box No. 891-W.

ELECTRICAL ENGINEER, grad. Univ. of N.B. '31. Experienced in surveying and draughting, requires position. Available at once. Will go anywhere. Apply to Box No. 893-W.

CIVIL ENGINEER, B.A.Sc., Jr.E.I.C., age 29, single. Experience includes two years in pulp mill as draughtsman and designer on additions, maintenance and plant layout. Tbree and a half years in the Toronto Buildings Department checking steel, reinforced concrete, and architectural plans. Available at once. Location immaterial. At present in Toronto. Apply to Box No. 899-W.

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A Selected List of Equipment, Apparatus and Supplies

For Alphabetical List of Advertisers see page 21.

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I

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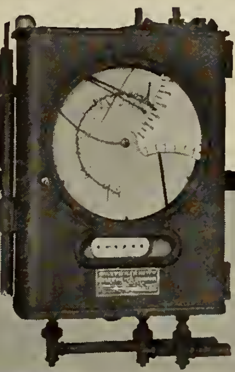

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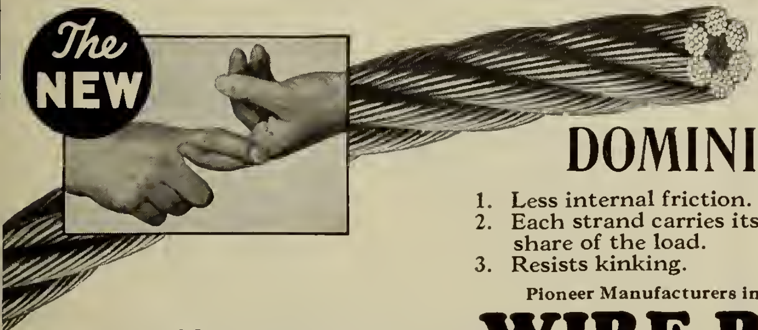

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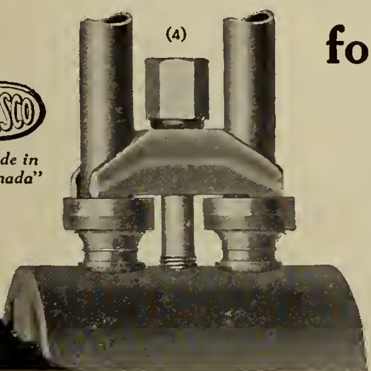

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THE ENGINEERING JOURNAL

VOL. XVI
No. 6

JUNE
1933

In this issue

PUBLISHED MONTHLY BY

THE ENGINEERING INSTITUTE *of* CANADA

HOW MUCH

will lightning cost YOU this year?

Records* from metropolitan and rural distribution systems show that:

When lightning blows just one primary fuse, the average total cost of replacement, including material, labor and transportation, is $5.20. Furthermore, the average loss in customer service is 53 customer-hours. When lightning damages a distribution transformer, repairs usually range from the replacement of bushings and leads to the replacement of the complete transformer. And the average loss in customer service is 86 customer-hours.

These costs can be almost entirely eliminated and customer service maintained by installation of G-E pellet or intershunt Thyrite arresters. The reliable performance of these arresters, together with advanced methods of installation, provide practical immunity from lightning troubles, justifying individual protection of every distribution transformer—from the smallest to the largest. Address the C-G-E office nearest you or Canadian General Electric Co. Limited, 212 King Street West, Toronto.

* Electrical News, July 1, July 15, August 1, 1932.

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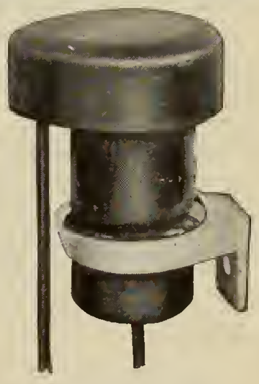

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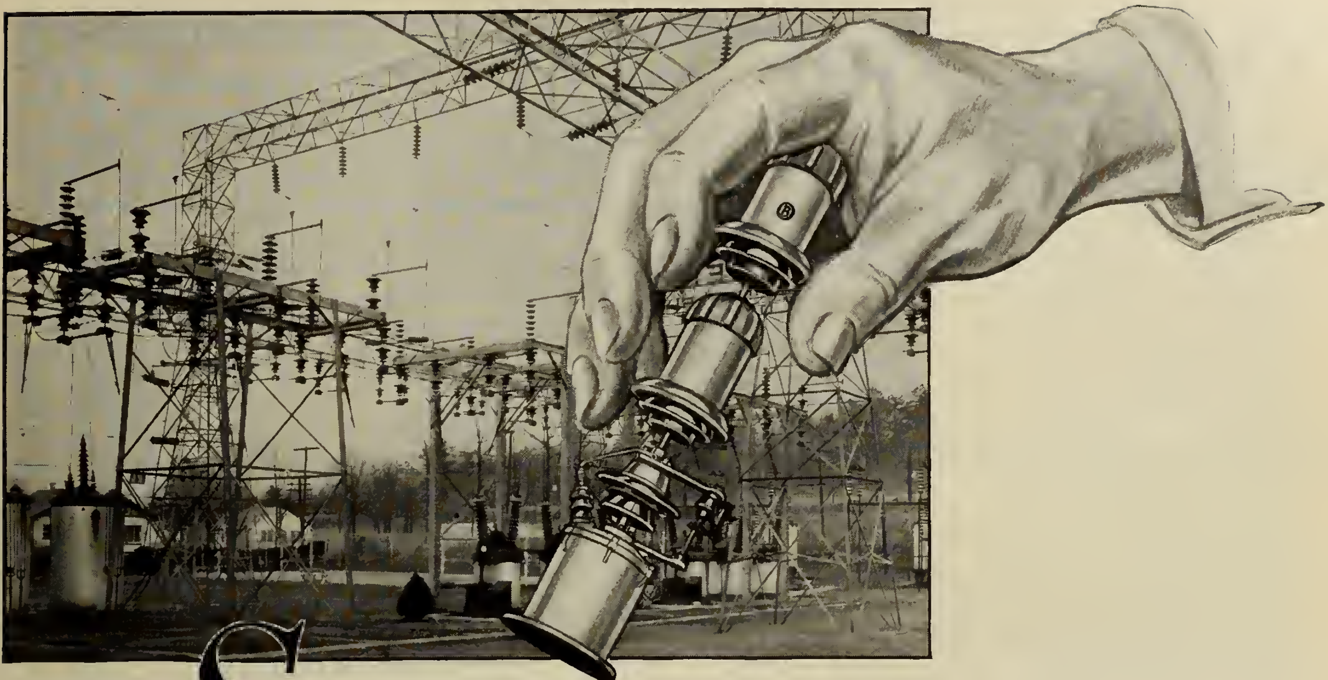


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June 1933 Volume XVI, No. 6

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The Effect of the Development of the Electronic Valve Upon Electrical Engineering and Industry

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From earliest times man has endeavored to improve his communication facilities. The very existence of primitive tribes in many cases depended upon the ability to warn members of approaching danger and those groups survived which had the most effective means of conveying information. The tom-tom of the African, the smoke signal of the Indian and the relay riders of Jenghiz Khan were all expressions of the highest type of communication which could be devised in their time but were only links in a long chain of ideas which have culminated in the world-wide radio facilities of the present day.

As we moderns in comfortable homes listen to the music of distant radio stations we rarely, if ever, give a thought to the many developments which have made possible the accurate reproduction of music and voice from afar. Fly power to seventy-five horse power—a jump of a thousand miles through space—microbe power and then deafening volume to fill an auditorium—instantaneous and faithful reproduction of tones and overtones of thousands of cycles per second—no other means could accomplish such miracles of modern communication but that product of engineering genius, the electronic valve.

Early Development

When Edison in 1883 noted that there was a flow of current between the positive terminal of the filament and an insulated plate in one of his experimental glow lamps (1)*, he little realized that the phenomenon he then observed would grow in the course of fifty years to be the basis of one of the world's greatest industries and the means of communicating to millions of people, scattered throughout the entire world, as effectively as though they were gathered around his own fireside.

Although Edison did not at once make any practical use of his observation he gave some of his two element vacuum tubes to Sir William Preece who observed that current would flow only as long as there was no obstruction between the filament and the plate. He therefore concluded that the effect was connected in some way with a discharge of particles in straight lines from the filament.

J. A. Fleming later took up the study of the discharge of particles and among other things he showed that the incandescent filament was giving off negative electricity. This confirmed the experiments of Elster and Geital who in 1889 published a paper mentioning the unilateral conductivity for direct currents of rarefied gases in tubes with one hot and one cold electrode.

Sir J. J. Thomson in 1889 showed that the discharge from heated filaments was due to the travel of electrons from the filament to the plate. Two years later O. W. Richardson made known his experiments which led to his theories regarding the escape of the electron from hot bodies when and only when its kinetic energy was greater than the work which must be done in escaping.

These and other discoveries aided Fleming in 1904 to apply a thermionic valve to the rectification of high frequency alternating currents to detect wireless telegraph signals. The valve which he used was substantially the same as the rectifying valve of today although great improvements have been made in the degree of vacuum, outgassing of parts and filament activity. (Fig. 1.)

The Triode

From this point more and more was learned of the action of the vacuum tube until in 1906 Lee de Forest (2) brought out his three electrode valve in which a grid was placed between the filament and plate and could be used as a control electrode. (Fig. 2.)

In this valve the stream of electrons from the filament to the plate, which had hitherto depended upon the filament temperature and plate potential, could be controlled by the grid alone which acted as a valve or shutter. The grid being closer to the source of electrons required smaller voltages and exercised more control than the plate. Swinging it more negative reduced the effect of the plate potential around the filament and caused less plate current to flow. Swinging it more positive reduced the throttling action and allowed more electrons to escape through the openings and reach the plate, causing more plate current to flow.

This introduction of the grid or third element was the great forward stride in the development of the vacuum tube which has resulted in the present gigantic business of radio and allied arts only a quarter of a century later.

*Figures in brackets refer to Bibliography at end of paper.

Development and insight into the action of the valve proceeded rapidly. It was known that heated filaments in vacua emitted a rapidly increasing supply of electrons up to a certain point, called the saturation point, and that beyond this point the supply did not increase much with further increase in temperature. This led to the practice of supplying sufficient steady current to keep the filament in saturation. The plate was kept at a steady rather high potential with respect to the filament. The grid, in most

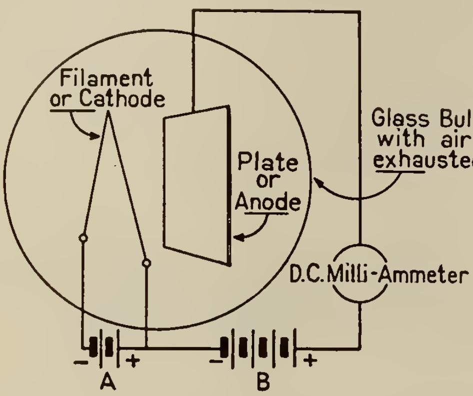

Fig. 1—Two-Electrode Vacuum Tube.

circuits, was supplied with a small negative potential with respect to the filament. (Fig. 3.)

This became the fundamental circuit of present day vacuum tube practice but it is capable of variations which allow it to perform a large number of different operations at almost incredible speeds. Since there is practically no time lag in the flow of electrons the grid voltages take instantaneous effect upon the plate current. If the grid voltage is suitably chosen the plate current changes are very nearly proportional to the grid voltage changes. The relation between the effects upon the plate current, of the grid voltage compared to the plate voltage, constitutes an important tube "constant" called the amplification factor.

Although it is impractical to go completely into the theory of electronic valve action some of the main applications (3) of the valve should be understood. The first and most important use to which the valve can be put is to reproduce accurately, and at the same time amplify, changes or variations in the voltage of the grid. This can

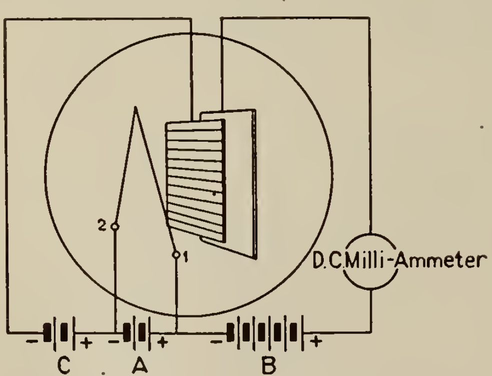

Fig. 2—Three-Electrode Vacuum Tube.

be accomplished with a suitable choice of grid and plate potentials. The amplification is due to the fact that small changes on the grid which is close to the plate, result in large changes in the plate circuit. (Fig. 4.)

Another use is to rectify input voltages by operating the grid at a point where reproduction of grid swings takes place to a much greater extent in one direction than in the other. (Fig. 5.) A third use is to oscillate or to amplify input voltages which are coupled to the plate circuit in such a way that the amplified output is fed back into the input and results in a continuous recurring cycle of voltage swings limited by the plate current and of a frequency depending upon the circuit conditions. (Fig. 6.) Another important use is to modulate or superimpose a low frequency on to a high frequency as is done when audio signals are united with the carrier or high frequency output of a broadcasting station. In no case does the tube supply power: it controls power from external sources.

At first experimenters were overjoyed with the new device which could be put to such a wide variety of uses and were content with a few standard types. Soon however special purpose tubes were demanded until the past ten years have produced a large number of valves of highly diversified types for a wide variety of applications. One example of a specialized type is the low interelectrode capacity screen grid tube which was developed primarily for radio frequency amplification in radio receiving sets where capacity between elements was particularly objectionable. Another example is the water-cooled power tube largely used in the output stages of radio transmitters.

A tremendous advance in adapting the valve to the needs of the consumer was the development of the heater type cathode or electron source. This enabled the ordinary house power supply to be coupled directly to a radio receiver and did away with the cumbersome storage battery. The speed with which new types of tubes have been produced and engineered into receivers is one of the marvels of this new electrical industry, while the patient research and painstaking care that have gone into these developments are entirely unappreciated by the vast audience of radio listeners.

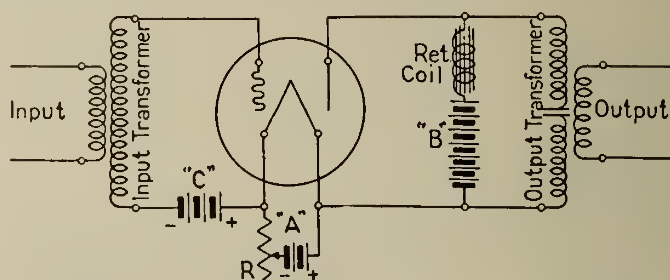

Fig. 3—Simple Amplifying Circuit.

An early event which drew the attention of the public to the electronic valve occurred in 1915, when the engineers of the American Telegraph and Telephone Company succeeded in talking from Arlington, Virginia, to Paris and Honolulu with apparatus containing valve oscillators and amplifiers. This was followed about six years later by the first broadcast programmes from Station KDKA.

Everyone today is familiar with the application of the electronic valve to radio broadcasting and receiving, which has resulted in the production by the million of radio tubes with an annual value in excess of $69,000,000 (4). In size the tubes range from the little "peanut" tube to the all-metal 500 kilowatt water-cooled giant (5) which has lately been developed in England.

Among the first spectacular applications of the vacuum tube to commercial purposes, other than radio, was its introduction into the circuit of the first coast to coast telephone system in America (6) which was opened to the public with impressive ceremonies on the 25th of January, 1915. This fulfilment of the life-long dreams of early telephone engineers was made possible by one of the first organized research groups of which we have record. As a result of the combined attack of Vail, Gherardi, Jewett and other telephone engineers under the leadership of General J. J. Carty the many problems were overcome, but it is doubtful if they would have met with success had they been unable to equip the repeater stations (7) with electronic valves.

Although it is now possible to talk from your own telephone to Europe, South America and even to ships at sea, the world has become so accustomed to communication marvels that little interest is aroused over the opening of a new inter-continental telephone link.

A recent achievement of popular interest was the application of the electronic valve to sound accompaniment

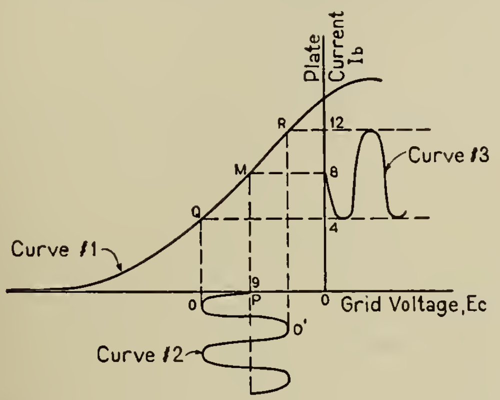

Fig. 4—Action of the Vacuum Tube as an Amplifier.

of moving pictures. This was the natural outgrowth of researches in public address systems. Today the "talking movies" in at least fifteen thousand theatres (8) throughout the world depend upon streams of electrons so accurately controlled that the voice of a favourite actor whom you have never seen in the flesh is as familiar as that of a personal acquaintance. Here is a new industry which has developed to major proportions in less than five years and employs a highly specialized group of engineers. Many of them bear new titles such as projection engineer and acoustical engineer. The world sales of sound picture equipment amounted to 150 million dollars in 1930 (9).

In the field of aviation the vacuum tube is playing an increasingly important role. On the main airways the pilots are in constant communication with ground stations, and it is becoming more and more apparent that only through this means can safety be assured. Planes can now

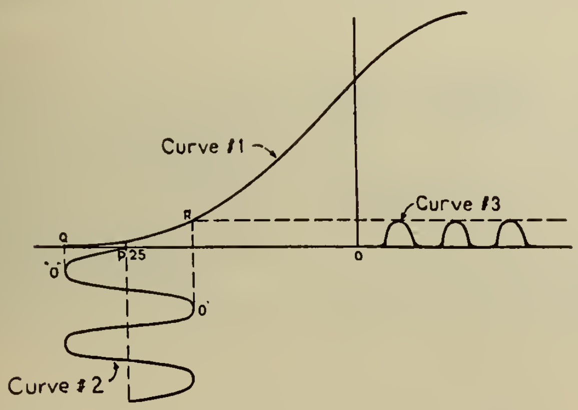

Fig. 5—Action of the Vacuum Tube as a Rectifier.

take off and land with the pilots flying by instruments alone and vacuum tubes play an important part in these stunts which may soon become everyday occurrences. (See Fig. 7.)

Although the three element vacuum tube lends itself admirably to the communication field it is rapidly coming out of the category of signalling devices and is becoming a real tool of the electrical engineer (10). Because of its sudden advent, its extraordinary versatility—in rectifying, converting, changing frequencies, controlling and performing other complex functions—has been largely overlooked by the power engineer. Vacuum tubes seem destined to supplement and replace much of our moving electrical machinery. They will find uses in switching high-tension currents and as lightning arresters for the protection of lines. In fact we may witness a complete re-design of our present electrical systems. The tube's oscillating properties present a ray of hope for wireless power transmission. Its field in carrier telephony and telegraphy (11), high frequency induction heating (12), measurement of low

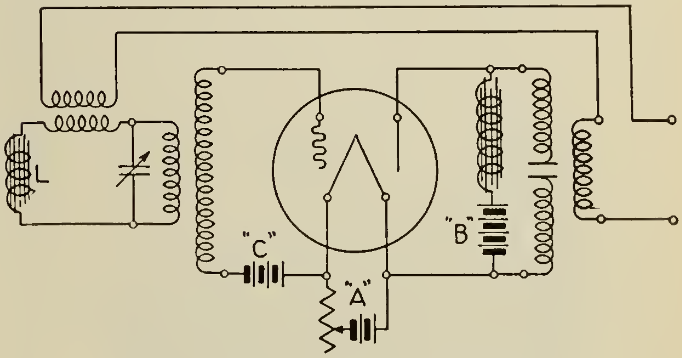

Fig. 6—Simple Vacuum Tube Oscillator.

pressures (13), measurement of minute currents (14) and other uses will continue to broaden.

It is impossible to proceed further or to go into the details of any great variety of electronic applications without considering some of the other electronic advances which have paralleled the development of the more common high vacuum triode.

The High Vacuum Rectifier

Although it was early recognized that a two element high vacuum tube would be suitable for the rectification of alternating currents to supply direct current at high voltages and limited power, as for the plate supply of radio receiving sets, and that very large types (15) also have possibilities as high voltage rectifiers for X-ray tubes, the field of use of high vacuum rectifiers is limited and more attention has been given to the development of greater current carrying types.

The Gas-Filled Rectifier

One of the early developments for power rectification purposes was the gas-filled rectifier of the type known almost entirely as the "tungar" rectifier (16). Heavy currents can be obtained from this tube which contains argon gas at a pressure when cold of about five centimeters of mercury. The increased current is carried to a considerable extent by electrons produced by ionization due to collisions between the electrons from the filament and the molecules of the inert gas in the bulb. The positive ions which are produced neutralize the negative charge around the cathode due to the potential difference between it and the anode, called the space charge effect, and give a low voltage drop across the tube. The introduction of the gas however greatly reduces the ability to hold back voltages in the reverse direction and the field of the gas-filled rectifier is therefore limited to applications of a few hundred volts. Its use has made possible low cost d.c. applications through the medium of storage batteries which would otherwise have to be accomplished by motor generator sets.

The Mercury Vapour Rectifier

A recent development somewhat similar to the gas-filled rectifier is the mercury vapour rectifier of the heavy coated filament, higher vacuum type which has been developed to supply high d.c. potentials for the plate supply of power tubes. A small amount of mercury in the bulb supplies sufficient vapour to cause ionization by collision and produce a copious supply of electrons, but the pressure in the bulb is not great enough to seriously affect the hold back characteristics. This rectifier can handle heavier currents than the high vacuum rectifier, has a low voltage drop and will hold back potentials of the order of several thousand volts. By its use vacuum tube equipment can be operated, without the use of rotating machinery, wherever alternating current is available.

The Mercury-Arc Rectifier

The mercury-arc rectifier (17) possesses the high hold back characteristics of the new types of mercury vapour rectifiers and has even greater current carrying capacity than the gas-filled rectifier. This results in an extremely useful device for power applications and one which seems destined to find increasing use in the power field. In this rectifier, the positive ions of the mercury vapour neutralize the space charge effect of the electrons so that a low voltage drop is obtained. It is however not quite as low as that of the gas-filled rectifier. Its losses are practically the same at any voltage and above 600 volts it is difficult to find a device giving greater efficiency and economy. The upper limit of the voltage which can be handled by the mercury-arc rectifier has not yet been established. Voltages up to 9000 (18) are in use at present and vacuum tight seals can be introduced into glass containers capable of carrying 2000 amperes (19).

The mercury-arc rectifier is entirely different from the other electronic devices which we have so far considered, in that the source of electrons, or cathode, is a pool of mercury instead of a heated filament. On the pool of mercury, during operation, is a bright spot which moves about on the surface and is sustained by the arc current itself. It is from this spot that the electrons are emitted. A very copious supply of electrons can be obtained from the bright spot and in the case of large currents several spots may occur on the same mercury pool.

No current can flow in either direction before the arc has struck, since there is no stream of electrons. To start, it is therefore necessary to bring an auxiliary anode into contact with the mercury pool and then withdraw it. By breaking a current passing between the two electrodes an arc is started and the cathode spot appears. In large rectifiers the auxiliary anode is made moveable. In small types it consists of a small pool of mercury or an extra anode which can be connected to the mercury pool by tilting the whole tube. As the cathode spot depends upon continuous current it is necessary to have two or more anodes with the circuit so arranged that at least one anode is always carrying current. In the polyphase types two or more anodes are carrying current most of the time. A space charge of positive ions builds up around the negative electrode and its field extends only a short distance. This prevents the anodes from interfering with one another and tending to neutralize the effect of each other while at opposite potentials.

Soon after the possibilities of the mercury-arc rectifier as a power device were discovered, it was recognized that the power which could be handled was limited by the glass envelope. Large water-cooled continuously pumped metal containers were soon evolved with suitably insulated elements. These are now built in capacities up to 6,500 kw. per set (20) as used by the Consolidated Mining and Smelting Company at Trail. For the operation of the new subways in New York City fifty-one mercury-arc rectifier sets have been installed having a total capacity of 153,000 kw. (21). All are equipped with automatic control with full supervision from the central station. Better efficiency, especially at low loads, is obtained from these electronic devices than could be obtained from rotating machinery (22).

The magnitude of these installations indicates that in this particular field of power work the mercury-arc rectifier has largely superseded the converter. With improvements in the rectifiers themselves and in the auxiliary control equipment these devices will continue to find applications in many fields. Their characteristics make them particularly suitable for electric railway use and we may expect to see them extensively applied when further electrification becomes practical.

The Grid Controlled Rectifier

A fairly recent development having great possibilities in the power field is the grid controlled rectifier (23). This is a hot cathode gas rectifier having a third element or grid. The grid exercises the same wattless control over the flow of electrons as in the ordinary triode valve. There is a very marked difference however in that the grid does not continuously control the amount of current flow but only the time of starting the arc. Once the arc has started, the grid exercises no further control; the current then being limited by circuit conditions.

The grid controlled rectifier contains a low pressure of gas or vapour which ionizes whenever the voltage rises above a certain point. Mercury is most often used to supply the vapour but for certain applications an inert gas is more suitable. The ionization of the vapour neutralizes the space charge so that there is a drop of only about fifteen volts across the tube. Heat reflecting shields can be placed around the cathode and this greatly increases its efficiency.

The purpose of the control grid is to vary the field at the cathode as in the case of the high vacuum tube. Once ionization takes place the positive ions neutralize the effect of any charge on the grid and the current which flows is then independent of the grid potential even if it is made more positive. However if the plate potential is reduced below the critical value the grid will again regain control. Thus if an alternating voltage is supplied to the plate, the grid has a chance to regain control once in every cycle and can exercise smooth control of the average plate current.

The characteristics of this rectifier are usually given in terms of the grid voltage for starting the plate current. This starting voltage may be either positive or negative depending upon the structure and plate voltage. The maximum instantaneous inverse voltage is determined by the ability of the tube to withstand negative plate voltages. The maximum instantaneous forward voltage is important when the tube is used as an inverter. It is the highest voltage at which the grid can prevent the starting of current.

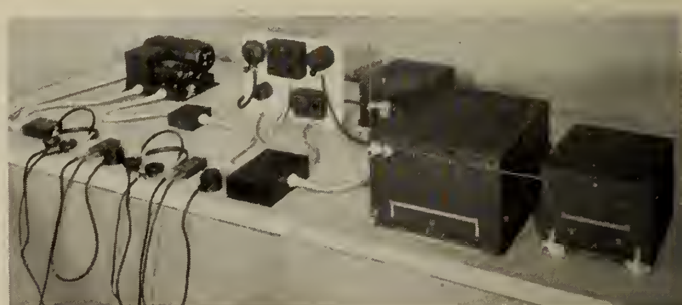

Fig. 7—Equipment for Two-Way Communication from an Aeroplane.

A common use of the grid controlled rectifier, as its name implies, is as a rectifier with grid control of the output. Here an a-c. input to the plate is controlled by varying the phase of the grid voltage. If the grid voltage is in phase with the plate voltage the maximum current will flow in the plate circuit. If the grid voltage is 180 degrees out of phase, no current will flow. Between these two extremes the plate current can be made to start at any point in the positive half cycle so that the average output current can be controlled as closely as desired.

The grid controlled rectifier can also be used as an inverter. In this case a combination of tubes in a circuit which is supplied with power from a d-c. source gives an a-c. output from either single phase or polyphase circuits. The scheme of operation is to switch the incoming direct current from one tube to another by purely electrical means to give the desired a-c. output. The tubes may be separately excited or if the output circuit is resonant self-excitation may be produced by coupling the input to the output circuit.

These rectifiers are at present made for potentials up to 15,000 volts and for average currents up to 100 amperes. The instantaneous currents are from four to six times the average. Current frequencies up to a few thousand cycles per second can be handled.

Although a comparatively recent development the grid controlled rectifier has already proved its worth in such a large number of applications that only a few of the most important can be considered here. In the intermittent line and spot welding field (24) apparatus has been designed using the grid controlled rectifier which gives much higher speeds than have been possible with mechanical interrupters or magnetic contactors. Interruptions as high as 1,000 per minute can be handled with one well-known make of welder. In this system the primary of a series transformer, with a high voltage secondary, is in series with the primary of the welding transformer. A pair of controlled rectifiers connected to the high voltage windings practically short circuit them when conducting. When this occurs the impedance of the primary of the series transformer is low and permits approximately full-load current to pass to the primary of the welding transformer. A switch operated by a cam on a variable speed motor controls the in-phase or out-of-phase voltage on the grids and controls the speed of welding.

Another application is for controlling the re-reeling spools of wire drawing machinery (25). In this case a small reactor supplies power to the controlled rectifier. When a loop of wire going to the reel shortens, which necessitates slowing of the motor, the reactor core is mechanically drawn into the reactor by a wheel in the loop, thereby increasing the reactance and causing the rectifier to pass less current. The motor then slows down. The reverse takes place when the loop lengthens.

The grid controlled rectifier puts instant operation of all lighting at the finger tips of a "lighting director" in some of the newer theatres. In one recently opened theatre in New York (26) incandescent lights totalling 367 kw. are used. In spite of the large amount of power controlled, only about 200 watts of control power is used and this is easily accommodated on a small control board located in front of the stage.

Another light device, the automatic colour organ (27), produces colours by means of music and synchronizes colours with music. Acoustic power of the order of microwatts controls lighting power of hundreds to millions of watts, which is varied in accordance with rapid fluctuations of the input.

The possibilities of using the conversion features of the controlled rectifier are tremendous and developments are under way which presage important modifications in transmission and interconnection practices for heavy duty power company service (28). The scheme involved is to use direct current for all transmission lines. A-c. generators would be used and these could be operated at practically unity power factor. They could be designed for any voltage which would have the lowest cost, most efficient and most reliable operation. The size of the generators would probably be reduced and it is probable that standardized types could be used. System stability as related to generator characteristics would be unimportant. Inductive interference would be less important and designers would not have to balance economics of design against this increasingly important factor. The troubles of paralleling operation of units and the synchronizing of units would disappear. Units would be paralleled only through d-c. ties.

With d-c. transmission high voltage oil circuit breakers would not be necessary. Concentration of large amounts of power in event of a short circuit would be limited. The only power which could flow into the short circuit would be that which could flow through the rectifier. No power could flow back from the inverter. A short circuit could be limited to full load or less on the circuit or could be stopped in a fraction of a cycle.

Fig. 8—Public Address and Reproducing System Control Room, Royal York Hotel, Toronto.

Tying together of systems with these versatile rectifiers would make possible the control of direction and power and as the tubes would not transmit the wattless component this trouble would vanish.

The cost of transmission circuits could be greatly reduced and the use of direct current would allow the economic transmission of power over aerial lines to greater distances than can be obtained with alternating current. The electrostatic capacity of cables would be unimportant and only the ohmic resistance of the circuits would limit their length. Underground circuits would be cheaper and would come into much greater use with consequent reduction in service interruptions due to lightning or storms. Two or more times the voltage could be handled in existing cables. All of these features would be of especial benefit in the economic development of Canadian water powers and the transmission of energy from remote districts to urban centres.

The grid controlled rectifier in conjunction with the photoelectric cell which we will next consider acts as an ideal control device for the more extensive mechanical motions which must be initiated as the result of photoelectric cell action. In fact small motors can be operated directly from controlled rectifier output. Usually the rectifier acts as a controller or "feeler" of the action which the photoelectric cell "sees" or the high vacuum triode "hears."

The Photoelectric Cell

The remarkably keen observation of Count Heinrich Hertz was in 1887 responsible for the first recorded phenomena of photoelectric effect (29), and to him belongs the credit of initiating research on a device which seems destined to play a very important part in the electrical engineering of the future. A year later Hallwachs observed that under the influence of ultra-violet light, negative electricity leaves a body and follows electrostatic lines of force.

Righi also in the same year showed that a current could be produced by the action of light and termed his arrangement a photoelectric cell. Stoletow too about this time produced a current, due to light, with a polished plate in series with a battery, galvanometer and grid. This approached recent methods for measuring photoelectric effects, which at best are very small.

Elster and Geital next observed that electropositive metals gave the best photoelectric sensitivity and in addition that sodium and potassium were photoelectrically active to visible radiation even through glass. They also produced sodium amalgam photoelectric cells enclosed in well evacuated glass bulbs and finally revealed that the photoelectric current could be greatly reduced when a magnetic field was applied in a direction at right angles to the path between cathode and anode. This led them to conclude that the photoelectric carrier was a negatively charged particle, probably the electron, then recently discovered and named by J. J. Thomson.

Merritt and Stewart in 1900 and Alberti in 1912 proved conclusively that the photoelectric effect was indeed electronic in action.

As more was learned about the action of the cell there gradually emerged two fundamental laws. The first law states:—The number of electrons released per unit time at a photoelectric surface is directly proportional to the intensity of the incident light. The second law disturbs our usual concept of light action:—The maximum energy of electrons released at a photoelectric surface is independent of the intensity of the incident light, but is directly proportional to the frequency of the light. This statement implies that when electrons are emitted under the influence of radiation they possess various velocities, but that there is a definite highest velocity determined by the greatest frequency of radiation; and no matter how intense the same kind of radiation may become, this highest velocity will not increase. From this, as far as photoelectric action is concerned, one is not to regard an intense beam of light as essentially more violent in action than a dimly visible beam of the same kind of light: one is rather to regard the intense light as simply operating upon a larger number of objects per unit area of illuminated surface.

By 1912, Elster and Geital had produced hydrogenated cells differing but little from some of the present day cells. As in the case of triodes a certain amount of gas in the cell gave greater currents due to ionization, and gas-filled as well as high vacuum cells have been developed depending on the use to which they are to be put. The gas-filled cell has a variable dynamic sensitivity which always decreases with increased frequency of light modulation. The vacuum cell gives current exactly proportional to the intensity of the incident light and results indicate that its dynamic response does not vary with the frequency of modulation of the incident light. The linearity of the vacuum cell is a valuable asset for photometry or for accurate reproduction of sound recording on films.

Present day cells can also be made with a maximum sensitivity in practically any part of the visible spectrum or in the ultra-violet and near infra-red. This gives the engineer a tool for refined colour selection, reception of invisible light in the form of secret signals (30) and for transmitting and receiving television in natural colour (31).

Photoelectric cells have come into such widespread use in the last few years and applications are so numerous that almost any processed article which we buy may have had some operation carried out through the agency of this device. By its use our breakfast cereal may be packaged (32) and our evening entertainment provided. The amount of smoke over our cities may be controlled (33) as well as the chlorine in our drinking water (34).

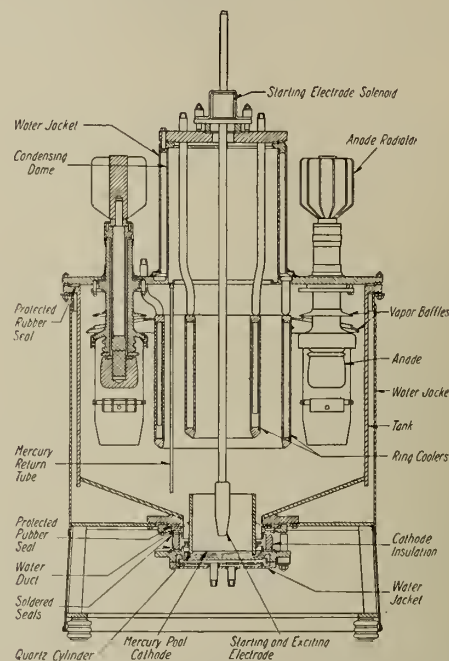

Fig. 9—Section of 500-kw. Steel Tank Mercury-Arc Rectifier Unit.

Man's industrial progress has been largely measured by his control of heat and accurate control of heat is of outstanding interest to the industrial engineer. The photoelectric cell can look into the furnace hour after hour, with no fatigue, and exercise the desired control. In one well-known system the photoelectric cell looks through a suitable optical system at the furnace wall or some object inside the furnace (35). The current through the cell varies with the amount of light radiated by the hot body, which corresponds to the temperature.

Since the radiation from a hot body varies much faster than its temperature, the photoelectric current is a very sensitive measure of the degree of heat. The current is amplified by triodes and operates a grid controlled rectifier which can be used to control the heat source.

The current through the triodes can also be measured by a meter calibrated in terms of temperature to provide a record of heat.

The instrument as developed can measure temperatures as low as 1,000 degrees C. and has no upper limit. It does not deteriorate from the action of the products in the furnace since no part is in the furnace itself. By means of two rectifiers both the upper and lower limits of temperature can be set.

The photoelectric cell and a counter have been applied to weigh conveyor belt loads. It is used to produce ready-mixed concrete with complete automatic control of the mix (36). The cell is used to control sprays which coat articles with paint as they pass along on conveyors (37). It protects the public from power operated doors (38). It controls the machining operations of lathes (39). It keeps a watchful eye on the thickness of paper in the paper mill and watches for breaks (40). It can even sort light bill stubs into any one of a hundred compartments in a machine which has recently been produced (41). Classification of small records, tickets, bills, checks and the like has always been a monotonous job and is subject to annoying and sometimes costly errors. In the new sorting machine, a stack of cards is placed in a feeding receptacle: a device frees the bottom stub and pushes it forward beneath a light beam. A photoelectric cell receives a set of signals from a printed code of heavy black lines and this results in a mechanical arm guiding the card to its proper compartment. The contents of any compartment can then be re-sorted into as many more sub-divisions and so on. The code combinations which are possible on small cards are enormous.

One uncanny device (42), which has been used in large city telephone circuits for some time, converts dialled telephone numbers originating in automatic exchange areas into spoken numbers in manually operated exchanges. The equipment makes use of film recorded speech. A series of drums, each with four recordings of the same number, revolve in front of as many photoelectric cells which have lights focused on them through suitable optical systems. Five stages of amplification are connected to the output of each cell to give some ten million fold amplification to raise the weak signals to a suitable level for the announcement.

In the future the electric eye will play an important part in many of our activities. It appears to be an essential part of the television of the future which will probably develop along the lines of theatre equipments using multichannel land lines as a transmission medium. Aircraft (43), railway trains (44) and even the motor car on the highways may be partially controlled by its action. Devices are also under development to aid the blind.

In industry the cell will control machines to an extent now undreamed of. It will be used to control the thickness, cut to length (45), check surface imperfections (46), machine to size (47), form the shape, control temperatures (48), throw out imperfect parts, assist in assembly, apply finish, grade the colour (49), pack (50), wrap (51) and sort many of the articles of which we will have need.

In the power field it will be used to keep a watchful eye on the functioning of the various pieces of equipment and to signal when dangerous conditions arise. Automatic operation will be aided from the burning of coal in the fires of the power company to the control of the voltage in the factory of the consumer.

The Cathode Ray Tube

Dr. F. Braun in 1897 modified a Crookes tube to make the first cathode ray tube (52). He introduced a shield having a small opening in it which had the effect of concentrating some of the electrons from the cathode into a small stream which then impinged upon a small area or spot on the other side of the tube. The spot could be made luminous by using a glass which would glow or by coating the inside of the glass or a target with a fluorescent material. He readily perceived that the stream of electrons, after passing through the opening, could be deflected by electric or magnetic influences. Since that time the cathode ray tube has not changed in principle although it has been greatly improved in form and degree of luminosity of the spot.

In the present day tube there is a small hot cathode which emits electrons. These are drawn towards a shield or accelerator which is kept at a rather high positive potential. Part of the electrons pass through an opening in a fine stream between two sets of parallel plates, at right angles to each other: and finally they strike a fluorescent screen some distance away. The target is a slightly rounded out end of a cone shaped bulb, and the hole through which the stream of electrons emerges is at the apex of the cone.

By suitably applied alternating potentials on one pair of deflecting plates the spot moves back and forth in step with the voltage changes and traces a line on the screen. With an alternating voltage of known frequency applied to the other pair of plates, the line can be changed to figures such as loops, coils and circles. Although valuable information can be obtained from such figures, the timed circuit has been largely replaced by a sweep circuit (53) which builds up a charge slowly and regularly in one direction and then suddenly discharges to start again. Such a circuit can be adjusted to the frequency of the varying potential so that the figure is a perfect picture on a time base of the shape of the wave which is being studied.

Although the cathode ray tube has found its most general use in the study of wave forms of high frequency, it has lately been used to some extent in experimental television and appears to offer a little hope of the solution of the low-cost home television receiving problem. Already certain optimistic manufacturers are offering outfits of this type to the public, but their entertainment value is doubtful.

As an engineering tool for the study of alternating current wave forms the cathode ray oscillograph is an extremely useful device. It is possible to see an accurate hysteresis diagram of a sample of iron in fewer minutes than hours are required for getting the same diagram by a ballistic galvanometer method (54). Furthermore, any changes in the magnetic properties can be followed continuously as they occur. Power engineers have used it to chart corona losses on high voltage lines and automotive engineers have found it useful in studying the operating characteristics of ignition systems.

In the future it will continue to aid in the solution of electrical engineering problems by providing an indicator of high speed electrical and magnetic changes (55) which cannot readily be obtained by any other means. (Fig. 10.)

The X-Ray Tube

Rontgen in 1895 noticed a fluorescence on a chemically coated paper which happened to be lying near a Crookes tube which he was using. This observation led to the discovery of X-rays (56) which are produced when the cathode rays strike a solid object.

Research by various physicists improved the tube and has resulted in the X-ray tube of the present day. This

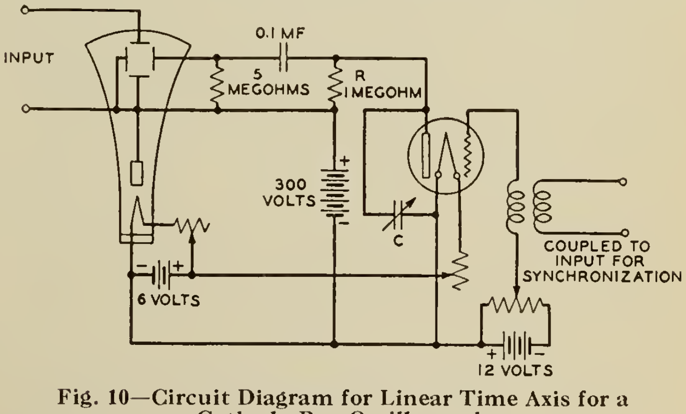

Fig. 10—Circuit Diagram for Linear Time Axis for a Cathode-Ray Oscillograph.

consists of a glass envelope with a spiral tungsten cathode surrounded by a tungsten cylinder which is mounted opposite to an anode consisting of a heavy copper rod. The end of the rod is cut at 45 degrees to its axis. The other end projects through the bulb and usually carries a number of vanes to conduct away the heat which is generated when the electrons impinge upon it.

A difference of 50,000 volts or upwards is maintained between the anode and cathode. X-rays are emitted when the electrons strike the anode. All of the electrons are absorbed by the anode but only about one per cent of the energy is converted into electromagnetic waves of very high frequency, the so-called X-rays. These have the remarkable property of penetrating objects which are opaque to visible light frequencies.

In industry high voltage X-ray apparatus is used for the radiographic examination of thick sections of metal (57). Hidden defects in welds, castings, electric machinery and rolled sections are now revealed before they are incorporated into equipment where failure might mean loss of life and property. Standard hospital deep-therapy equipment with a 200,000-volt X-ray tube is suitable for this work. By means of two X-ray photographs and a stereoscopic viewing apparatus it is possible to look into the object and see details or defects in their proper relative positions.

The radio tube industry has found X-ray inspection of considerable value for the examination of cathodes for alternating current tubes. A quantity of cathodes is placed in numbered rows on a tray: the whole is X-ray photographed and it is then an easy matter to pick out defective assemblies. The method is also used for the inspection of large water-cooled tubes. In these the metal anode is so long that inspection, by ordinary methods, of the grid and filament assemblies is impossible after sealing-in.

This method of inspection will be used to a greater extent in the future. It should be useful for examination of older structures in locating flaws as well as concealed details when changes are to be made.

In medical work the X-rays will continue to be of increasing value as more is learned of their behaviour. There appears to be no upper limit to the voltage which may be used. A two section X-ray tube (58) operating at 900,000 volts and five milliamperes of current was recently installed in the Memorial Hospital in New York city.

The problems of handling voltages of the high orders involved in X-ray work with reasonable sized equipment and safety have been met by the electrical engineer in such a satisfactory manner that accidents are comparatively rare. In the newest apparatus both the high tension transformer and X-ray tube are immersed in oil in a sealed tank which is grounded (59).

The Lenard Tube

During the early days of cathode ray tubes Lenard constructed a tube having a very thin foil window which allowed electrons to pass through into the open air (60). This type of tube has been improved to the point where it is possible to use potentials of the order of 100,000 to 1,000,000 volts which cause electrons to pass through a thin glass window and strike objects in the open air. Some peculiar effects are produced in objects which they strike. Rayed solutions of cane sugar, starch and glycerine give an acid reaction to litmus paper. Linseed oil and prilla oils are bleached crystal clear. Small insects and fruit flies are killed. Fluorescence is produced in diamonds. Insulating oils and varnishes are affected much the same way as when exposed to continued high voltage stresses and cable insulation has been treated by the rays to determine its probable life. These and other effects are produced by an electronic device which may have important fields of use for the electrical engineer as well as the physicist of the future. It is an odd fact that rays from a Lenard tube cause milk and butter to become rancid, while foods kept in the field of high frequency oscillations of a triode are said to be preserved as well as though kept in a refrigerator. It is out of such observations that new industries are born. The electronic valve may replace the electro-mechanical unit of your refrigerator as the latter has replaced the ice-man.

The Glow Tube

The study of electrical conduction in the gases of glow lamps has been carried on for many years but not until recently have commercial devices been available which are of practical use to the electrical engineer. These tubes (61) usually depend for their current carrying properties upon the movement of electrons produced by ionization. The ionization is started by free electrons whose presence in rarefied gases is not entirely understood.

A distinctive colour or glow, characteristic of the gas remaining in the tube, is produced by the ionization. Two element types in the form of neon signs have become common during the past five years. On account of the rapid response of the glow to current changes, small lamps have been used to a considerable extent with stroboscopes for checking the speeds of rotating machinery. These devices however can hardly be classed as valves, but types have been developed with one electrode much larger than the other and in these the flow of current is from the small electrode, or anode, to the large electrode, or cathode. The glow occurs on the cathode which consists of a cylinder surrounding the small anode. These tubes can be used for rectification and regulator purposes.

As the brightness of the glow is a function of the current, large flat cathode water-cooled tubes of high current carrying capacity have been developed to give the great brilliance which is so desirable for colour television receiving. The basic red is produced by lamps containing neon while the blue and green are obtained with tubes containing argon (62).

A device much more useful than the two element lamp was produced by D. D. Knowles with the addition of a third electrode or grid which consists of a short wire bent close to the anode. The grid is used to control only the starting of the current and it exercises no further control after the discharge has started. In one small common type of tube, with the grid unconnected (or free), it is impossible to get a breakdown even when 900 volts are applied between the anode and cathode. The grid obtains a negative charge from the free electrons in the gas which are attracted to the positive anode. This negative charge repels any further negatively charged electrons which may be drawn towards the anode. By means of a suitable bias on the grid with respect to the anode (about — 550 to + 350 volts), the discharge can be started at any potential desired.

On alternating current the glow is automatically shut off toward the end of each cycle when the instantaneous voltage of the a-c. wave becomes less than the drop across the tube.

Due to its simplicity, the grid-glow tube is suitable for low cost applications as a relay sensitive to feeble stimuli for the operation of mechanical contacts that are in turn the control for larger electrical devices.

Two neon grid-glow tubes have been used to blink alternately as a danger signal (63). Moving flashes of light have been found to be the most notable signal to the human eye and the orange-red glow of neon, on account of its fog piercing quality, is one of the best of flashers. The grid-glow flasher can provide the signal without moving parts and in case of failure of one lamp, the other continues to blink.

There is promise that photo-glow tubes (64) also will soon be available. These give currents far in excess of photoelectric cells. They have been used in the laboratory to watch for flashovers on a generator and for arcs between bus bars which carry heavy currents.

Many applications will be found in the future for these comparatively new devices which are already beginning to replace older members of the electronic family.

Production of the Electronic Valve

The production of the electronic valve has been a challenge to the ingenuity of the electrical engineer ever since the device emerged from the laboratory. In fact the engineer has usually brought the laboratory into the factory or else he could never have met the problems which daily present themselves. A vacuum tube which does not pass the test requirements is junk. It costs more and requires far more care to rebuild a tube than to produce a new one. Welded construction has been found the only practical means of assembly and this does not lend itself to repair operations. Pressures of the order of 10^{-6} m.m. of mercury must be maintained in glass envelopes with several lead-in wires. In power tubes, the copper anodes must be sealed to glass bulbs. Surface layers of barium of the order of one molecule in thickness must be obtained on coated filaments (65.) Brittle thoriated tungsten filaments, of several inches in length between supports, must be mounted not only so as to expand with the high temperatures encountered, but also to withstand the handling processes of shipment. Glass must be worked so as to avoid electrolysis. Parts must be thoroughly outgassed. Assemblies must be clean. Pump schedules must be maintained. These and many other operations must be watched with great care or else the final product will be rejected. The vacuum tube engineer has met all of these problems so that modern plants, with small shrinkage, turn out tubes by the million, of good quality and long life.

Ingenious machines have been developed to apply mechanically the alkaline earths to the core of coated filaments. Alloys (66) have been developed to replace platinum as a filament core. Glass-working machines and automatic pump machinery have been developed to the point where only a few highly skilled operators are required to set machines to perform very complex operations. The result has been a steady decrease in the cost of the tube to the consumer, while at the same time there has been a marked improvement in the quality. The problems which have been overcome have aided the electrical engineer in other fields. The tube engineer's demand for an insulator which would stand up to the high frequencies encountered has resulted in the production of superior insulators for the electrical industry in general. The success with which a multitude of difficult problems has been met is reflected in a broader field of knowledge and a deeper appreciation for the ability of the whole engineering profession.

Research

Too much emphasis cannot be given to the value of research in the vacuum tube field. Engineers with that keenness of observation and questioning attitude which are absolutely necessary for the full development of any art have noticed the little differences which have resulted in the steady progress of electronic devices. To organized research belongs the credit for the development of those devices which give most promise for the future, and to organized research we must look for the continued widening of the fields of application to power and industrial uses. The grouping together of research workers having broad experience in many fields best creates that atmosphere of co-ordination which results in a sane and logical process of electronic development in harmony with associated mechanical advances. This is the path which will lead us most quickly toward the electronic age of the future.

Conclusion

In this paper the attempt has been made to discuss, in the language of the electrical engineer, the more important devices which are electronic—in that they depend for their current carrying properties upon the emission of electrons, and are valves—in the sense that they act either as control devices or as one way devices. The latter implies the emission of electrons from a single source.

The importance of the electronic valve in industry is becoming generally realized. Such apparatus, owing to the increasing knowledge of the principles involved, can be manufactured as reliable articles of commerce (67). In a large number of possible applications, however, an electronic device can only replace an existing already perfected mechanical device, and consequently there is a reluctance to make the change. But devices that will perform useful operations that either cannot be done or done only in a cumbersome manner by normal electro-mechanical means, should be carefully considered by engineers and experimental departments, for they may make possible hitherto impossible methods, thus leading to an improved or less expensive product. The facility with which certain classes of work can be done by the electronic device will often justify considerable preliminary development.

The story of man's ascent is the story of his tools. New tools (flint, axe, plough, lathe, loom, steam-engine, printing press, telegraph, motor car, radio) entirely change our modes of life. Tools and workers react. New tools develop new types of workers, and reshape their standards of living.

The new tool, electricity, is the greatest tool that has ever come into the hands of man. He has not yet learned how to use it well or how to readjust his industrial, economic and social relations to get the most out of life. The electronic valve, one of the most important devices for controlling electricity, is one of man's most recent and versatile tools. Its continued development and use will aid in the solution of electrical engineering problems and its application to industry will be of great benefit to mankind.

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Nipawin Bridge

Highway-Railway Bridge over the Saskatchewan River at Nipawin, Sask.

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SUMMARY.—This paper deals with the design and erection of a bridge over the Saskatchewan river, carrying a highway below the railway tracks. Its length is 1,908 feet between abutments, and it includes four 280-foot deck truss spans which were erected by cantilevering. Problems arising from the nature of the foundations are discussed. The design and method of erection of the bridge were also affected by the severe winter conditions and by the heavy floods to which the Saskatchewan river is liable. It was necessary to strengthen the main spans to enable them to stand the stresses arising during erection, and particulars are given of the method adopted.

In recent years that portion of the province of Saskatchewan lying north of the Saskatchewan river has shown indications of having extensive mineral as well as agricultural resources but has always lacked the transportation facilities necessary for active development. In order to provide railway access, and to assist in the development of that part of the province, the Canadian Pacific Railway recently completed the construction of a bridge over the Saskatchewan river at Nipawin. This place is located on the south bank of the river and, prior to the completion of the bridge, was the northern terminus of a branch line, which, starting at Goudie, Sask. (on the Winnipeg-Edmonton line) ran practically due north for 132 miles until it reached the river. The construction of the bridge enabled that branch to be extended north of the river.

This structure, which is one of the largest in western Canada, is a combination railway and highway bridge, the provincial government having contributed the additional sum necessary to provide a much needed highway facility to replace the ferry which had hitherto been used to transport vehicles and passengers across the river, and, incidentally, involved steep descents to the water level in order to reach it.

Owing to the heavy ice run in the river every spring, ferry operation was often hampered. During the spring "break-up" the ice sometimes piled up on the banks to a height of over twenty feet, remaining there long after the river was clear, and the water level had fallen, thus forming an ice cliff on the banks. Under such conditions it was necessary to cut through this ice cliff to enable the ferry to "ground" on the natural bank. Further, a run of slush ice in the late fall was almost a yearly occurrence and made ferry operation very irregular and difficult for several days at that season.

In the author's opinion, the provincial government shewed considerable business acumen and foresight in offering to contribute the additional sum necessary to incorporate the highway facility in this structure, as they saved the province several hundred thousand dollars when compared with the cost of an independent highway bridge across this river, a project which would no doubt require to have been undertaken sooner or later.

The bridge has a total length of 1,908 feet between abutments and comprises four 280-foot deck truss spans over the river flanked by a steel trestle approach 516 feet long at the north end and one of similar construction 276 feet long at the south or Nipawin end. These trestle approaches are composed of 45-foot spans over the towers and spans about 75 feet long between the towers.

On the 280-foot spans the railway is carried at the upper chord level and the highway is located immediately underneath (between the trusses) at the level of the lower chords. Where these combination railway and highway spans join the steel trestle approach at each end, the highway swings out from underneath the railway and runs alongside the railway trestle on separate spans. This separation is effected at each end by using independent highway spans between the extreme piers and the adjacent steel towers of the railway trestle—these independent spans being "skewed" by having one end supported on an outer pier and the other end carried by steel supports cantilevered from the near bent of the adjacent steel tower. From that point to its junction with the river banks the highway is carried part of the distance on independent steel spans and part on a timber pile trestle. (See Fig. 3.)

The structure is designed for a live load equivalent to Cooper's E-60 on the railway deck and 15 ton trucks on the highway deck. The highway has a clear width of 16 feet between curbs and 17 feet 6 inches clear between handrails.

Substructure

Probably the most important items of general interest in connection with the substructure are the high piers which support the truss spans. These are over 112 feet high from bed of river to bridge seat level and about 127 feet high from foundation to bridge seat. The total height from foundation to track level is about 170 feet and the clear height of the truss spans above ordinary high water level is 95 feet. While there are several piers on the system which exceed these in height, the author believes that they can be classified as unusually high.

Borings made previously at the approximate location of the various piers indicated that, under the first few feet of overlying material, the strata, generally speaking, consisted of layers of clay containing gravel, alternating with layers of sandy clay, or sand, and that this condition obtained for a depth of over 80 feet.

In view of the fact, therefore, that these units are not founded on rock it may not be out of place to review, in this paper, some of the questions which commonly require consideration and judgment in the design of such high piers.

The borings indicated that the stratum, which would likely be the most suitable for a foundation, and involve the least depth of excavation, while providing sufficient overlying material to be safe from scour, was one consisting of "clay with gravel" about 18 feet below the river bed. It was considered that, in actual construction, there would be no material advantage found in going deeper since there was no indication from the borings that there was anything more suitable within a reasonably lower depth. However, having in mind the method by which such borings are obtained, the actual "consist" of the strata is largely a matter of judgment, and the borings in themselves furnish no really definite information to indicate the safe bearing capacity of strata such as that reported as "clay with gravel," which might vary from one having comparatively little bearing power to a well consolidated mass of the nature of hard pan.

The bearing capacity of such soil increases with the proportion of sand and gravel to the clay, so that when the proportion of clay is just sufficient to thoroughly bond the coarser material into a well consolidated mass an excellent foundation is obtained. The interpretation of the actual consistency of the soil from the material which comes up in the wash requires considerable experience and judgment, as very often the proportion of the coarse material in the residue is greater than exists in the actual soil since a considerable proportion of the finer material is carried away in the wash.

The effect of settlement, especially if unequal, is a danger to any structure, but is especially so in piers of such height and mass, as it would obviously lead to very serious results. For instance, taking the length of the footing course as 75 feet and assuming a small difference in settlement—say two inches—between the down stream and the upstream end (i.e. a slope of two inches in 75 feet at the footing), the pier would be tilted about 3½ inches out of plumb at the bridge seat level. Provided unequal settlement did occur, the difference mentioned could not be considered abnormal and if it took place without such previous evidence as would permit time to jack up, re-align, and shim the spans (an expensive operation in itself) the track would be thrown about 4½ inches out of line. These figures neglect the probability of the pier drifting slightly in the direction of the tilt, a contingency which often accompanies unequal settlement. Such a condition on a railway bridge would, having once started, no doubt progressively increase and immediately impair the "safety of traffic" (an expression synonymous with the Ten Commandments in the mind of the railway employee) and to rectify it in such a high structure would involve a very large outlay.

The author believes it is axiomatic that every substructure unit placed in a river constitutes (with very limited qualifications) a potential hazard throughout the life of the structure unless it be founded on rock, and even then the overlying material should be of such character as will provide protection against foundation erosion.

In the design, the principal objective was a layout which would involve the minimum number of high piers consistent with obtaining a structure which, as a whole, was economical in first cost, having in mind possible future maintenance and also the fact that the construction of both the super and the substructure would be carried out working from one end.

This obviously involves the estimate, since, at the designing stage, the structure which is apparently most economical in first cost only exists on paper, and while, as a rule, a reasonably close estimate can be made of the superstructure cost, there is always the probability that a number of conditions may arise during the construction of the substructure which make its final cost more difficult to accurately forecast.

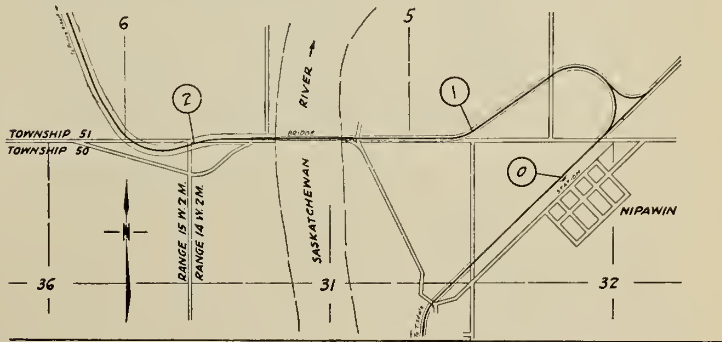


Fig. 1—Key Plan of Bridge and Approaches.

An old rule of bridge economics (applying to a series of truss spans supported on piers) states that the most economical layout is that in which the cost of a pier is one half the sum of the cost of the trusses and the lateral systems of the two spans which it helps to support. The application of this rule gives, within limits, an approximate relation between the span length and the number of piers for maximum economy for a given length of structure, and it will invariably be found that it will give several layouts

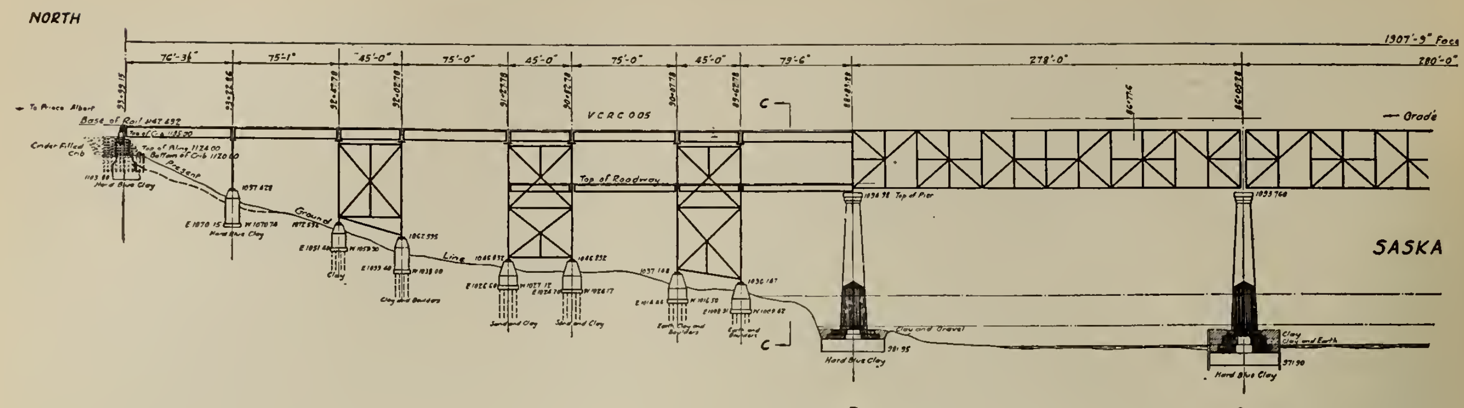


Fig. 2—Elevation,

which will only vary slightly from one another in estimated cost. Unless, however, the substructure conditions are so definitely known beforehand that its cost can be estimated with the same degree of accuracy as that of the superstructure, in the author's judgment the engineer will be justified in favouring the layout having the longest spans and the fewest piers even if its estimated cost appears to be somewhat greater, as when the work is finished, he will find, in the majority of cases, that, in final cost, he has built the most economical structure. In addition, he has eliminated sub-aqueous units which, since they cannot be examined with the same convenience and economy as the superstructure, are usually inspected less frequently and, therefore, represent a greater risk. Further, when repairs are required they are usually of a major character and costly.

The number of river piers, therefore, was principally based on the longest simple truss span which could be erected as a cantilever for its complete length without introducing special erection features which would add so much to the cost of the finished bridge as to make the question of eliminating one or more piers a secondary consideration.

Studies and estimates were made using five 225-foot spans involving six piers, four 280-foot spans with five piers and three 375-foot spans with four piers. Each of these schemes covered about 1,120 feet of structure. Either the 225-foot or the 280-foot spans could be cantilevered without involving very special erection considerations. The 375-foot spans would, however, have involved much more expensive erection problems, and the additional cost of this scheme as a whole, over one using 280-foot spans, did not appear to be justified simply by the elimination of one pier. It was decided, therefore, that the 280-foot spans would be the most suitable from every standpoint.

The piers were designed for the following forces (See Fig. 4), viz.:—

Wind of 300 pounds per lineal foot on train applied 8 feet above rail.

A lateral force equal to 5 per cent of the uniform live load per lineal foot of structure to provide for the combined effect of side sway of engine and train. This force was assumed to act at rail level.

Wind force of 200 pounds per running foot on top chord of spans.

Wind force of 150 pounds per running foot on bottom chord of spans.

Wind force of 30 pounds per square foot on exposed surface of pier between high water level and bridge seat.

Force on piers due to pressure of ice two feet thick having a crushing strength of 300 pounds per square inch on a flat surface. The actual force assumed was one half of this on account of the sharp steel clad cutwaters on the upstream end of the piers.

Force on piers due to current of ten miles per hour assumed to act one third down from highwater level.

Longitudinal force due to the application of brakes on a train assumed as acting at level of lower chord.

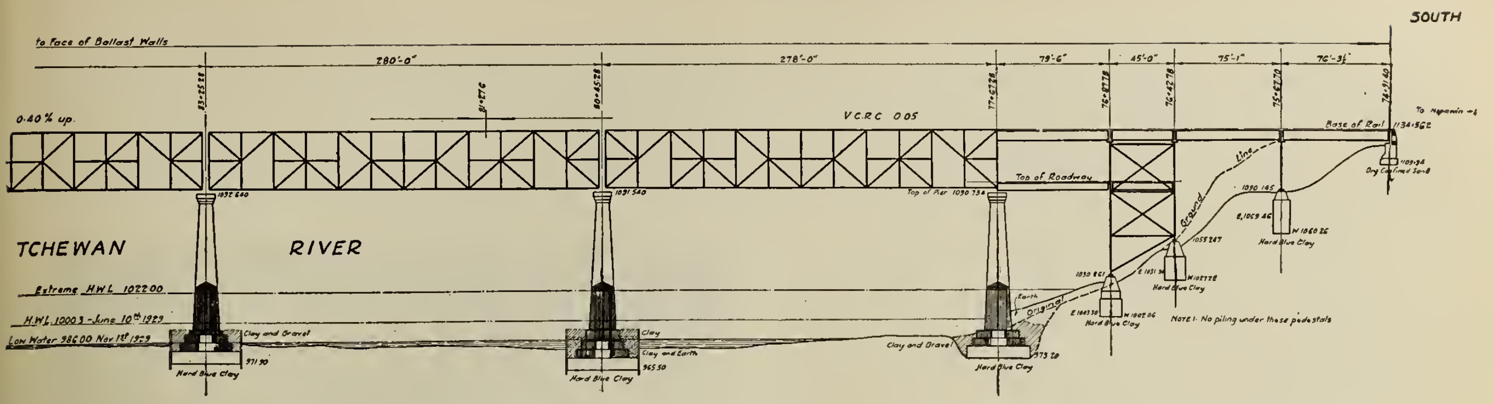
Combining the foundation pressure due to the moments of the foregoing forces about the base of the pier with the pressure due to the dead and live load transferred from the superstructure (2,000 tons) and with the weight of the pier itself (over 8,000 tons) gave a maximum pressure of 4.5 tons per square foot on the downstream corners of the foundation.

After the foundations were opened up, bearing tests made on the hard blue clay on which the piers are founded indicated that it is good for a load up to eight tons per square foot. This stratum was found to be very hard and blasting was necessary to break it up so that the clam shell could handle it.

If it had not been confirmed by the difficulty in excavating, the result of the test in itself would not have been accepted as conclusive evidence that there was a margin of 3½ tons per square foot between the calculated service pressure and the safe bearing capacity of the soil, for the reason that the test load was applied on only one square foot of surface. A 12 by 12 post was used with a platform on top, which was gradually loaded until it carried eight tons, observation of the settlement being recorded while the load was being applied. As a small area will sustain a larger load per square foot for a short period than a large area will for an indefinite period, results which would more closely approximate the actual conditions would naturally be obtained by loading a larger area—say, at least four square feet. Unfortunately, however, when testing soil which will sustain a considerable unit load, it would usually be an expensive procedure to handle sufficient weight to fully load such a large test surface and let it remain more than a limited time, so that one square foot is a common area to test, and the engineer must draw his conclusions from the results.

The faces of the pier shaft were given a batter of 1 in 20 to ensure that the resultant pressure on any horizontal section of the shaft would be within the "middle third" for the most severe combination of forces producing bending on the particular section. In calculating the eccentricity of the resultant pressure due to forces producing bending about the long axis of a section, the moment due to unsymmetrical live load reaction on the bridge seat when only one span is loaded was combined with the moment due to the braking forces.

In order to provide access for the excavators, pile drivers, etc., to the site of the various river piers, a low level pile trestle was constructed across the river from the south bank (Nipawin end). Track laying had previously reached that end and it provided the main, in fact the only, access for material and equipment. This construction trestle, the deck of which was only a few feet above the water level,



Nipawin Bridge.

was located so as to pass clear of the upstream end of the cofferdams and, projecting out from it, a trestle was constructed around the site of each pier to enable the excavators and pile drivers to travel around the cofferdam. (See Fig. 5.)

For the foundations of piers 4, 5 and 6 the cofferdam consisted of a double row of steel sheet piling with the outer row driven three feet from the inner one and the space between filled with puddle. This procedure proved quite effective for the depth to which it was found necessary to carry the foundation and the pumps had no difficulty in handling the water.

The foundation course of the river piers is 45 feet wide by 75 feet long and the corresponding inside dimensions of the cofferdams were 50 feet by 80 feet. This allowed a space of more than two feet between the neat dimension of the footing course and the steel sheet piling, except at the upstream end where a 5-foot space was left in order to provide for a sump in the event of water trouble.

As all the foundation work for these piers was carried out in winter when the water was low, no cofferdam was used for the construction of pier 3 or 7, located near the low water mark on the south and the north bank respectively. Except for a few days in November when, owing to an ice jam downstream from the bridge site, the water rose about seven feet and flooded the excavation of pier 3, no great difficulty was experienced in constructing the foundations of these two piers.

The concrete and other material required for the construction of the substructure was conveyed to the various piers from the south end by means of a cableway across the river. This had a span of 2,000 feet between towers 85 feet high,—which were located at the top of each bank. The main cable, which was approximately over the centre line of the bridge, was 2 inches in diameter and the system had a capacity of six tons. (See Fig. 6.)

The concrete mixing plant, cement shed, power plant and other services were set up on the south bank, the mixing plant being located on the slope of the bank just west of the centre line of the bridge.

As the bank was very steep, the aggregate bunker had its top about level with the ground immediately behind, which eliminated the necessity of having to elevate the aggregate to load the bunker.

The cement and gravel were gravity fed to a one-yard motor-driven mixer, which in turn dumped the mix into a two-yard bucket carried by a small car running on rails. This car was then hauled under the cableway by a small electric hoist, where the bucket was picked up by the blocks suspended from the cableway carriage and transported to its place of deposit in the forms.

The power for the cableway was furnished by a double drum steam driven Lidgerwood hoist. During concreting operations, telephone communication was maintained between the operator, the mixing plant, and the point at which concrete was being poured. A man was stationed at each of the latter points with head phone directly connected to the head phone of the hoist operator. These men controlled the spotting of the concrete bucket for unloading or for picking up and advised the hoist operator when the bucket had been lowered or raised to its proper elevation.

The lifting speed was about 150 feet per minute and the travel speed about 1,200 feet per minute.

The maximum pour in an eight-hour shift was 182 cubic yards, and the maximum concrete handled in a continuous working day of twenty-four hours was 495 cubic yards.

After the temporary trestle (previously referred to) had been removed from the river before the spring "break-up" the cableway was used for transporting all labour and material to the points at which they were required.

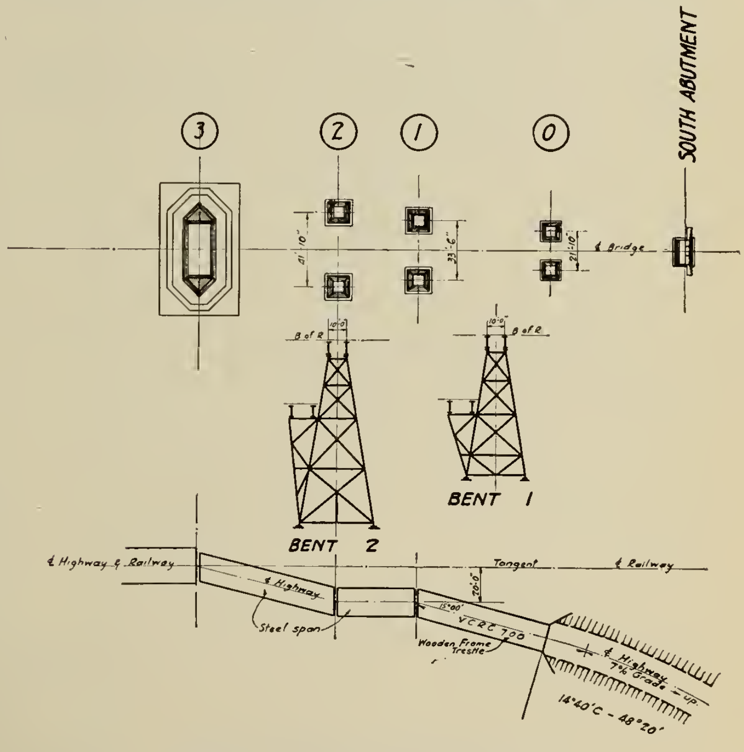


Fig. 3—South Highway Approach.

As the greater portion of the substructure was constructed during a very cold winter, all the concrete ingredients were, of course, heated, and the work of keeping the mix at the proper temperature until it had set was one of the difficulties which had to be contended with. The greatest care, therefore, had to be exercised to prevent the concrete freezing. The temperature of the mix when dumped from the mixer was usually from 100 to 120 degrees and from 70 to 90 degrees by the time it was deposited in the forms. After each pour was completed, it was covered with canvas and kept heated with steam pipes for at least three days. In the case of some of the footing courses where forms were used, these were built double, with an air space between, and live steam kept circulating in these spaces during the setting period.

The river piers are provided with a skin reinforcing on all four faces consisting of one-inch diameter vertical bars at three feet centres tied to three-quarter inch diameter horizontal bars, spaced at 10 feet centres vertically.

As a protection against the heavy ice flow, which is usual on this river, the upstream cutwater on each of the five river piers is completely encased by a steel plate which extends the full height of the cutwater and is carried back around the shoulder of the pier shaft. This plate is one-half inch thick and is anchored into the concrete at close intervals by one-inch diameter bolts 14 inches long.

Superstructure

The principal consideration in connection with the superstructure was, of course, the long spans over the waterway.

Owing to the height of the steelwork above the river bed, economy required that the cantilever method of erection be adopted in order to avoid assembling them on high falsework, which would have materially increased the cost and the risk, and would have added very considerably to the time required for erection.

As the trestle construction at the south end was not suitable to act as the anchor arm for cantilevering truss span No. 1 (the first from the south end) two schemes were considered for attaining that purpose.

First, instead of erecting the 276-foot trestle approach at the south end, it was proposed to erect (in that location) ten of the twelve panels of truss span No. 2 to provide the anchor arm for cantilevering truss span No. 1. Owing to the steep slope of the ground line at this location, there was not sufficient room to erect all of span No. 2, but the dead weight and the loss of leverage represented by the two panels omitted could be made up by adding the necessary counterweight. Obviously, because of the steep slope of the bank,

Fig. 5—Pile Trestle and Cofferdams, December, 1928.

this scheme involved the minimum falsework and required no piling under the timber towers, as sufficient bearing area could be obtained for their base by cribbing and mudsills. It had also the merit of being safe at all seasons as it kept the river clear of falsework, which was important especially in the late fall and spring. Its principal disadvantage was that it involved extra handling, in that span No. 2 would require to be erected twice, viz.: first, as an anchor arm in a temporary location, then dismantled in

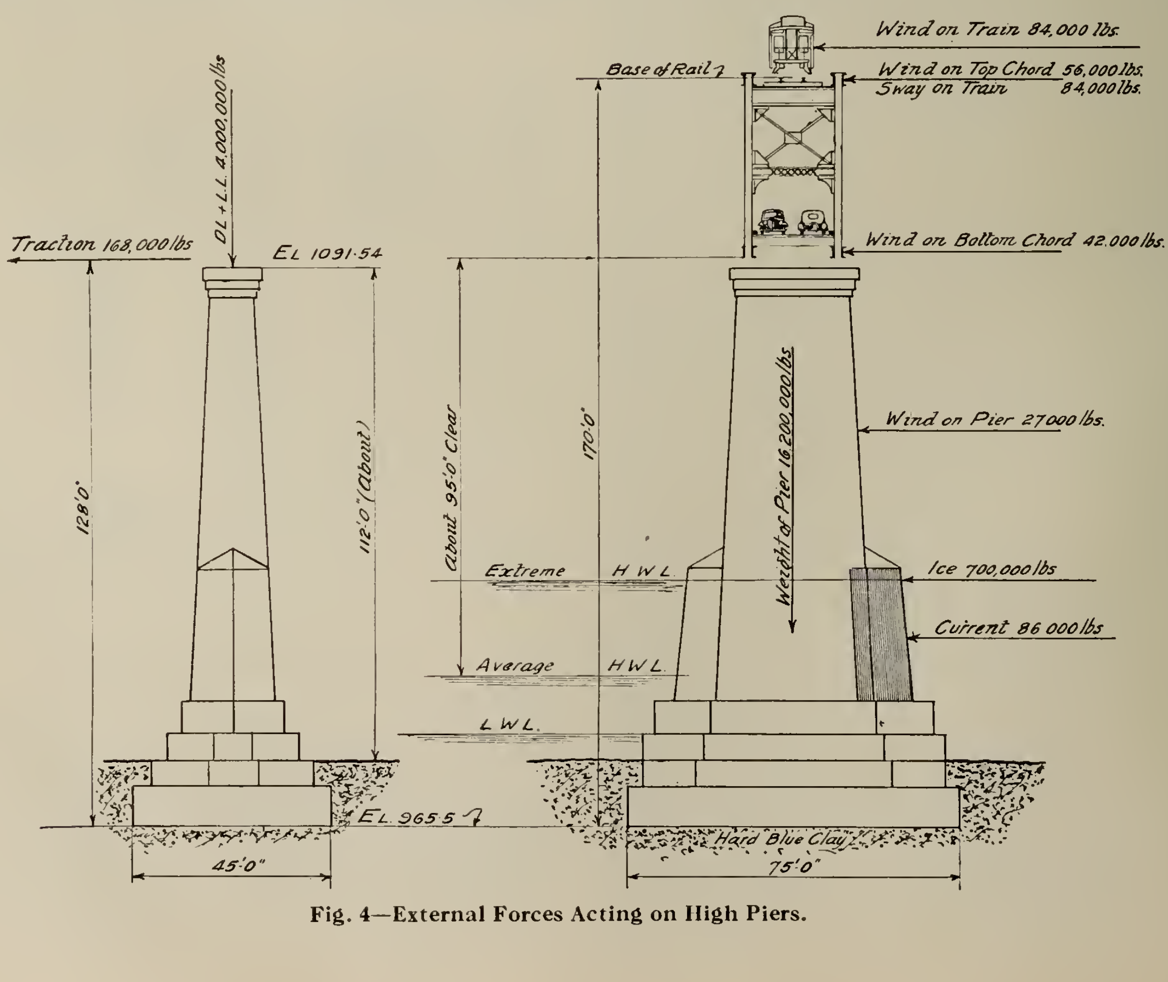


Fig. 4—External Forces Acting on High Piers.

order that the trestle approach could be erected, then, finally erected in its permanent position.

The alternative scheme proposed (instead of cantilevering all four spans) to erect truss span No. 1 on falsework and cantilever the remaining three. This, of course, required high falsework towers carried on piling, which called for a very much larger quantity of timber than would be necessary for the previous scheme, although it had the advantage that it did not involve so much extra handling and permitted the work to go straight ahead. It had the disadvantage, however, that it could only be adopted if the water level was low and the river running free of ice, debris, etc., as such an obstruction in the river would create a serious hazard especially considering the height of the falsework. Obviously, the time taken to erect span No. 1 on falsework would be much greater than by cantilevering, but a large proportion, if not all of the time saved in the erection of this span by cantilevering would be offset by the time required to first erect span No. 2 as its anchor arm, and then dismantle the latter in order to erect the trestle.

Fig. 6—View of Concrete Piers and Cableway, June, 1929.

As far as the railway company's engineers were concerned, either scheme was acceptable, provided water conditions did not prohibit the alternative proposal as it was considered the time required to erect the structure from south abutment to pier 4 would be practically the same for either proposal.

As the construction of the substructure proceeded, it became evident that erection of the superstructure would not begin until late in July when the water level would be low, and it was, therefore, decided to erect span No. 1 on falsework in its final position and cantilever the other three.

When spans are intended to be "simple supported" in service, but are erected as cantilevers throughout their length, it is often the case that certain members near the support from which the span is being built out are called upon to resist greater stresses during erection than they will in

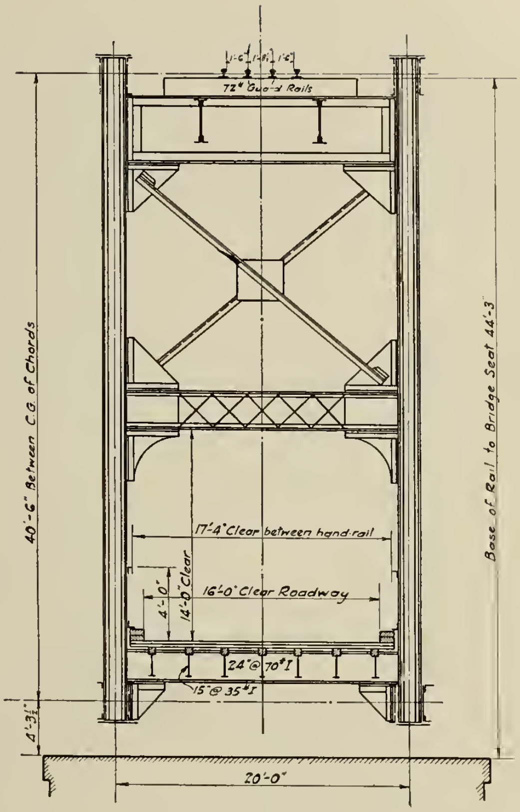


Fig. 7—Typical Section Through Deck Truss.

service, and for that reason it is necessary to provide such members with a considerable excess of material over and above their service requirements—this material being of course redundant as far as the finished structure is concerned. In order to reduce this redundant material to a minimum, and to increase the vertical stiffness of the cantilever trusses during erection, the temporary tension members, which were introduced to provide the necessary continuity over the supports during erection of the major portion of the span sloped upward from their connection to the fourth panel on the top chord of the cantilever trusses and, passing over the top of a post erected at the second panel point on the top chord of these trusses, then over the top of a post erected at the corresponding point (relative to the support) on the anchor trusses from which they sloped downward to their connection with the fourth panel of the anchor trusses. (See Fig. 8.)

This temporary harness, which could be moved ahead for use on the succeeding span, had the effect of deepening

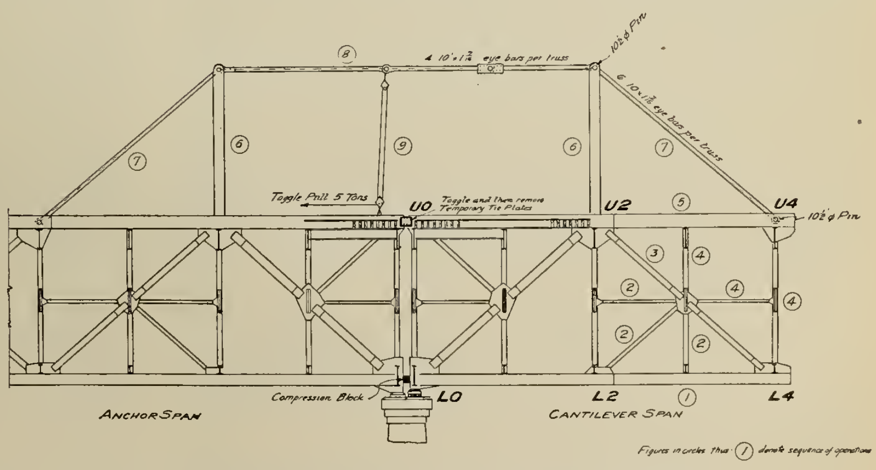


Fig. 8—Temporary Harness for Cantilever Erection.

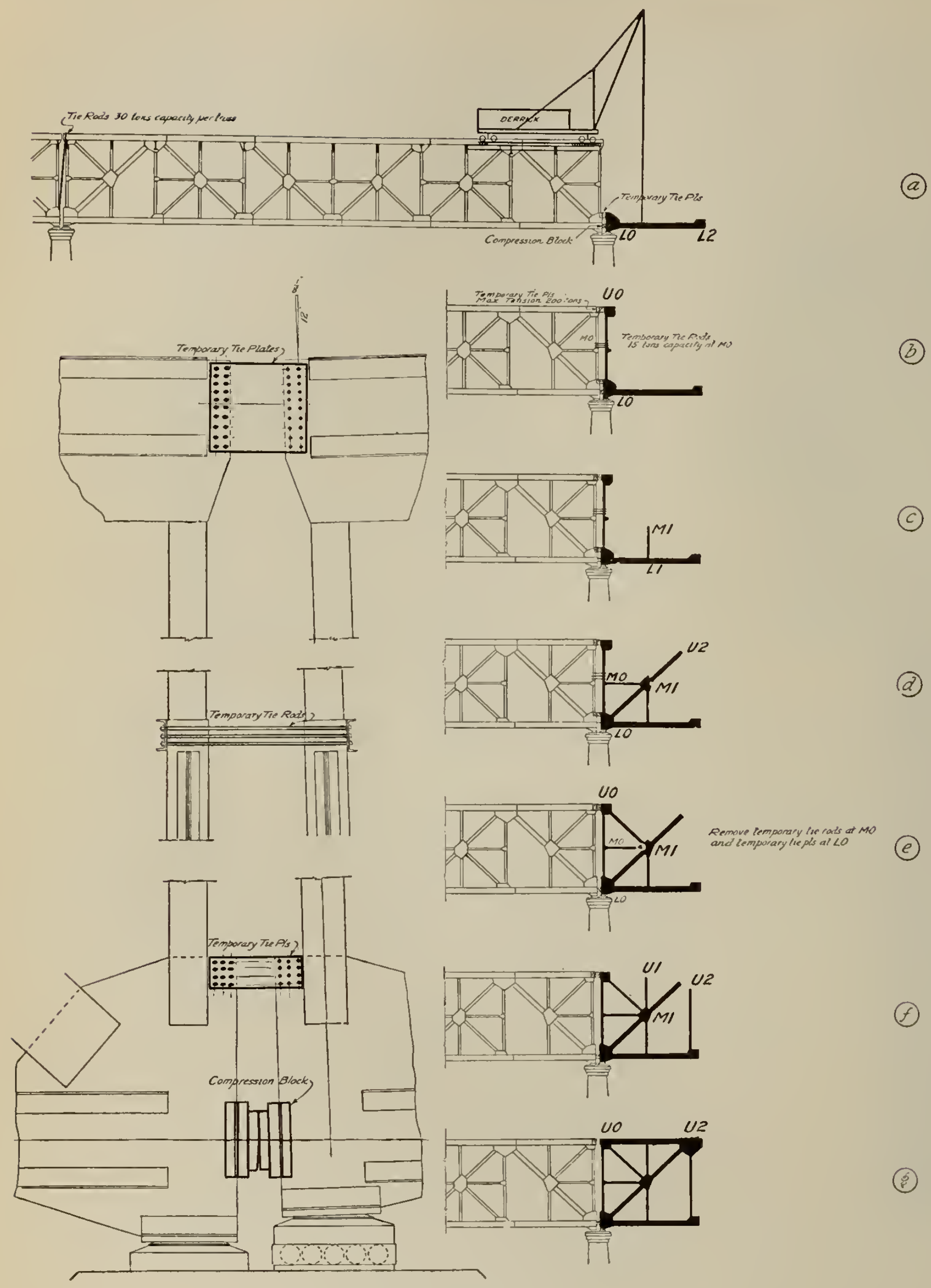


Fig. 9—Cantilever Erection.

the trusses in the vicinity of the piers during erection, with the result that the material required for erection stresses in the members near the support (with the exception of the lower section of a diagonal and one post on each side of the centre line) did not exceed that required in the same members with the spans in service and carrying their maximum live load on the railway track and the highway deck. This condition was further assisted by the fact that each member of the trusses had its quota of material provided to resist stresses due to the dead and live load on the highway deck, which loads, of course, did not exist during erection.

The section of the angle bars comprising the lateral bracing was increased somewhat over what would be required for simple supported spans in order to provide lateral stiffness to resist wind stresses which might occur during erection, especially at the stage when the cantilever had almost reached the farther pier.

As previously stated, the first of the 280-foot spans to be erected was assembled on falsework and served as the anchor arm for cantilevering span No. 2. This falsework consisted of timber towers 90 feet high, spaced at 46-foot centres and approximately under the panel points, each tower being composed of double frame bents braced as a unit and carried by a double row of piles capped about ten feet above the water level. The towers were built in three storeys, each story being framed on the shore and lowered into place as a complete unit by the derrick car.

The elapsed time between driving the first pile for this falsework and completion of erection of the span was forty-six days. As the 276-foot trestle approach was being erected at the same time pile driving was proceeding, the actual time occupied in erecting the trestle approach and the first truss span, including the falsework, was fifty days.

Fig. 9 (*a*) to (*g*) shows, in sequence, the various steps in the erection of the first panel of the cantilevered spans.

The bottom chord members, *LO-L*2, which were placed first and projected over 52 feet beyond the pier, were temporarily tied back to the anchor span by plates connecting the top of their gusset (at *LO*) to the gusset on the lower chord of the anchor arm. At the same time compression blocks (or kickers) were placed in the space between the ends of the lower chords of the cantilever and the anchor span to transfer the thrust from the cantilever.

This was followed by the erection of end posts *LO-UO*, and the placing of six seven-eighths-inch diameter temporary tie rods of fifteen tons capacity at *MO*, also the introduction of temporary tie plates of 200 tons capacity connecting gusset at top of these posts (point *UO*) to the top chords of the adjoining anchor span. After sub-diagonals *UO-M*1 were placed (see Fig. 9-*e*), the tie rods at *MO* were no longer necessary, also the tie plates at *LO*. The tie plates connecting the two spans together at *UO* were, however, required to take the tension during the erection of the first two main panels, after which the harness was erected and the tension in these ties was transferred to it.

Fig. 8 indicates the extent of the erection when the harness was introduced, and the system of "toggling" in order to transfer the tension in the tie plates at *UO* to it.

The tension members of the harness were composed of a chain of eye bars engaging 10½-inch diameter nickel steel pins at their connections. Each of the inclined members, which were designed for a tension of 1,040 tons per truss, consisted of a group of six 10-inch by 1-7/16-inch bars. The horizontal members joining the top of the posts were designed for a pull of 790 tons per truss and consisted of a group of four 10 by 1-7/16-inch bars in each link of the chain.

These horizontal members were made up of three lengths of bars requiring two intermediate pins. At one of these pins the ends of the connecting bars were blocked and stiffened in order to limit their relative rotation about the pin, while at the other pin the bars were free to rotate.

In order to transfer the tension from the link plate between the top chords at UO, which had, up till this stage, resisted the tension due to continuity, a sheave block was hung from this pin and another was connected to the top chord of the anchor truss immediately underneath. A comparatively small pull, (about 5 tons) on the whip line of a cable reeved through these blocks "toggled" the eye bars connecting at the pin and permitted the tie plates at UO to be disconnected. The holes at one end of these tie plates were slotted in the direction of the pull, so that by previously slackening slightly the bolts in these slotted holes the tie plates were free to slip backward towards the anchor span during the operation of toggling, thus preventing any resistance from them during that operation, and facilitating their removal. The removal of these ties eliminated ambiguity and ensured that all continuity was provided by the harness.

When erecting panel 8-10 a temporary subdiagonal U-8 M-9 was introduced to complete the triangulation in this panel for erection stresses.

When erection had reached L-10, i.e. one panel length short of the farther pier, it was provided that one-inch diameter guy lines be run in a diagonal direction by connecting one end to the east bottom lateral plate at L-10 and snubbing the other end around a hitching post, com-

Fig. 10—Superstructure Under Erection, October, 1929.

posed of a 6-inch diameter heavy duty pipe embedded in the coping at west side of bridge seat. A similar guy line to be attached to the lateral plate immediately opposite on the west truss and hitched around a similar snubbing post at the East side of the bridge seat. The X bracing thus formed was intended to hold the span against the wind pressure as well as the side sway due to the working of the derrick when erecting the last panel.

During the erection of the cantilever, additional counterweight was required on the anchor arm in order to resist uplift due to the overhanging deadweight combined with the overturning effect when the ninety-ton derrick car was located at the outer tip of the overhang in the act of lowering a heavy member into place.

This uplift, in the case of spans 3 and 4, was counteracted by anchoring the end of the anchor span down to the span immediately behind it by means of tie rods connecting the gusset plate at the top of the end posts of the former to the gusset plate at the bottom of the end posts of the latter. When erecting the last panel, additional anchorage was provided by placing another derrick car (or its equivalent weight) over the end panel of the anchor span. When cantilevering span No. 2, however, as its anchor span (No. 1) had no suitable span behind it, a kentledge of steel rails performed the duty of the tie rods previously mentioned.

In order to ensure that when the cantilever reached the farther pier the increasing deflection, due to the increasing overhang, would not bring the bottom chord of the last panel below the level of the bridge seat, the tie plates connecting the top chords of the cantilever at point UO to the anchor span had their connection holes so arranged that

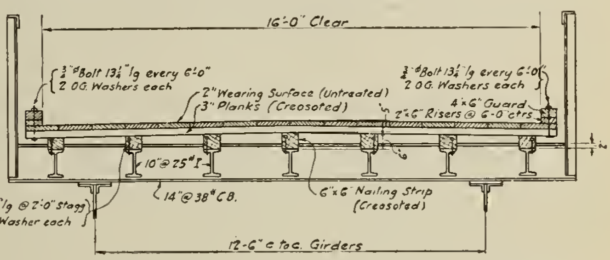


Fig. 11—Typical Section Through Roadway Approaches.

the first panel of the cantilever span was set with a tilt upward from the normal. As the span was built out, of course, the natural sag due to the overhang gradually nullified the effect of the upward tilt, so that by the time the last panel was erected the free end was about five inches below normal, but there was sufficient space between the shoe plate on the bottom chord and the bridge seat of the pier to permit the insertion of timber blocking. This end was then jacked up a sufficient height above normal to permit driving out the pins connecting the inclined tension members of the harness to the top chord of the cantilever. The continuity due to the harness being thus released, the span was then lowered on the jacks to its normal position on its pier members and thereafter functioned as a "simple supported" span.

As each member was erected, particular attention was given to connections. Definite and detailed instructions were issued to the field forces regarding the minimum number of bolts which must be inserted in the connection as each member was erected before adding additional weight to the cantilever. The erection drawings stipulated whether a member must be rivetted, fully bolted, or have a minimum of 75 per cent or 50 per cent bolts, depending upon the erection stress. These drawings also definitely outlined the sequence of the steps which the erectors were to follow in the process of assembling the cantilever span and the location of the front trucks of the derrick car while placing the various members.

The time required for erecting each of the cantilevered spans was twenty-one days. The writer wishes to emphasize the smoothness and expedition with which the erection work was carried out. Everything worked out in accordance with the preconceived plan and reflected the greatest credit on all members of the Bridge Company's personnel associated with the work.

PERSONNEL

The structure was designed, and the fabrication and erection of the superstructure supervised, by the bridge engineering staff of the Canadian Pacific Railway, J. M. R. Fairbairn, D.Sc., M.E.I.C., chief engineer, and P. B. Motley, M.E.I.C., engineer of bridges. The construction work in the field was under the direction of T. C. Macnabb, M.E.I.C., engineer of construction, Western Lines, with H. D. Brydone-Jack, M.C., A.M.E.I.C., engineer at the site.

The Sydney E. Junkins Company Ltd., Winnipeg, were contractors for the substructure.

The Dominion Bridge Company Ltd., were the contractors for the superstructure, which was fabricated in their Winnipeg plant. The erection work was carried out under the general direction of F. P. Shearwood, M.E.I.C., chief engineer of the bridge company, with H. M. White, A.M.E.I.C., engineer, Winnipeg division in local charge.

The Development of Special Portland Cements in Canada

Part II

Alkali Resistant Cement*

A. G. Fleming, M.E.I.C.,
Chief Chemist, Canada Cement Company Limited, Montreal.

SUMMARY.—The author recalls the experimental work which began in 1920 to study and overcome the deterioration in Portland cement concrete caused by exposure to alkali sulphates. Ultimately accelerated laboratory tests were adopted and a detailed study made of the individual compounds found in hydrated cement. This research after a number of years lead to the experiments described in this paper, and the production of a satisfactory alkali resistant cement.

In June 1920, a conference was held at Winnipeg through the initiative of some of the western members of The Engineering Institute of Canada for the purpose of planning a thorough investigation of the cause and prevention of disintegration of foundations and underground conduits of concrete in the alkali soils of the prairies.

Messrs. W. G. Chace, M.E.I.C., and B. S. McKenzie, M.E.I.C., were two of the men more actively concerned in organizing this proposed investigation, and engineers and chemists engaged in the manufacture or use of cement on both sides of the border were called together for this initial discussion of the problem.

Among others present at this gathering were Messrs. Duff Abrams, Freeman and E. Ashton of the Portland Cement Association, G. M. Williams, A.M.E.I.C., of the Bureau of Standards, who had been working for several years on a study of the same problem in the United States alkali infested regions, Mr. Archibald Blackie, city chemist of Winnipeg, A. A. Young, A.M.E.I.C., engineer and contractor, H. S. Van Scoyoc, M.E.I.C., of the Canada Cement Company and the author.

The discussion disclosed that the foundations of several important structures in the west were disintegrating as the result of the reaction between the alkali sulphates of the soil and the cement, and it was considered to be a vitally important matter to all western engineers. It was decided to request The Institute to organize all parties interested for the purpose of subsidizing research to find methods of combatting the effects of the alkali action and overcoming this serious trouble.

Organized Investigation

In the early autumn of the same year The Engineering Institute held a General Meeting at Banff and the proposed organization was completed. A committee was formed under the chairmanship of Dean C. J. Mackenzie, M.E.I.C., of the University of Saskatchewan to make a thorough study of the problem. The Research Council of Canada were among the first of the organizations approached for aid in the proposed investigation and their total contribution to the work has been libeial, amounting to over $50,000. The other cooperating organizations were:—The Canadian Pacific Railway, City of Winnipeg, Province of Saskatchewan, Province of Alberta, Province of Manitoba, Canada Cement Company.

The research was carried out at the University of Saskatchewan. G. M. Williams, A.M.E.I.C., was appointed to the staff of the university and was of service in directing the field work of the investigation, having already had useful experience in that connection while on the staff of the Bureau of Standards. The main problems for investigation were considered to be of a chemical nature and Dr. T. Thorvaldson was placed in charge of this work.

For the field study of the action of alkali solutions on concrete, specimens were exposed in areas known to be highly impregnated: at Deakin, Manitoba, near Winnipeg; at Grandora Lake near Saskatoon and at Cassils, Alberta, near Calgary, and later at Antelope Creek, Alberta. (See Fig. 1.)

These specimens included concrete of various mixes made with cement bought from dealers and selected samples from other sources, including a number of concrete specimens made in the Portland Cement Association laboratories under the supervision of Professor Duff Abrams, who was supervising a similar investigation of concrete exposed at Medicine Lake, Dakota, and at Montrose, Colorado. Some specimens of alumina cement concrete were also exposed.

The specimens were examined periodically and a record made of their comparative resistance to the alkali exposure. Reports by the committee of their observations of the conditions of these blocks were published for several years in the Journal of The Engineering Institute.

Results of Field Tests

There was a difference found in the resistance in several cases which might be attributed to difference in the cements, and in general the resistance to disintegration increased with the richer mixes, up to approximately a 1-2 mix. This observation was of value in showing that by using sufficient cement to make dense and impermeable concrete the life of a structure exposed to alkali soil solutions would be considerably lengthened. In order to test the value of various admixtures and coatings offered for sale as preventives of the destructive action of the sulphates a large

Fig. 1—Grandora Lake Exposure Site.

number of test specimens were made, and the admixtures offered as possible cures, also the coatings, were all or nearly all given a fair trial under conditions of equal exposure. This programme for the investigation of the value of nostrums was also tried out, perhaps more extensively, in the field exposure tests of the Portland Cement Association. As a result of all this work it was found that some of the admixtures and coatings seemed to be actually harmful, decreasing resistance to the alkalis rather than making the specimens more durable. Others did no harm, but were of no apparent benefit, as comparable specimens made without them lasted for the same period of time under similar conditions of exposure. It was found however in the

*The special cement developed for this purpose by the author is registered by the Canada Cement Company under the trade name of Kalicrete.

experiments made across the border that boiled linseed oil gave a protective coating and also coatings in which the same substance was the principal ingredient were apparently very beneficial. Some specimens so coated, it is said, have remained in good condition for nine or ten years.

Laboratory Tests

During this time the author's company were carrying on similar tests using neat cement and mixes of sand and cement, the proportions of which were from 1-2 to 1-4, and exposing to test briquettes or 2-inch by 4-inch cylinders. A number of compounds were investigated which it was considered might possibly be of value, but the results were disappointing. It was found, however, from tests on a series of briquettes made at Exshaw in 1922 and 1923, that precipitated silicic acid, H_2SiO_3, a fine white colloidal powder, increased the resistance of the mortar to disintegration by sodium sulphate solutions very considerably when used in moderately large amounts. Neat cement and 1-3 sand mortars containing 10 to 50 per cent by weight of the cement of this colloidal silica continued to gain strength in briquettes up to six months when immersed in a 10 per cent solution of sodium sulphate, although briquettes made from the same cement without the colloidal silica admixture disintegrated in a few weeks when immersed in that solution. These results were communicated to Dr. Thorvaldson, who had started experiments or had under consideration experimentation with the same substance and the results of the work under his direction were published in the Canadian Journal of Research. The experiments along this line were more extensive than those previously carried out, but led to the same conclusion, namely that the substance was too expensive to render its use practicable.

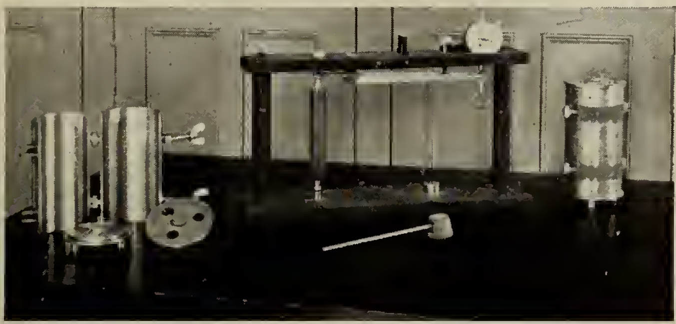


Fig. 2—Humboldt Apparatus for Concrete Durability Tests. Used in obtaining Results shown in Fig. 11.

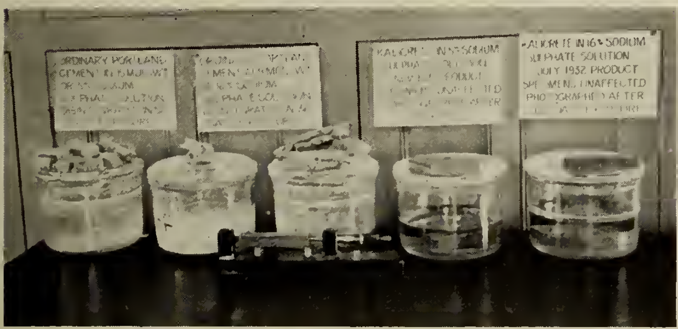


Fig. 3—Accelerated Durability Tests.

Some slight difference was found in the relative durability of several of the cements tested in sodium and magnesium sulphates in ordinary exposure tests and it was observed that the cements of highest silica content were the more resistant to the disintegrating action of such solutions.

Accelerated Expansion Test of Thorvaldson

The testing of the durability of cement in concrete or mortar of the usual proportions by setting test blocks in alkali impregnated ground or in strong solutions of the alkali sulphates was found to be a slow process. Specimens used for such tests were usually well made and relatively impermeable to the solutions and many resisted the chemical action of the salts for years, which was too long to wait for a verdict. Dr. Thorvaldson and his colleagues however developed a relatively quick quantitative method for measuring the disintegrating action of alkali waters on Portland cement mortars. This was based on the measurement of the linear expansion of rectangular bars of standard sand with only a small proportion of cement. The bars were immersed in sodium magnesium or calcium sulphate solutions of certain concentrations when they were strong enough to handle. The test bars were quite porous and therefore the solution could attack the particles of cement on all sides. If there was a reaction it caused an expansion of the bar which was definitely related to the progress of the reaction, and this made possible an accelerated expansion test of the durability of cements.

This method of testing shortened the time required for measurement of the comparative durability of cements to a matter of days or weeks as contrasted with the months or years required for the simple exposure test in field or laboratory solutions previously in use.

Several other important studies were also undertaken by the University of Saskatchewan.

Action of Magnesium and Sodium Sulphates on Calcium Aluminates

In 1925, G. R. Shelton* published the results of a study of the action of sodium and magnesium sulphate on the calcium aluminates. This research covered a microscopic study of the compounds formed when mixtures of the aluminates were made with various concentrations of sodium sulphate solutions and magnesium sulphate solutions. It was found that the hydration products of the three calcium aluminates $5CaO.\ 3Al_2O_3$, $CaO.\ Al_2O_3$ and $3CaO.\ 5Al_2O_3$ are hydrated tri-calcium aluminate ($3CaO.\ Al_2O_3$) and amorphous matter differing from that obtained in the hydration of tri-calcium aluminate ($3CaO.\ Al_2O_3$, the compound present in Portland cement) which was hydrated tri-calcium aluminate only. The amount of gel or amorphous matter was found to increase in proportion to the alumina in the compound and the time required for complete hydration was found to increase with the alumina content of the compound.

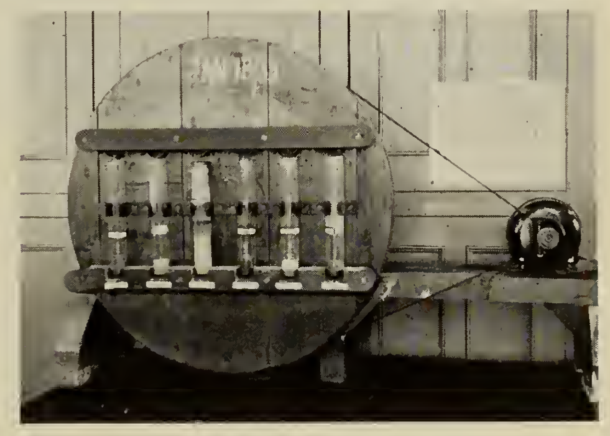


Fig. 4—Merriman Wheel for Sugar Lime Test.

The formation of calcium sulpho-aluminate crystals is characteristic of the reactions between all calcium aluminates, crystalline and hydrated, and solutions of sodium sulphates in all concentrations and of magnesium sulphates below 0.1 mol (say 1 to 2 per cent solutions). Above this

*Industrial and Engineering Chemistry, December 1925.

concentration of the latter salt the only crystalline product is gypsum. Very large quantities of calcium sulpho-aluminate crystals are formed from the hydrated aluminates and dilute sulphate solutions, amorphous matter in the original hydrated suspension being largely used up in the process. Layers of gel surround the crystalline aluminate grains protecting them from further sulphate action and are more plentiful in solutions of magnesium sulphate; probably being composed in part of amorphous magnesium hydroxides.

Probable Reason Why Fused Alumina Cements Show Some Resistance To Magnesium Sulphate

The results of this study offer some explanation for the anomaly observed in the superior resistance of Ciment Fondu and other fused alumina cements to the action of magnesium sulphate. The alumina compound in Portland cement is the tri-calcium aluminate, $3CaO.\ Al_2O_3$. The compound identified in the alumina cements is $5CaO.\ 3Al_2O_3$ which contains relatively more alumina and less lime, and according to Shelton's observation throws off layers of gelatinous substance which surrounds the hydrated calcium aluminate crystals and protects them from rapid action. The alumina cements however were not found to be immune to the deteriorating action of sulphate waters.

In the field tests carried out under Dean Mackenzie he reported in 1927 that of the twelve high alumina cement concrete specimens only two were in good condition. The unattacked specimens were two of rich concrete exposed at Deakin. All the lean concretes of the alumina cement had deteriorated. Disintegration had generally been slower than for the Portland cement specimens with most of the apparent action above the ground line. It had been found in the laboratory that this particular cement (Ciment Electrique) offered an especially high resistance to magnesium sulphate which is the predominating salt at Deakin where the rich concretes have been apparently unattacked. The predominating sulphate at the Saskatchewan and Alberta field exposure plots is sodium sulphate, although smaller amounts of calcium sulphate and magnesium sulphate are present, also some sodium carbonate.

Effect of Steam Treatment on Resistance of Portland Cement

Dr. Thorvaldson in Canada and Dalton Miller* both carried out extensive experimental research on the effect of vapour and steam treatment on concrete.† It was found by both investigators that steam at the boiling point of water is quite an effective treatment in increasing the resistance of Portland cement mortar or concrete to sodium sulphate and to a lesser extent magnesium sulphate. On the other hand, treatment of mortars with saturated water vapour at 50 degrees C. reduced the resistance to sulphate action. Water vapour above 75 degrees C. increased the resistance and the higher the temperatures the more efficient the treatment was found to be and the shorter the time of treatment required. A recent application in Canada of this discovery was made in Winnipeg last year when the large concrete pipes made for a new sewer were steam cured under pressure for several days in order to increase their resistance to alkali ground waters.

Dr. Thorvaldson's study of the hydration of the aluminate of calcium indicated that the compound formed by the hydration of tri-calcium aluminate under normal conditions of room temperature had the same composition $3CaO.\ Al_2O_3.\ 6H_2O$ as the hydration product of tri-calcium aluminate in saturated steam at 150 degrees C., although the latter product was relatively quite resistant to sulphate action while the former was not. He concluded that the reason for this was that the steam treatment modified the condition of the substance and changed it from the colloidal to the crystalline state and so decreased its reactivity to sulphate action.

The lime silicate compounds present in Portland cement as well as tri-calcium aluminate were prepared and tested separately by the bar expansion method to determine their reactivity or resistance to the sulphates of sodium, lime and magnesia. As anticipated it was found that tri-calcium aluminate without steam treatment succumbed rapidly in all solutions. Beta dicalcium silicate was practically unaffected. Tri-calcium silicate was not quite so resistant to magnesium sulphate, but as hydrated tri-calcium silicate shows the presence of calcium hydroxide in the amount required by the reaction $3CaO.\ SiO_2 + 3H_2O = 2CaO.\ SiO_2.\ 2H_2O + Ca(OH)_2$ it is probable that some gypsum is formed by reaction of the sulphates with the calcium hydroxide released from the tri-calcium silicate while it is hydrating.

Obstacles to Development of Alkali-Resisting Portland Cement

It is not intended to present a synopsis of all the studies made on the problem of the development of an alkali resistant concrete, but merely to touch on some of the more important conclusions resulting from these studies in field and laboratory. A mass of scientific work was well done by the chemists, physicists, petrographers and engineers engaged in the research, but it appeared to the author that many of the conclusions they reached were not very helpful to the manufacturer who hoped to produce a Portland cement at reasonable cost which would withstand satisfactorily the action of the alkali waters of the prairies.

Here was the situation as it appeared; Portland cement was found to be composed of the three main compounds:—

Tri-calcium silicate	$3CaO.\ SiO_2$
Beta Di-calcium silicate	$2CaO.\ SiO_2$
Tri-calcium aluminate	$3CaO.\ Al_2O_3$

and as iron is always present in small amounts in the materials, clay and limestone, used in the manufacture of Portland cement, it was believed to be present as di-calcium ferrite, a compound of rather poor setting properties and low potential strength.

Tri-calcium silicate is the compound which gives to Portland cement the greater part of its strength in tension and compression at all periods. This compound was found to be nearly immune to the action of sodium sulphate and comparatively resistant to magnesium sulphate. Portland cement of present day manufacture may contain from 35 to 70 per cent tri-calcium silicate, depending upon the mixture, its preparation and the heat treatment the material receives in the kiln. The silica remaining in a properly made cement would be present as di-calcium silicate.

Di-calcium silicate hydrates much more slowly than tri-calcium silicate and consequently does not develop much strength in concrete or mortar until later periods in the processes of hydration which commence soon after water is added to the mixture of cement, sand and stone.

The di-calcium silicate does not appear to be affected by nor to deteriorate from the action of the sulphates.

Tri-calcium aluminate hydrates with comparative rapidity. It produces much of the early strength developed by the cement, especially up to the three day period. It is however vulnerable to the action of the sulphates, which react with it to form calcium sulpho-aluminate, a product of greater volume than the hydrated tri-calcium aluminate it displaces and hence a potent cause of expansion and disintegration.

Since clay is essentially silicate of alumina derived from the decay of feldspathic rocks it is almost impossible to find any way of leaving the alumina out of the ensuing Portland cement and thus obtaining a cement composed of

*Drainage Engineer, United States Department of Agriculture.

†Thorvaldson and Vigfusson, Engineering Journal, March 1928, p. 174.

the resistant calcium silicates, without the complete substitution of quartz sand for the argillaceous part of the mix. Anyone who has had experience in burning a very siliceous mix in a Portland cement kiln and knows how difficult it is to burn, particularly when the high silica content is due partly to the presence of free silica sand which tends to separate from, rather than fuse into, the mass of material, cannot be convinced that a product of any value could be

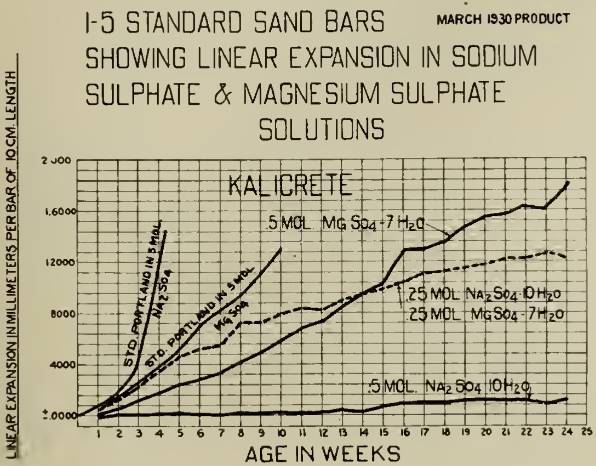


Fig. 5.*

made on a commercial basis from pure limestone and quartz even if these materials were pulverized to extreme fineness and proportioned and burned in the kilns at high temperatures.

The resulting product would be a mixture of the dicalcium silicates, free or uncombined lime and free silica, all of which are uncementitious products except the beta di-calcium silicate which is extremely slow setting. The cost would be prohibitive in fuel, power, and raw materials and the greater proportion of the product worthless as compared to the Portland cements now on the market. It would be almost impossible to make concrete with such a material that would not fail under load; nor would it be resistant to the exposure of the ordinary agencies of our northern climate nor to the action of sulphate waters or even fresh water, on account of its free lime content and tendency to expansion.

Even in the laboratory preparation of di-calcium and tri-calcium silicates it has been found difficult to make small quantities of the desired products. In the methods usually adopted the calcium carbonate is added in small increments to the silica and the mixture heated to 1,500-1,525 degrees C. after each addition and maintained at that temperature for several hours.

Weakness of Iron-Cement

Michaelis in 1905 produced an iron-cement made from limestone or chalk and iron ore, eliminating in this way practically all the alumina present in all clay. Even at this time the calcium aluminates were blamed for the tendency of cement to disintegrate in sea water.

Iron-cements however as made by his process were none too satisfactory. They set and hardened very slowly and were comparatively weak, and therefore did not seem to be a good prospect for western Canada where iron ore deposits are extremely scarce.

Identification of Tetracalcium Alumina Ferrite

This seemed to the author the baffling part of the problem and he therefore considered first the feasibility of substituting quartz sand for clay, and using some other flux, but (for obvious reasons) nothing looked quite so good as the materials now in use. It was because these occurred in large deposits throughout the country that it had been possible to make and sell cement in large quantities at very moderate cost.

The possible use of iron was kept in mind, but on the other hand it was recalled that the Germans years ago by the substitution of iron ore for clay had produced a so-called iron-cement which was not very highly rated.

It had long been the author's opinion, however, that when iron and alumina were both present in a cement they were to a certain extent combined in the same lime-compound. So when confirmation of this view came through microscopic investigations by the Portland Cement Association, identifying the compound tetra-calcium alumina ferrite ($4CaO.\ Al_2O_3.\ Fe_2O_3$) in all the Portland cements examined, along with small amounts of $2CaO.\ Fe_2O_3$ and varying amounts of $3CaO.\ Al_2O_3$, it was determined to experiment and find out what could be done.

Experiments Leading to Alkali Resistant Cement

The work was begun at one of the company's eastern plants where there was available a quantity of cherty limestone which proved ideal for the production of a cement high in lime silicates but much lower than Portland cement in tri-calcium aluminate content. Since iron has a lower melting point than alumina, it seemed probable that the ternary compound of iron alumina and calcium would form first in the kiln, and that under proper conditions of well blended finely-pulverized mix and proper kiln conditions, an equilibrium of composition would be reached which would permit the desired compound to remain in combination until the whole clinkering process was completed. In brief, the theory was, that if the correct amount of iron were used, it would be possible to clinker what would otherwise be a very refractory high-silica lime mixture, *and to lock up the alumina, or most of it, in the tetra-calcium alumina ferrite,* which would form first in the kiln on account of its lower liquid formation temperature. Without any actual

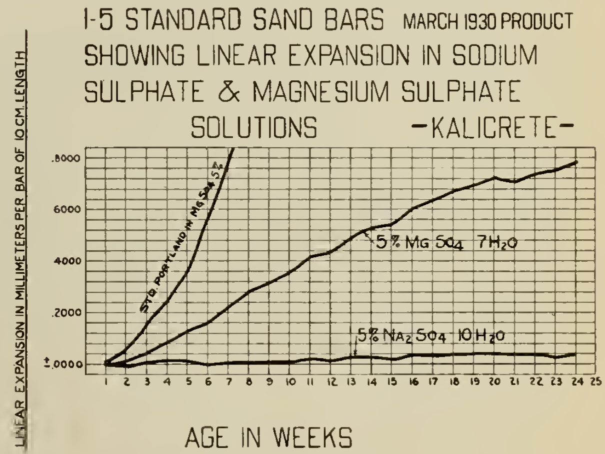


Fig. 6.*

proof of superior resistance, it was believed that this compound was likely to have greater stability than the tri-calcium aluminate had been proved to possess. At the same time this product would have better cementitious properties than the iron-cements, and would meet the requirements of present day specifications.

To verify this the author obtained the company's consent to arrange a trial run of a week's duration in March 1930, and samples of the resulting cement were sent at once to the University of Saskatchewan who seemed best equipped to pass on the durability of the product by their accelerated test methods.

The trial run samples proved to be very resistant to expansion in the lean mortar test bars immersed in sodium sulphate and magnesium sulphate solutions.

*See appendix p. 265.

In June 1931 it was arranged to make another experimental run at another of the company's plants, and this time Dr. Thorvaldson, having returned from Europe, was invited to be present. For this run there was some difficulty in securing a supply of iron, and the shale obtained for the test was not quite as high in silica as required. At Dr. Thorvaldson's request the mixes were varied to some extent in order to provide him with cement of compositions which he wished to study.

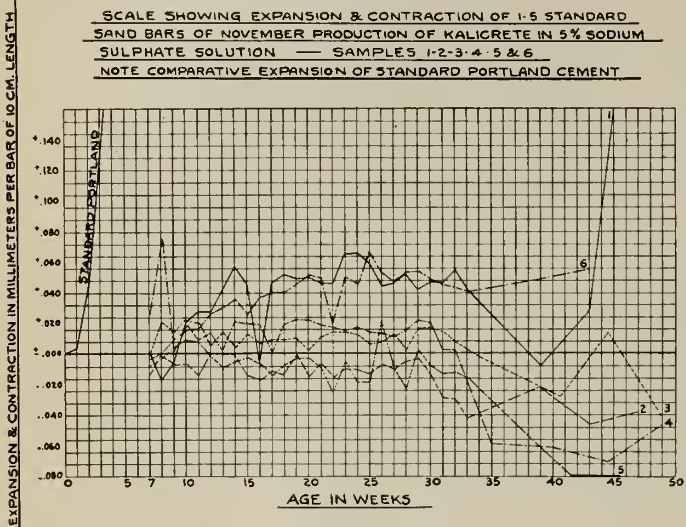


Fig. 7.*

This June 1931 product proved to be much more alkali-resistant than the normal Portland cement and was in demand in the fall and winter of 1931-32 for the construction of sewer pipe in the city of Saskatoon on the recommendation of the University of Saskatchewan.

Conditions of Production and Testing

Two production runs of this special type of cement, which has now been called "Kalicrete," have been made since June 1931, one in November 1931 and the other in 1932. For these two runs a shale of considerably higher silica and lower alumina content was used in the effort to increase the lime silicates to a maximum content and to reduce the tri-calcium aluminate content to a minimum.

Great care has been taken in each step of the manufacture in the drying, proportioning, blending and pulverization of the raw materials to obtain uniformity of composition and such intimacy of contact between the particles of the mixture that the right combinations will be developed in the ensuing process of burning.

The temperatures of burning are kept under control by the use of a Leeds-Northrup optical pyrometer. The raw materials and clinker are sampled and analysed at even more frequent intervals than is usual for the ordinary product as it is the hope of the company to improve the product with each successive run. Further, the University of Saskatchewan have been good enough to cooperate in testing the quality of all the product so far made. Many samples have been sent and examined by them for the relative durability of each day's production, to ascertain what influence any slight modification in the composition may have on its resistance to alkali sulphate waters.

The results of the expansion tests of the 1930-1931 product are shown in Figs. 5, 6, 7 and 8, and are discussed in the appendix.

The company's laboratories have been equipped with the moulds for making the test bars and the measuring apparatus devised by Dr. Thorvaldson for measuring their expansion. These bars are exposed in solutions of two concentrations of sodium and magnesium sulphate. The measuring apparatus is simply a micrometer head in a steel

Table I

Table Taken from Canadian Journal of Research.—Studies on the Action of Sulphates on Portland Cement by T. Thorvaldson, O. Wolochow and V. A. Vigfusson, 1929.—Results of Similar Tests by Canada Cement Co. on Nov. 1931 Run of Kalicrete for Comparison

Relative Expansion of Cement Mortars in Sulphate Solutions

Linear Exp. Per Cent in $0.15M.Na_2So_4$	Time in Days to Produce Given Expansion			
	St'd. Portland 127	St'd. Portland 326	St'd. Portland 826	Kalicrete
0.01	1	4	3	91
0.02	3	6	6	147
0.05	5	7	10	Per Cent of
0.10	6.5	8	14	Expansion at
0.20	7.5	9	20	357 days was
0.50	9	11	30	0.034
1.00	10.7	13	42	
In $0.15M.MgSo_4$				
0.01	1	2	1	
0.02	1	3.5	3	
0.05	3	5.5	7	
0.10	4	7	9	49
0.20	5	9	12	56
0.50	6.5	11	18	87
1.00	9.5	14	33	357

frame. (Fig. 3.) The micrometer is graduated to read 0.01 mm. The bars or prisms are approximately 10 cms. in length by 1.5 cms. square. Use is made of a mix of 1-5 standard sand and a mortar of normal consistency as calculated by formula from the neat consistency of the cement under test. In order to judge of the relative durability of the product parallel tests are run on standard Portland cement. The per cent of linear expansion in millimetres; the linear extension of the 10-centimetre bars and the time of exposure are given. Although in magnesium sulphate the expansion of the bars may continue until it has reached more than 3 millimetres or 3 per cent of the

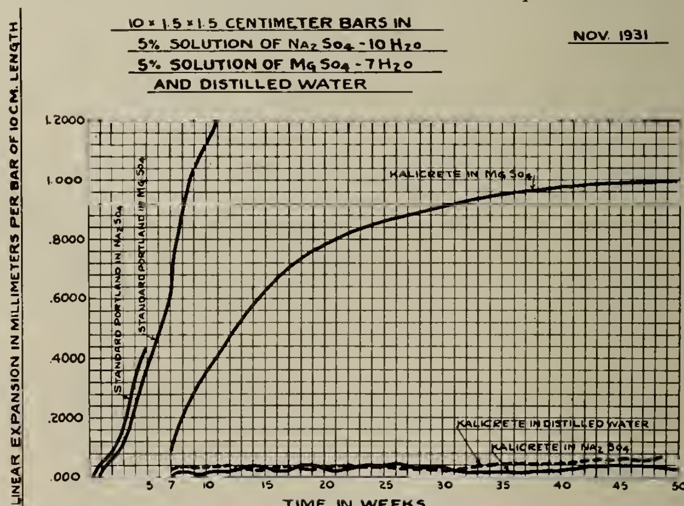


Fig. 8.*

original length of the bar, the relative time required to reach 1 millimetre in expansion is considered as the limit in comparing the resistances of the samples under test.

With the exception of the expansion tests shown in Table I all tests were made in the laboratory of the author's company. As indicated, other laboratories have been testing it by exposure tests made in different ways. The University of Saskatchewan have made some tests in 1-10 and 1-7½ bars and in other ways. The Portland Cement

*See appendix p. 266.

Table II

1-3 Compressive Strength of 2″ by 2″ Cubes of Kalicrete After Storing One Year in Tap Water, 5 Per Cent Solution of Sodium Sulphate and 5 Per Cent Solution of Magnesium Sulphate.

Sample of Original Product Made March 1930		Sample of Exshaw Product Made June 1931
Storage Solution	Compressive Strength Lbs. Per Sq. Inch	Compressive Strength Lbs. Per Sq. Inch
Tap Water..........	5125	6347
Magnesium Sulphate.	5625	5547
Sodium Sulphate.....	6119	6333

Association are using 3-inch by 6-inch specimens of concrete and measure the volume changes with the apparatus shown in Fig. 2. Mr. Blackie, city chemist of Winnipeg, is carrying on certain tests devised by himself. Mr. Brown, the western chemist of the Canada Cement Company, in addition to making Thorvaldson expansion bar tests on 1-5 specimens, has been trying to find a quicker method of determining the potential durability of a cement. Sooner or later some such test may be devised which will be an improvement on the present method.

Commercial Use of Alkali Resistant Cement

While Kalicrete is undoubtedly quite resistant to sodium sulphate waters and, compared to ordinary cement, quite resistant to magnesium sulphate, it is not foolproof. It would be a waste of money to use it in concrete that is not moderately rich and with good aggregates, well mixed and carefully placed, so that a dense watertight concrete will be obtained, capable of resisting the weather.

In recent years through research and observation much has been learned regarding the methods to be avoided and the procedure to be followed when structures are desired that will resist the deteriorating agencies of our northern climate. The research work of Abrams, MacMillan and Bogue and their staff in the Portland Cement Association and their contributions to the literature on the subject of good concrete have been of inestimable value as also has been the work of E. Viens, M.E.I.C., Director of Testing Laboratories, Public Works Department of Canada, R. B. Young, M.E.I.C., of the Ontario Hydro Electric Commission, Dean Mackenzie and Dr. T. Thorvaldson and colleagues of the University of Saskatchewan, to name some of the more notable of those who have spent years in the effort to develop knowledge that will guide those who build with concrete to build for permanence. In regard to the durability of concrete the paper contributed by R. B. Young in 1928 to The Engineering Institute of Canada* should be studied. Valuable information is contained also in the address given in 1932 by R. S. Phillips of the Portland Cement Association to the Lethbridge branch of The Institute† and in the paper presented before the American Society for Testing Materials in 1931 by Mr. E. Viens‡.

Appendix

Notes on Durability and other tests

Accelerated Durability Tests—Thorvaldson Method

Fig. 5 shows the results of expansion tests on the original alkali resistant cement of the March, 1930 production. 1-5 standard sand bars were tested in strong solutions of sodium and magnesium sulphate in separate solution and mixtures.

Expansion tests on 1-5 bars of standard Portland cement are shown for comparison. Standard Portland bars expanded 1.3 per cent in thirty days exposure in .5 mol sodium sulphate when the bars fell apart; they expanded less rapidly in .5 $MgSo_4$, but passed the one per cent line in sixty days. These bars did not disintegrate until they had reached an expansion of 4.4 per cent in one hundred and fifty-four days exposure.

The alkali resistant cement in bars in .5 mol sodium sulphate showed no expansion for twelve weeks. In the next twelve weeks it expanded about one-tenth of one per cent of the original length, and is still in perfect condition.

Magnesium sulphate and mixed solutions of sodium and magnesium sulphates in equal concentrations expanded these samples, causing one per cent expansion in fifteen to sixteen weeks as compared to eight and a half weeks required for the same expansion of the standard Portland bars.

Fig. 6 shows expansion tests on 1-5 standard sand bars made with the original alkali resistant cement of March, 1930 production in 5 per cent solutions of $MgSo_4. 7H_2O$ and 5 per cent $Na_2So_4. 10H_2O$. The bars have reached an average expansion of slightly less than eight-tenths of one per cent in twenty-five weeks exposure in magnesium sulphate.

1-5 standard Portland cement bars in the same solution reached the same expansion in seven weeks showing

*Vol. XXXVI, Transactions of The Institute, p. 90.
†Engineering Journal, Sept. 1932, p. 423.
‡Vol. XXXI, Proceedings of the American Society for Testing Materials.

Table III

Comparative Physical Properties of Kalicrete and Standard Portland Cement

Physical Test	Original Kalicrete Mar. 1930	Kalicrete Produced June 1931	Kalicrete Produced Nov. 1931	Kalicrete Produced July 1932	Plant No. 12 Standard Port. Cement	Plant No. 1 Standard Port. Cement
Fineness No. 200 Sieve......................	84 Per Cent	85 Per Cent	93.5 Per Cent	92.2 Per Cent	82 Per Cent	84.8 Per Cent
Setting Time—Initial......................	4°-05′	2°-40′	2°-17′	2°-50′	2°-45′	3°-26′
" " Final......................	7°-0′	5°-05′	4°-50′	5°-35′	4°-45′	5°-26′
Soundness—5 Hours—Steam	O K	O K	O K	O K	O K	O K
Tensile Strength 1-3 Briquettes						
Average 3 Days..........................	184	225	209	...	228	310
" 7 "	248	318	275	282	314	349
" 28 "	393	448	408	440	464	422
" 3 Months..........................	...	...	466	462	467	436
" 6 "	...	...	457	469	432	531
Compressive Strength 2″ by 2″ Cubes Mix 1-3						
Average 3 Days..........................	1237	1076	1311	972	1082	1907
" 7 "	1550	1876	2508	3053	1700	2393
" 28 "	2870	3550	4080	5379	2705	3353
" 6 Months..........................	....	....	4512	6300	3367	4300

Each Result Average of 9 Tests

that in magnesium sulphate of moderate concentration the relative resistance of the alkali resistant cement was at least three times the ordinary Portland.

In 5 per cent solution of sodium sulphate the alkali resistant cement showed scarcely any expansion, averaging less than four one-hundredths of one per cent in twenty-five weeks which is no greater than the usual moist air expansion.

Accelerated Durability Tests on Kalicrete, November 1931 Production

Fig. 7 is on an exaggerated scale and shows the expansion and contraction of 1-5 standard sand bars made

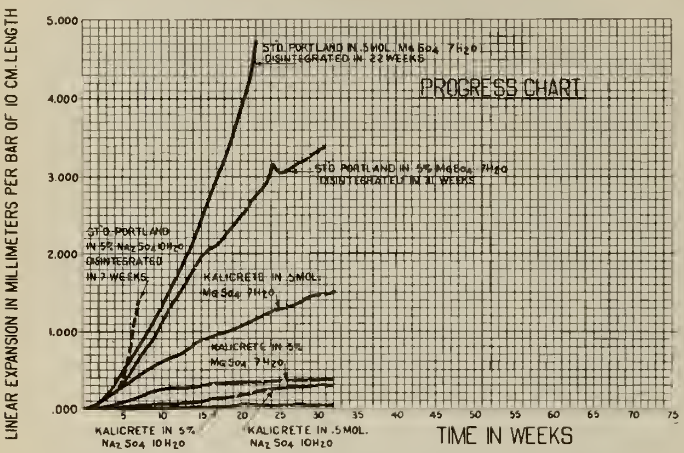


Fig. 9—Comparative Volume Change 1-5 Standard Sand Bars of Portland Cement and Kalicrete.

with alkali resistant cement of the November, 1931 production when placed in 5 per cent sodium sulphate solution.

The average daily samples of the run were tested individually, No. 1 apparently had some of the cement of usual composition, as it expanded fairly rapidly after the forty-third week, increasing in length to .15 per cent in forty-six weeks. The other samples showed slight contraction at many periods which might be attributed to slight variation in room temperatures at time of measurement.

In general sodium sulphate of 5 per cent strength has had no effect on these samples.

When placed in 5 per cent magnesium sulphate solution, the average expansion of thirty-six bars, six for each sample was .2 per cent in eight weeks, .8 per cent in twenty-one weeks when the curve tended to flatten out so that at fifty weeks it had about reached the one per cent expansion mark used as danger line.

In three and a half weeks the standard Portland had expanded .2 per cent and rapidly expanded to cross the one per cent line at eight weeks. On this basis, the resistance to magnesium sulphate of the Portland cement was one-eighth of the Kalicrete or the latter had eight times the resistance.

Fig. 8 shows only the average curve for 1-5 standard sand bars in sodium and magnesium sulphate solutions as contrasted with the behaviour of standard Portland.

Table I, taken from Canadian Journal of Research Studies on the "Action of Sulphates on Portland Cement" by T. Thorvaldson, O. Wolochow and V. G. Vigfusson, 1929, shows the time in days to produce given expansion in .15 mol sodium sulphate and .15 mol magnesium sulphate of three Portland cements tested in the University of Saskatchewan laboratory. For comparison is shown the time required to reach an equal expansion of the November 1931 Kalicrete in slightly stronger solutions.

Exshaw, July 1932—Kalicrete

In Fig. 9 is shown the comparative volume change up to a period of thirty-three weeks of 1-5 standard sand bars of Portland cement and Kalicrete of 1932 production in 5 per cent solutions of sodium sulphate and magnesium sulphate.

In sodium sulphate the bars of Portland cement mortar began to disintegrate at one per cent linear expansion. Several of the bars were sufficiently strong however to resist disintegration until they had increased, 1.3 millimetres or 1.3

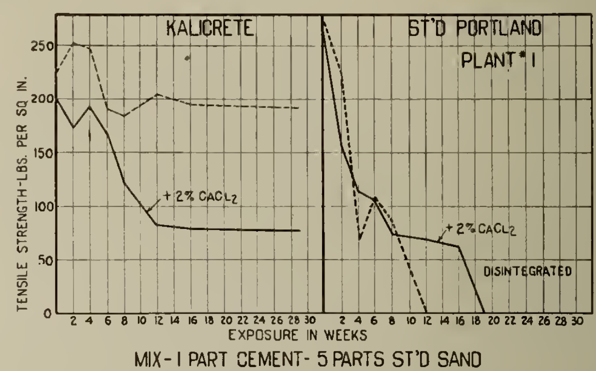


Fig. 10—Effect of Strong Solution of Magnesium Sulphate on Tensile Strength with and without 2 per cent Calcium Chloride. Briquettes Stored 14 days in Moist Air Before Immersion. (See Table V.)

per cent of their original length, average time required for disintegration being seven weeks. Kalicrete 1-5 bars in sodium sulphate of the same strength (5 per cent solution) increased in length about .04 per cent in eleven weeks and remained fairly constant at that length up to the last period of measurement.

The 5 per cent solution of magnesium sulphate although expanding the Portland cement bars nearly as rapidly as

Table IV

Average Composition, in Terms of Compounds, of Various Production Runs of Kalicrete in Sulphate Solution Expansion Tests—Standard Portland Used for Comparison

Constituent	Original Kalicrete Produced 1930	Kalicrete Produced June 1931	Kalicrete Produced Nov. 1931	Kalicrete Produced July 1932	Plant No. 12 Standard Port. Cement	Plant No. 1 Standard Port. Cement
Insoluble Residue	....	....	0.19 Per Cent	0.31 Per Cent	0.20 Per Cent	0.12 Per Cent
Free Lime—*CaO*	....	....	0.10 " "	0.01 " "	0.10 " "	....
Loss on Ignition	1.22 Per Cent	0.94 Per Cent	0.95 " "	0.76 " "	1.06 " "	1.12 " "
Magnesia	3.10 " "	2.56 " "	2.43 " "	2.03 " "	2.36 " "	3.10 " "
Compounds as Calculated from Chemical Analysis						
$C_3A = 3\,CaO.\ AL_2O_3$	4.90 Per Cent	7.97 Per Cent	3.98 Per Cent	3.24 Per Cent	12.48 Per Cent	12.46 Per Cent
$C_4AF = 4\,CaO.\ AL_2O_3.\ F_2O_3$	11.60 " "	13.09 " "	13.01 " "	12.95 " "	6.13 " "	7.87 " "
$C_3S = 3\,CaO.\ S_1O_2$	44.97 " "	42.57 " "	50.06 " "	42.39 " "	42.78 " "	52.02 " "
$C_2S = 2\,CaO.\ S_1O_2$	31.00 " "	30.51 " "	27.07 " "	35.98 " "	31.65 " "	19.59 " "
$CaSo_4$ = Gypsum-Anhy.	2.94 " "	2.12 " "	1.88 " "	2.17 " "	2.82 " "	3.28 " "
MgO	3.10 " "	2.56 " "	2.43 " "	2.03 " "	2.36 " "	3.10 " "
Merriman Sugar-Lime Disintegration Index	1.76 " "	No Test	1.68 " "	1.50 " "	6.46 " "	5.80 " "

the sodium sulphate solutions did not cause complete disintegration until over 3.3 millimetres or 3.3 per cent approximately had been added to their length thirty-one weeks after they were put into the solution.

The Portland cement bars expanded 0.4 per cent in approximately six weeks, while at thirty-two weeks the Kalicrete bars had not reached this expansion. Moreover the rate of expansion of the Kalicrete bars lessened considerably during the last ten weeks of exposure and the bars are now showing greater apparent resistance to the

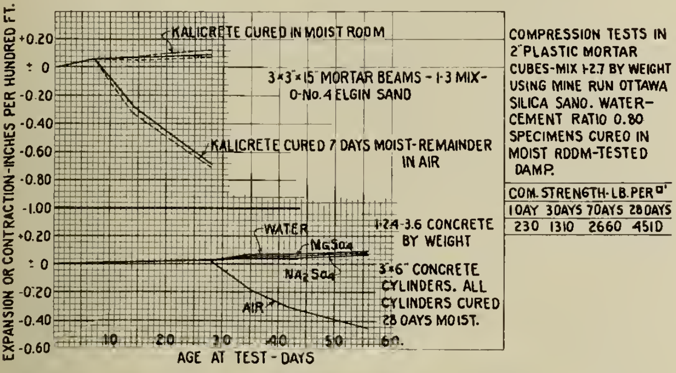


Fig. 11—Comparison of Expansion in Air-Water-*$MgSo_4$* and *Na_2So_4* Solutions on Sample of Kalicrete*.

action of the $MgSo_4$ solution than they did during the first weeks of exposure. On the basis of the time required to expand the 1-5 specimens of the two cements a given amount in length e.g., 0.38 per cent the comparative resistance of the Kalicrete to 5 per cent $MgSo_4$ is more than 6 to 1.

In properly made concrete of good density the relative resistance of the product would be without doubt considerably greater, but it is difficult to estimate how much more the difference of durability in the two products would amount to in time.

Fig. 9 shows a progress chart of the relative expansion of 1-5 standard sand mortar bars of standard Portland cement and Kalicrete in solutions of $Na_2So_4.10H_2O$ and $MgSo_4.7H_2O$ of two concentrations, namely 5 per cent. (50 grams of salt per litre) and 0.5 mol solutions 123 grams of $MgSo_4.7H_2O$ per litre, 161 grams of $Na_2So_4.10H_2O$ per litre.

The expansion of the standard Portland in the strong $MgSo_4.7H_2O$ solution reached one per cent in eight and a half weeks. The expansion of the Kalicrete in the solution was approximately one per cent in nineteen weeks and has reached 1.5 mms. or 1.5 per cent in thirty-two weeks. The standard Portland had expanded 1.5 per cent in eleven weeks and the 1-5 bars disintegrated in twenty-two weeks after expanding approximately 4.5 per cent as was expected. The strong $MgSo_4.7H_2O$ solution reacted more rapidly on the 1-5 bars of both cements and the difference in resistivity of the two cements to this solution was less marked. The ratio of relative resistance Kalicrete to standard Portland as measured by the time interval required to reach a given expansion is apparently only about 2½-1 as compared to the relative resistance of 6-1 in the 5 per cent $MgSo_4.7H_2O$ solution.

No tests were made in strong $Na_2So_4.10H_2O$ of the 1-5 standard Portland bars, but in order to determine if the .5 mol $Na_2So_4.10H_2O$ solution would react on the 1-5 bars of Kalicrete found to be more or less immune to 5 per cent solutions of this salt several samples of Kalicrete are being exposed in solution of each strength. In thirty-two weeks time the expansion of the Kalicrete bars is approximately 0.3 per cent while in the 5 per cent solution it is only 0.02 per cent.

*Tests by Research Laboratory, Portland Cement Association, Chicago, by Humboldt Measuring Apparatus.

Comparative Effect of Strong Magnesium Sulphate Solution (.5 mol) on the tensile strength of 1-5 standard sand mortars of normal consistency made with Kalicrete and with standard Portland cement. Also the effect of 2 per cent calcium chloride added as an admixture.

Table V gives average tensile strength in pounds per square inch of 1-5 briquettes at various periods.

All specimens exposed to $MgSo_4.7H_2O$ two weeks after molding.

Merriman Wheel for Use in Sugar Lime Test of Durability of Cement

Mr. Thaddeus Merriman, in an article entitled "Durability of Portland Cement,"* has given data of tests covering the comparative solubility of some thirty-two different cements in sugar lime solution which indicated that the solubility of the lime from the cement in this solution parallels the disintegration of the cement in sodium sulphate solution. Data were also given indicating that the resistance of the cement to sulphate solution is inversely as the amount of alumina in the cement. (See Fig. 4 and Table IV.)

It will be noted from this that Kalicrete has a very low sugar lime disintegration index.

Table V

Period of Exposure in .5 *M.* $MgSo_4$	Kalicrete		Standard Portland	
	Without $CaCl_2$	2 per cent $CaCl_2$	Without $CaCl_2$	2 per cent $CaCl_2$
Initial strength at time of immersion........	225	200	273	270
After two weeks exposure...........	252	172	222	157
After four weeks exposure...........	249	193	107	115
After six weeks exposure...........	190	166	97	108
After eight weeks exposure...........	184	122	104	75
After twelve weeks exposure...........	202	82	disintegrated	70
After sixteen weeks exposure...........	196	80	...	62
After twenty-nine weeks exposure...........	192	77	...	...

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*Engineering News Record, January 9th, 1930.

Discussion on Papers on Chats Falls Power Development[1]

General Professional Meeting, Ottawa, February 8th, 1933

In opening the discussions the chairman remarked that the papers which had been presented formed a series dealing with the various aspects of the Chats Falls development, and it would be desirable, as far as possible, to discuss them together. Dr. Hogg's paper was a general description of the development and the organization for its execution. Colonel Trotter and Mr. Dick followed with a paper covering the construction features. The testing engineers, Mr. Floyd and Mr. Traill, described the tests of the equipment after it was placed in service. Mr. Holden treated of the various elements of the hydraulic and mechanical design, and Mr. E. T. J. Brandon described the electrical features of the development, the five papers giving a comprehensive view of the entire project.

In view of the difficulties attaching to developments on the international or interprovincial sections of rivers he found it very gratifying that Canadians had been able to carry out so effectively this development at Chats Falls in which both Ontario and Quebec were concerned.

The Ottawa River from Lake Temiskaming to the Lake of the Two Mountains had a potential horse power of over two million, which was divided among ten sites. This huge amount of water could be readily developed to meet necessary market demands.

J. T. Farmer, M.E.I.C.[2]

Dr. Hogg had stated in his paper that one of the causes of delay in the development at Chats Falls was the complication due to the previous charter for the Georgian Bay Ship Canal. Mr. Farmer would inquire whether any provision had been made for the future protection of navigation on the Ottawa river.

Dr. T. H. Hogg, M.E.I.C.[3]

Dr. Hogg replied that the charter of the Montreal, Ottawa and Georgian Bay Canal Company lapsed in 1927. If that were not so he doubted whether the Chats Falls development would be in existence to-day.

Plans of the development, of course, had to be submitted under the Navigable Waters Protection Act, to the Federal government for approval, after being approved of by each provincial government. Approval was subject to certain stipulations with reference to protection of power and navigation. Provision is made in the undertakings to care for future navigation works.

W. G. Chace, M.E.I.C.[4]

Mr. Chace asked if Dr. Hogg would give his sluice formula, as there was considerable variety of opinion on this subject.

Would Dr. Hogg also give information regarding the choice of large sluice gates as compared with the multiple unit log system, which appeared to be related to the question of changes in elevation due to the flood flow of the river. In Mr. Chace's opinion it was desirable to avoid large openings in the concrete sluiceways, especially in smaller plants.

Dr. T. H. Hogg, M.E.I.C.

Dr. Hogg stated that conditions at Chats Falls were rather difficult in that the rapids extended for a mile below the outlet of Chats Lake and would, in times of flood, control the discharge to a considerable degree. At such times it will be necessary to lower the forebay level in order that a sufficient fall will occur through the constricted channel between lake and forebay, to discharge the flood waters without raising the lake above its natural level. It becomes necessary, therefore, to take full advantage of the long crest at the falls by using a great number of stop-log sluiceways (seventy-four in all), in order that the flow may be spread over the whole width of the river. The concentration of the flow at a few large sluiceways, on the other hand, would involve serious hydraulic losses at a time when the head on the plant is already greatly reduced by the lowered forebay and high tailwater levels.

The stop-log sluices are used to discharge flood waters when the river flow is considerably above normal. To provide for quick forebay level regulation and to maintain a constant flow downstream from the plant, four sluiceways, with electrically operated gates, are located adjacent to the power house. The stop-log sluices thus provide the requisite discharging capacity to cope with large variations that occur in May, June and July, while the sluice gates enable close regulation of water level and discharge to be made.

J. W. Lucas, Jr.E.I.C.[5]

Mr. Lucas remarked on the interesting fact that at Chats Falls concrete was carried in continuous lifts from the rock foundations to the finished level without horizontal joints. This had successfully prevented any leakage in the breast walls and dams, a point which was often one of considerable difficulty.

He would ask by what method control of the concrete mixers was maintained, as he was interested in mixers operated electrically.

Dr. T. H. Hogg, M.E.I.C.

Dr. Hogg replied that the method of concrete control was covered in full detail in a paper by Colonel H. L. Trotter, M.E.I.C., and Wilfred Schnarr, entitled "Concreting Problems, Chats Falls Power Development," which was published in the Journal of the American Concrete Institute, February 1933. The matter, therefore, was not covered in this series of papers.

A. Aeberli, M.E.I.C.[6]

Referring to the paper by Messrs. Trotter and Dick, Mr. Aeberli observed that a feature of unusual interest in the Chats Falls plant was the placing of concrete surrounding the turbine parts. This work was carried out during zero and sub-zero weather, and with very simple conveying machinery. The construction joints were placed in a rather unconventional position, and it was feared from a mechanical point of view that distortion of embedded parts might be experienced as a result of the

[1] "General Description of the Chats Falls Development and Organization for Construction" by Dr. T. H. Hogg, M.E.I.C., published in the February, 1933, issue of The Journal;
"Construction Features of the Chats Falls Development" by H. L. Trotter, M.E.I.C., and James Dick, A.M.E.I.C., published in the February, 1933, issue of The Journal;
"Electrical and Hydraulic Tests at the Chats Falls Development" by G. D. Floyd, and J. J. Traill, M.E.I.C., published in the March, 1933, issue of The Journal;
"Hydraulic Design—Chats Falls Development" by O. Holden, A.M.E.I.C., published in the February, 1933, issue of The Journal;
"The Electrical Design of the Chats Falls Development" by E. T. J. Brandon, A.M.E.I.C., published in the March, 1933, issue of The Journal.
These five papers were presented at the General Professional Meeting of The Engineering Institute of Canada, in Ottawa on February 8th, 1933.

[2] Ste. Anne de Bellevue, Que.

[3] Chief Hydraulic Engineer, Hydro-Electric Power Commission of Ontario, Toronto, Ont.

[4] 65 Pleasant Blvd., Toronto, Ont.

[5] Testing Laboratories, Department of Public Works, Ottawa, Ont.

[6] Mechanical Engineer, Hydro-Electric Power Commission of Ontario, Toronto, Ont.

method adopted. Careful inspection of the embedded parts was made during the placing of concrete and while indications of movement were detected during the progress of the work, on completion the alignment was found to be satisfactory.

The tightness of the pressure casings and the smooth running of the machines, as well as all auxiliaries, under all kinds of operating conditions, vouched sufficiently for the successful execution of this rather extensive development.

On many occasions during the early days, Mr. Aeberli had prepared preliminary estimates and layouts on various proposals suggested for the Chats Falls power scheme, but none even approached the output of one machine as now installed. A rather striking illustration of this progress was the comparison between this new development of eight 28,000 h.p. and the ones located around the Chaudiere dam above the city of Ottawa, where, only a few years ago, a 7,200 h.p. turbine was considered a mammoth amongst the gathering of small horizontal types of open flume turbines.

In regard to the paper by Messrs. Floyd and Traill, Mr. Aeberli had noted that the electrical tests were made to check the correctness and insulation of wiring and adjustments of equipment that had been erected in the field, etc.

Where a number of similar machines are made from the same design and pattern, and manufactured in the same shop, one would naturally expect similar performance in operation. Experience, however, differed in regard to this. It would therefore seem necessary that tests be carried out on every machine, in order to actually check up the reliability of workmanship on machines where so many factors are involved.

He had opportunities of observing many hydraulic tests of various kinds, and was convinced that the Gibson hydraulic test method was applicable to any water power plant where the physical dimensions of pressure conduit can be measured, and where the water flow can be closed off reasonably tight. The degree of accuracy of such tests was, however, a matter that required further investigation as time went on. By careful preparation, Mr. Traill had succeeded in obtaining consistent results with this method for several low-head plants, for which even the inventor hesitated to recommend it.

Water measurements made on turbines of such magnitude as described in the paper, should not be compared with tests made in laboratories. A reasonable tolerance is thus desirable to take care of unknown factors.

The test points as given in the performance curves of gate-discharge-relation for the three distribution supply pipes were exceedingly interesting, and would indicate that the diagrams obtained by the Gibson method clearly demonstrate the relation of maximum efficiency to power output, which was apparently at slightly over 90 per cent load.

Referring to the degree of accuracy of tests on hydraulic turbines, it had been sufficiently demonstrated by repeated tests that such results can only be accepted as relative and are valuable for the purpose of operation. Viewing it from this angle it seems that any simpler method for obtaining approximate results could be accepted in general. It is well known that the velocity coefficient

$$C = \frac{V}{\sqrt{2gH}}$$

through an orifice is nearly constant for similar types of orifices. This accepted law should also be true for such orifices as are used in hydraulic turbines (gates and runners). In this respect it might be stated that generally the area of the runner vent, or exit bucket area, is equal to the area of gate at the opening of best performance.

Mr. Aeberli pointed out that for turbines of equal specific speed, this coefficient C varied very little, but increased slightly with reduced gate. The coefficient could be established from field tests, or on a model runner in the testing flume. It could then be applied to the full size installation, and by careful measuring of gate area for given servomotor stroke, the amount of water for a given load could be quickly calculated. In this way the general performance of a turbine could be obtained, and check results could be made quickly at any time. He had tried this method often and found it of some merit.

E. E. Carpenter, M.E.I.C.[7]

One item on which Mr. Carpenter would like to hear some discussion was the provision of vertical contraction joints in the power house structure at right angles to the axis of the building.

From the description given in the paper on the construction features it appeared that vertical construction joints, located midway between the centre lines of units, were carried from the rock foundation up to the level of the bottom of scroll case. From this latter elevation to the generator floor level the construction joint was located at the centre line of units. From this arrangement of construction joints he would infer that they were not considered as contraction joints and that it was not the intention to provide contraction joints in the substructure of the power house. Mr. Carpenter did not suggest that such joints were necessary but merely wished to bring out the thought of the designer in regard thereto. In the case of the Ruskin power house of the British Columbia Power Corporation, completed some two years ago, no contraction joints were provided either in the substructure or the superstructure. This building was 172 feet in length and showed no objectionable cracking. No cracks were evident in the substructure. In the superstructure a few hair-line cracks could be found, generally extending diagonally out from the corners of the windows.

He noted that in the Chats Falls power house, contraction joints were provided through the concrete and the steel work at 62-foot centres, the curtain wall surrounding each window being separated from the pilaster by a construction joint. He wished to inquire as to the location of the contraction joint with respect to the centre line of units and whether such joints were extended through the roof slab.

R. E. Heartz, A.M.E.I.C.[8]

The paper on "Construction Features of the Chats Falls Development" was considered by Mr. Heartz to contain a great amount of useful information, but many details of interest had necessarily been omitted.

One of the unusual features of the development had been the concreting of main dam and intake section in one continuous pour from rock foundations to finished level. This procedure eliminated the leakage which was sometimes found in horizontal joints when care was not taken, but only at the cost of greater difficulty in construction. Building the headworks 55 feet high above the intake floor, by continuous pouring in sections 20 feet wide, must have required much heavier bracing than was usually built; it involved great difficulty in placing and supporting reinforcing steel with long outstanding ends, and in pouring concrete. There was also a new danger from cracks caused by settlement of form work and from shrinkage at the junction of horizontal and vertical surfaces. The usual method of construction in lifts some 6 to 10 feet apart, was simpler and more flexible in every way; a little care would

[7] Consulting Engineer, B.C. Electric Railway Company, Ltd., Vancouver, B.C.

[8] Power Engineering Company, Montreal.

insure against leaks at horizontal joints, even in vital portions like thin intake head walls, as had often been proved.

A further point of unusual interest was the procedure of placing the turbine stay vanes, the upper stay ring and the pit liner during the early stages of construction, for concreting at the same time as the scroll case. The difficulty of bracing these parts, especially when subdivided to bring them within the capacity of construction equipment, and the danger of possible misalignment must have been great. The usual and easier method of leaving checks in the concrete, in which the various embedded parts are quickly and cheaply placed by the powerhouse crane, had been perfectly satisfactory on a large number of major projects. Conditions were then ideal for securing proper alignment with little bracing while these parts were being grouted.

The reasons for these variations at Chats Falls from accepted practice were not apparent from the information available and all of those interested in hydro-electric work would appreciate further details.

H. L. Trotter, M.E.I.C., and James Dick, A.M.E.I.C.[9]

The authors in reply to Mr. Carpenter observed that the construction joints in the substructure of the Chats Falls power house were not intended to act as contraction joints. In fact, in every case the reinforcing steel was placed continuous, or was lapped, across the construction joints.

No cracks had appeared in the substructure, and it had been the experience in other buildings of this type that the continuously reinforced method was the best.

In the superstructure the pilasters were built first, up to the level of the tops of windows; next the window frames were placed, and the panels surrounding them on side and bottom were concreted to the tops of windows.

At this level double corrugated plates of copper were laid in the wall over the pilasters to provide a sliding joint and prevent the diagonal cracking from the corners of the windows. The wall from top of window to roof was then built in 62-foot lengths, which corresponded with the spacing of the expansion joints in the steel frame of the building. The joints between the sections of wall thus built were made as contraction joints, with a special design of water stop to prevent the passing of rain during storms. This contraction joint also extended through the roof slab.

They agreed with Mr. Heartz that more detail in the paper would have been of interest and in answer to his inquiry stated that experience on a number of hydro-electric developments in the past had shown that horizontal joints could often be made watertight; but that in spite of keys, stops, and vigilant supervision, such joints frequently showed leakage.

In the dam at Chats Falls the area inside the forms had been sufficient to make the rate of rise of the concrete in the forms quite slow up to an elevation about ten feet from the top, after which part of the mixer output was diverted elsewhere. Thus there had been no unusual pressure on the forms, and continuous placing simply saved the delay consequent on preparing an old surface for concrete, and eliminated the risk of leakage.

In constructing the headworks piers it had been necessary to build the forms to the full height to secure perfect alignment and centering. The forms being in place simplified the supporting of reinforcing steel and gate guides and anchors in their proper place.

The danger of cracks caused by the settlement from shrinkage at the junction of horizontal and vertical walls had been foreseen, and a delay in placing was arranged at each of these points. The rate of placing had been about five feet per hour on account of physical conditions; and at this rate the strain on the forms did not call for any unusual bracing.

Regarding the method of placing the speed ring and pit liner, it had been recognized that this was a matter of expediency, and in some cases of preference on the part of the engineers. The authors had had experience with both methods, and were inclined to favour that of placing the embedded parts as the work proceeded.

In this case the separate vanes were erected first. Then the stay ring was bolted on, making it into a rigid unit. Inside the stay ring was placed a steel frame, in the nature of a head cover, to insure against distortion during the placing of concrete. The cast iron pit ring was then bolted on above.

A small gap was left between the stay ring and the scroll case form, which prevented direct lateral pressure on the speed ring during placing of concrete.

E. V. Caton, M.E.I.C.[10]

Mr. Floyd had referred to the method of using the auxiliary exciter as a means for speed determinations instead of the chronograph, and in Mr. Caton's opinion this should be of great use. At Winnipeg a set of special chronometers had been tried without success and the computations involved were very tedious. He would be glad to have Mr. Floyd's opinion as to the limits within which this method could be used.

G. D. Floyd.[11]

Mr. Floyd in reply stated that this was the first time he had used the auxiliary exciter as a tachometer, and the results proved very interesting. The only precaution that appeared to be necessary was to measure time intervals accurately and maintain constant field current. An ordinary stop watch had been used. This method of speed measurement could be improved now that it is known to be fundamentally sound. The range of speed as shown on the curves was from 132 to 118. They had made the test over a small range as they were interested in the losses at synchronous speed only.

He had not given details regarding the measurement of losses by retardation as this would have involved considerable detail and increased the length of the paper; the actual procedure had been fully described in a recent paper[⊗] by J. P. Fraser, A.M.E.I.C.

E. G. Cullwick, Jr.E.I.C.[12]

As an electrical engineer who had no claim to being a hydraulic expert, Mr. Cullwick was sorry that Messrs. Floyd and Traill had dismissed the theory of the interesting Gibson time-pressure of velocity measurement so briefly. He would be glad to have further information on one or two points about it.

Consider two normal sections of a penstock, of uniform cross-section, distant S from each other. If the penstock is not horizontal the pressure at the two sections will not be the same, due to the difference in head and wall friction. Consider a tube of flow of small cross-sectional area δa when the valve is closed at time T: at any time t after the valve has commenced to close let the pressure on the up-stream end of the elementary tube be p_1 greater than the pressure when the valve is open, and let the pressure on the down-stream end be p_2 greater than its normal value.

(9) Trotter and Cate, Consulting Engineers, Montreal.
Vice-President, Morrow and Beatty Co. Ltd., Peterborough, Ont.

(10) Winnipeg Electric Railway Company, Winnipeg, Man.

(11) Testing Engineer, Hydro-Electric Power Commission of Ontario Laboratories, Toronto, Ont.

⊗ Tests of Generators at Seven Sisters Development, Engineering Journal, September 1932, p. 427.

(12) Assistant Professor of Electrical Engineering, University of British Columbia, Vancouver, B.C.

Then it is the difference between these pressures, $(p_2 - p_1)$, which retards a mass of water of volume $S\ \delta a$. If the velocity of flow along the tube at $t = 0$ (when the valve commences to close) is V, and that at time T (when the valve closes) is U, we have:

$$\int_0^T (p_2 - p_1)\ \delta a\ dt = \rho S\ \delta a\ (V - U)$$

where ρ is the density of water,

or:

$$\int_0^T (p_2 - p_1)\ dt = \rho S\ (V - U)$$

If piezometer openings are arranged at each end of the elementary tube the value of the left-hand side of this equation can be obtained as described in the paper, and hence the change in velocity can be found. The velocity of flow across the section of the penstock is not, however, uniform and it would appear that if piezometer openings are arranged, as described in these tests, in the walls of the penstock the result will give the velocity along the surface of these walls, which is less than that at any other part of a cross-section. It would therefore appear that, if no correction is made for this fact, the efficiency of the turbine as calculated will be too high. Also, the penstock is so short that the velocity distribution over a cross-section would appear to be highly conjectural and hence a correction factor difficult to determine.

Again, suppose the cross-sectional area at the upstream end of the test section is greater than that at the downstream end: it is the difference between the total forces (due to the valve closing) which brings the volume of water to rest, and the actual pressure at the up-stream end will be less than its value when the area is uniform. This would result in the calculated change of velocity being too high, and the authors did not state whether the 18 foot length was of uniform section.

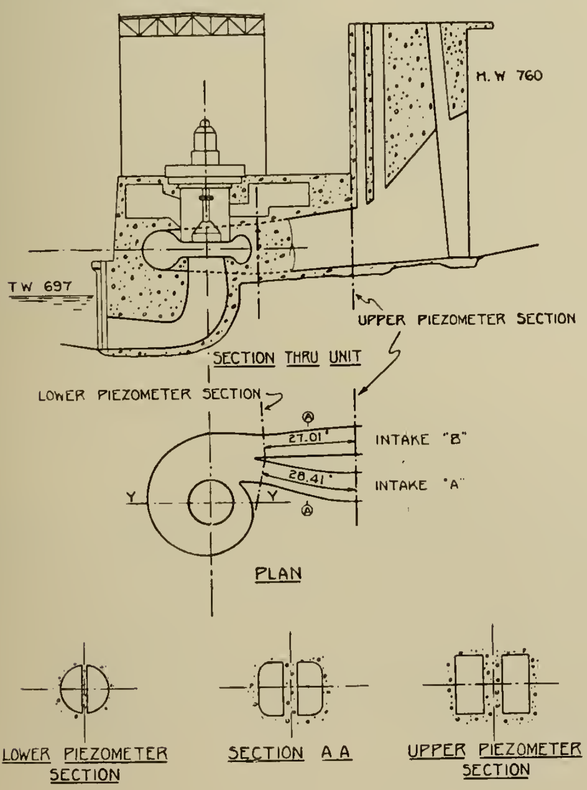

Fig. 11.

In efficiency tests on the 44,000 kv.-a. unit in the Ruskin plant of the British Columbia Electric Railway Co. the velocity of flow was determined by the "salt velocity" method, brine being injected at one point of the penstock and the time taken for it to reach a point at a definite distance downstream found by means of a graphical record of the conductivity of the water. Mr. Cullwick would ask if the authors had any data giving the comparative merits of the two methods.

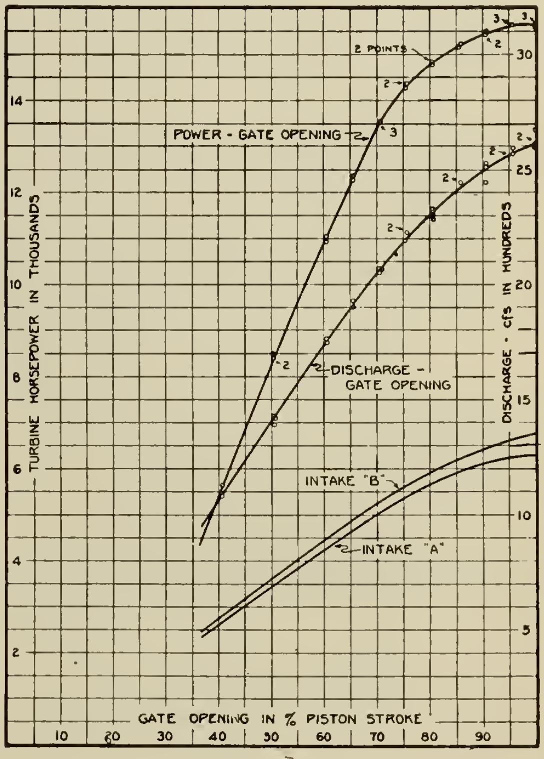

Fig. 12.

E. B. Strowger[13]

Mr. Strowger remarked that the Chats Falls plant presented at least two conditions which made the water measurement tests of special interest. These were (1) the short length of penstock together with low penstock velocity and (2) the division of the intake into three parts.

The first condition provided a relatively small impulse available for measurement by the Gibson diagram produced by closing the turbine gates and consequently resulted in a relatively small diagram. Although this diagram accurately measured the impulse produced, the variable errors of delineation and measurement became relatively large. To obtain as large a diagram as possible in such a case a sensitive manometer gauge should of course be used. Such a gauge would have a large riser, say two inches in diameter, and a small glass tube say about 3/16 inch in diameter. Mr. Traill had gone one step farther by replacing the mercury, the usual gauge medium, with acetylene tetrabromide, a liquid of lower specific gravity. Mr. Strowger had just recently experimented with the use of this liquid coloured red with Sudan III on some tests involving a twelve-inch experimental pipe line. Like the author, he had found that this liquid tended to adhere to the glass tube and finally discarded it in favour of mercury. However, further experiments would doubtless result in finding a medium of low specific gravity which would be suitable.

Several tests with satisfactory results had been made under his direction involving low values of impulse due either to short penstock lengths or low velocities or both. Among these, he would mention two which would probably be of interest in connection with this paper.

Fig. 11 showed a cross section of Station W and a plan of the water passages from which it would be noted

[13] Buffalo Niagara and Eastern Power Corporation, Buffalo, N.Y.

that the length of penstock utilized was about 27.7 feet. The penstock was divided into two parts and each part varied in shape from a rectangular section near the upper piezometers to a semi-circular section at the lower piezometers. The results of the test are shown on Fig. 12.

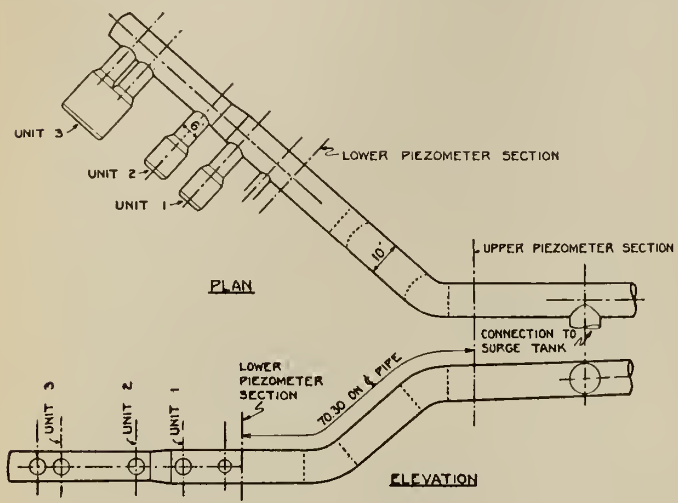

Fig. 13.

The impulse measured by the Gibson diagram at full gate was about 8.7 foot seconds which compared with an estimated value of the impulse measured at Chats Falls of approximately

$$\frac{18 \times 4}{32.2} = 2.2 \text{ foot seconds.}$$

The second test referred to was that on Station D, the hydraulic layout of which was shown on Fig. 13. In this

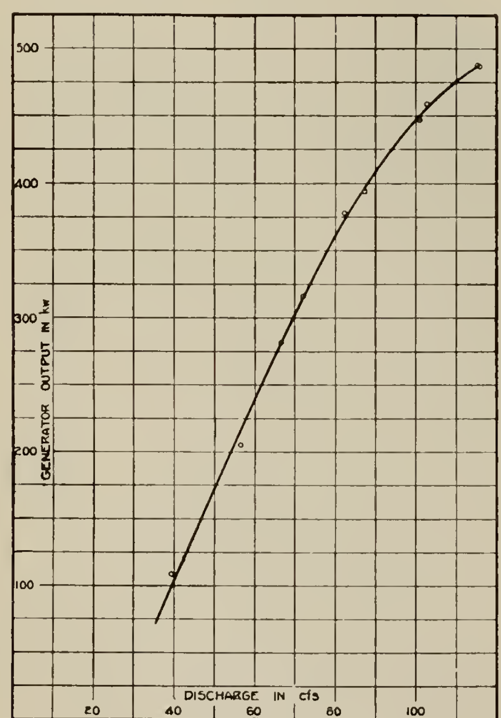

Fig. 14.

case, the length of penstock utilized was 70.30 feet, and the velocity at full gate 1.49 feet per second, making the impulse to be measured at full gate 3.3 foot seconds. The area of the diagram at full load amounted to only about two square inches. The diagrams, as in the case of Chats Falls, required special means of determining the end. Due to certain local limitations the governor timing was relatively slow and the end of diagram was taken on an "afterwave" well beyond the body of the diagram.

Fig. 14 showed the power-discharge relation of unit No. 2 at Station D. It should be noted that although the length of penstock used at this station 70.3 feet compared with 18 feet at Chats Falls, the full gate velocity at Station D was only 1.49 feet per second. This meant that for the same impulse, the velocity at Chats Falls would be about

$$\frac{70.30}{18.0} \times 1.489 = 5.8 \text{ feet per second.}$$

It would be of interest to examine the distribution of the flow in the various intakes of Figs. 7 and 11. Mr. Traill had informed him that the right hand intake of Fig. 7 looking downstream is the intake designated A in Fig. 9, the centre intake is the one labelled B and the left hand intake is intake C. Fig. 9 indicated that a slightly greater quantity of water flowed down the intake passage leading to the small end of the scroll than in the other intakes. This suggested moving the "baffle point" of the scroll around the centre line of the unit in order to make intake A discharge more water, and thus effect a better pressure distribution around the distributor of the runner.

Referring to Figs. 11 and 12, if the baffle were moved slightly toward the indicated centre line Y-Y of the turbine, the distribution of flow in the two intakes would become

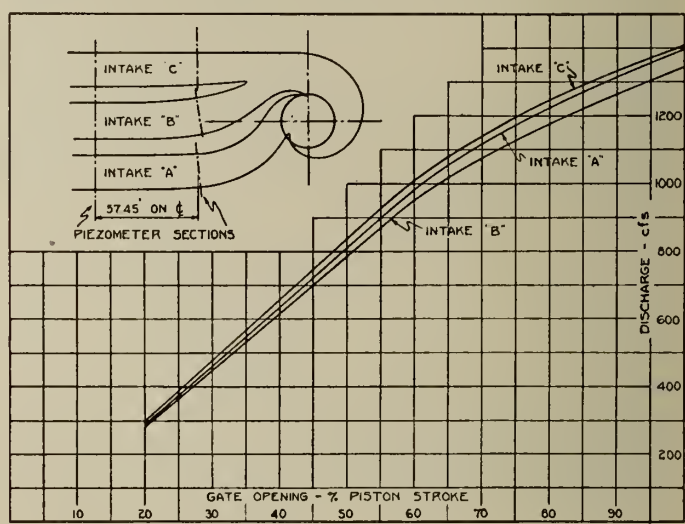

Fig. 15.

more nearly equal and a smaller pressure drop would exist to the small end of the scroll, resulting again in a more uniform pressure around the guide case of the runner and therefore a better hydraulic balance.

Figs. 15 and 16 gave the distribution in two more stations, which might be referred to as Stations WD and C respectively. Each of these stations had three intake passages. The curves shown are results of a Gibson test with simultaneous measurements made on each intake by using three sets of apparatus. The distribution in the case of Station WD was remarkably uniform, but in the case of Station C the results indicated that it would be better to have had the baffle point moved toward the centre line labelled X – X.

J. J. Traill, M.E.I.C.[14]

Mr. Traill stated that Mr. Cullwick appeared to assume that the pressure in a cross-section of the pipe varies from point to point with the velocity. Experimental investiga-

[14] Engineer of Tests, Hydraulic Dept., Hydro-Electric Power Commission of Ontario, Toronto, Ont.

tions have shown quite definitely that the pressure does not vary in this way. The pressure-time diagram obtained by a connection to one point on the wall of the pipe is thus exactly the same as that which would be obtained were it possible to carry the connection to the centre of the pipe, or any other point.* No factor, such as Mr. Cullwick suggests as necessary, is required to correct for the fact that the pressure measurements are made at the wall of the pipe in a region of low velocity. While tests have indicated that a single connection to a cross-section is all that is necessary, it has been the practice on short, large penstocks to use four connections per cross-section, as was done at Chats Falls.

In cases where a differential application of the method is made, the pipe need not be of uniform cross-section. Proper allowance is made for the variations in cross-sectional area, in computing the pipe factor.

The tests at Station D, described in Mr. Strowger's discussion, were of interest, as, while there is a considerable length of penstock, the velocities are so low that it was necessary to contend with difficulties quite comparable with those at Chats Falls, so far as the size of the Gibson diagrams is concerned. The consistency of the results shown in Fig. 14 is very satisfactory.

Dean E. Brown, M.E.I.C.[15]

Dean Brown believed that all engineers who had experience in testing models of turbines, or large units, realized the great difficulties in obtaining dependable results, and thought that in view of the special difficulties in

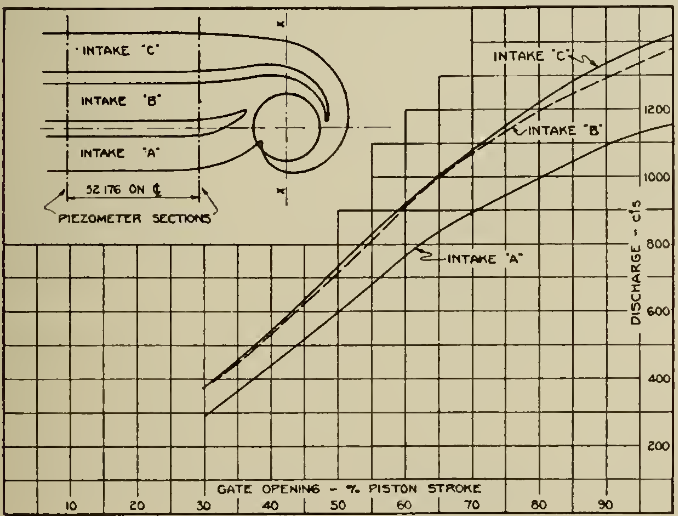

Fig. 16.

lowhead units, the authors were to be commended for their attempt to use the Gibson method. He suggested the possibility of floating a small aluminum disc or cylinder between the water and acetylene tetra-bromide solution in an endeavour to obtain a more definite boundary of the pressure-time curve.

The authors referred to the consistent results of tests made at the Alexander power development. Was this consistency between different tests using one method, or between the results of tests using different methods?

He had had some experience in using the current meter method, and believed it well suited for low head conditions. It is to be used in testing the 42,500 h.p. Kaplan turbines installed recently at Safe Harbour. It is recognized that results of such tests are not likely to be accurate within one or two per cent. Probably such a degree of accuracy is applicable to any method of testing in low head plants. The current meter method, although used almost solely in Europe, has not yet been widely used on this continent. Special forms of current meters and recording devices have been developed, and the method offers certain advantages over the Gibson or salt velocity methods in the case of low head plants.

E. V. Caton, M.E.I.C.

Mr. Caton referred to the heating of the sluicegates at the Winnipeg city plant where fairly good success had been obtained with air blowers or even electric lamps placed along the top of the wall. Considerable difficulties were experienced there due to the intense cold and high winds during the winter months. He would ask if any provision had been made at Chats Falls in connection with ice thrust or if any trouble had been experienced.

O. Holden, A.M.E.I.C.[16]

Mr. Holden replied that provision had been made for the protection of the gates against ice thrust by the addition of a heavy girder near the top of each gate. The shape of the forebay was such that extensive ice thrust is not likely to develop. The dam was designed with an allowance for ice thrust on both the bulkhead section and sluiceway section of 5,000 pounds per lineal foot.

C. G. Moon, A.M.E.I.C.[17]

With reference to Mr. Holden's paper Mr. Moon asked for information on the method of heating the sluice gates and rollers to prevent ice forming.

O. Holden, A.M.E.I.C.

The author stated that to heat the gates themselves, the downstream side of the gate is enclosed by a timber diaphragm. Inside electrical space heaters are provided and openings in the girders with the necessary draught pipes distribute the heat to the areas most likely to require it. Care is taken to get heat to the water line and to each end of the gates.

The other part of the heating apparatus consisted of electric strip heaters in spaces provided in the steel gate checks—one located at the upstream side and the other at the downstream side. These heaters are kept in service as required throughout the season.

F. Newell, M.E.I.C.[18]

Mr. Newell remarked that through the kindness of the Hydro-Electric Commission heating test experiments had been made on the gates at Chats Falls. Various ideas had been obtained as to the best method of heating the gates and two different schemes were tried out—one by artificial circulation and the other by natural circulation, and in his opinion the natural circulation was the better method, though perhaps Mr. Holden might think differently. It was found that by placing the heaters in close proximity to the point where most of the cold air would strike the gate, better results were obtained than by attempting to drive the heat to the various areas where heat was required. It was only possible to get a general idea of what was required, as the direction of the flow of the stream whether north, south, east or west, would have a bearing on the heat required.

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*"Piezometer Investigations" by C. M. Allen and Leslie J. Hooper, Trans. A.S.M.E., 1932.

[15] Dean of the Faculty of Engineering, McGill University, Montreal.

[16] Assistant Hydraulic Engineer, Hydro-Electric Power Commission of Ontario, Toronto, Ont.

[17] Welland Ship Canal, St. Catharines, Ont.

[18] Assistant Chief Engineer, Dominion Bridge Company Ltd., Montreal.

W. G. Chace, M.E.I.C.

Mr. Chace had noticed that at Chat Falls the draught tube structure was carried outside the power house. This would cause considerable excess in cost of construction over what would be the case if the draught tube were made much shorter. The rate of deceleration in the draught tube should be kept constant, and he could not see why that rate should be so small in the design of the Chats Falls draught tubes.

No information had been given as to the freeboard of the retaining walls, and the elevations did not seem to take account of the flood conditions in the upper reach. He would take it that the flood conditions were not considered to be serious.

O. Holden, A.M.E.I.C.

Regarding Mr. Chace's inquiry as to the draught tube, Mr. Holden stated that the length of the draught tube was determined by hydraulic conditions and nothing was added for any structural reasons. He would point out that the rate not only of deceleration but of divergence in any large tube, resulting in a decreasing velocity, was more or less definitely limited. To have the entire draught tube area effective at all times, the angle of divergence must be kept within very definite limits. This requirement of course was one of the factors determining the length of the tube. In these units a longer draught tube was usual than in turbines of the Francis type where a much smaller percentage of the head is to be recovered.

As to the freeboard, he was sorry the figure was not complete. The forebay was not raised to its final level in the picture shown. The freeboard on the bulkhead is three feet for low flows, but the freeboard is greater for flood conditions, since the water in the forebay must be lower for high flows to give sufficient slope to allow the water to flow down from Chats Lake.

Dean E. Brown, M.E.I.C.

Dean Brown remarked that like Mr. Caton he was interested in the question of ice pressure, having made a number of laboratory tests. Ice pressure must depend on the shape of the forebay and the nature of the shore, whether it was sloping or nearly vertical. He inquired how the ice pressure of 5,000 pounds per lineal foot used in the design of the dams at Chats Falls, had been arrived at. Was it a figure corresponding to that used in other designs for plants exposed to similar conditions? He referred to the fact that ice pressure is more important on a low dam than on a high dam, and noted that in the case of the highest sections of the dam the over-turning moment, including ice thrust at the assumed level, differed only slightly from the overturning moment corresponding to water-pressure with a higher level of the forebay. In other words, the overturning moment due to ice thrust was of the same order of magnitude as the difference of over turning moments corresponding to water only at different levels. This would not be the case in the low sections of the dam for which ice pressure becomes more important.

He noted that the elbow type of draught tube had been adopted. Was this the result of a preference for this type of tube, or was the choice based on laboratory tests using different types of draught tube?

O. Holden, A.M.E.I.C.

Mr. Holden said that the figure of 5,000 pounds per lineal foot for ice thrust was decided on after consideration of other structures and of the conditions existing at this development. The effect of ice thrust would be greater in proportion on low dams than on high dams, and in determining the amount of ice pressure all factors in the design of the structure must be given weight. For instance, allowance for uplift on the base had been made. This might vary from two-thirds of the static head at the upstream toe to zero at the downstream toe. In such an assumption it should be remembered that in the rock formation found at Chats Falls the likelihood of getting uplift over an extended section is very much less than in a stratified formation and consequently such an allowance must be given weight when considering the added force of a possible ice thrust.

The turbine runners at Chats Falls were of the Moody propeller type and were practically the same as the last runner installed at the LaGabelle plant of the Shawinigan Water and Power Company. In the latter case the head was slightly higher. Tests of models of the Chats Falls runners had been made by the I. P. Morris Company and the results of these tests submitted to the Engineering Board.

The elbow type of draught tube was decided on by the Engineering Board since the guarantees of the turbine performance were the same as for the Moody tube, and no advantage in regard to the latter was apparent that would warrant its construction.

W. G. Chace, M.E.I.C.

Mr. Chace was able to describe a specific case of injurious ice pressure in connection with the operation of a dam, controlled by the city of Winnipeg and built in 1908-11.

In 1925-26 when the low water period occurred the water was not permitted to spill over the flood sections of the dam, but was all passed through the power house. This permitted a heavy sheet of ice to form above this overflow section, and although the nearest shore was one thousand feet or more away, there developed a heavy horizontal thrust against the wing and overflow walls and one of the lighter structures of the latter type failed, partly because this thrust tilted the portion of the wall above one of the horizontal construction joints. This fact was proved by the crushing of the concrete on the lower face along the line of the construction joint.

A mass of concrete was afterwards placed against the wall on the wetted side with a slope of 45 degrees below the crest and reaching out ten feet or so. This was a convenient method of repair and this angle of approach was chosen with the idea that if ice thrust ever repeated itself against that wall a shearing would be created which would cause the ice to rise over the weir rather than to cause high pressure against the wall.

He might mention an incident that occurred in connection with the Winnipeg aqueduct, regarding the setting of concrete. The upper forms were left open at the top of the arch units to permit the entrance of the concrete over an area of three or four feet wide. Careful study showed that certain longitudinal cracks began to appear before the concrete had begun to set. This was purely a matter of the settling away of moist concrete within the deep side walls. In this case Mr. Chace had disregarded the rule never to disturb concrete when it is settling, the result being that by consistent puddling, more concrete was got into the arch sections of 45 feet length than had previously been possible. It seemed as if this principle might have been applied by Mr. Holden in his pier section.

Dean E. Brown, M.E.I.C.

Dean Brown asked whether in connection with the failure of the dam at Winnipeg there was any change in the level of the forebay, particularly a raising thereof, after the ice thrust began to form?

W. G. Chace, M.E.I.C.

Mr. Chace replied that an uplifting by rise of water below the thick ice sheet was very unlikely with a 1,000 foot surface. There was no evidence that the water had been raised at that time. It was argued by other engineers that ice thrust was not the cause of the damage, but his diagnosis was amply supported by proof, through careful inspection of the outer and the fractured surfaces, along with consideration of the conditions at similar walls outside the 500 feet fractured.

H. G. Ross, A.M.E.I.C.[19]

Referring to Mr. Brandon's paper, Mr. Ross questioned the propriety of using standard insulation on station service circuits and thought it was much better to use 2,200-volt insulation throughout all of the station service circuits, as had been done at Chats Falls.

E. T. J. Brandon, A.M.E.I.C.[20]

The author remarked that in installations of this character some of the most serious troubles experienced were due to difficulties arising in the station service circuits. He pointed out that while the standard 750-volt insulation would be perfectly satisfactory for station service and auxiliaries in the power station of a manufacturing plant, he felt that the additional security obtained by using 2,200-volt insulation for the main feeds and important circuits as at the Chats Falls Development was warranted in a large station of the character referred to in the paper. He did not agree with Mr. Ross that 2,200-volt insulation should be applied to all service circuits. Standard insulation would be quite satisfactory in 95 per cent of the cases.

B. Ottewell, A.M.E.I.C.[21]

Mr. Ottewell referred to the system of excitation, which he presumed was the so-called high-speed system. He inquired as to the experience with this system, and as to the rate of building up the main exciter voltage which had been attained. He also inquired as to the method of driving the governors.

The following information was supplied by the author in reply to Mr. Ottewell's question:—

E. T. J. Brandon, A.M.E.I.C.

The excitation system is the high-speed type. The maximum voltage rate of build up of the main exciter is 520 volts per second as stated in the paper. Experience with this has been entirely satisfactory. The 220-kv. lines are protected by high speed relays and it is not possible to say whether the rapid clearance of faults or the high speed excitation is mainly responsible for the satisfactory operation under fault conditions.

The governors are motor driven, the power being obtained from transformers connected to the generator leads.

As stated in the paper, no spare excitation system is provided. The station service transformers are connected so that station service power may be obtained from any generator. In case of a shut down of all generators resulting in a failure of station service supply, power may be fed back into the station from the 220-kv. system in order to provide station service power.

(19) Engineer, Westinghouse Electric and Mfg. Company, East Pittsburgh, Pa.

(20) Chief Electrical Engineer, Hydro-Electric Power Commission of Ontario, Toronto, Ont.

(21) Canadian General Electric Company Ltd., Peterborough, Ont.

THE
ENGINEERING JOURNAL
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OF CANADA

VOLUME XVI JUNE 1933 No. 6

The President's Visits to the Branches

The hearty welcome which the President received from our western branches during his recent journey to the Pacific coast gave abundant proof, if any were needed, of our members' hospitality and interest in the affairs of The Institute, but tours such as that which Dr. Lefebvre has just completed are not merely occasions for social intercourse and the renewal of personal acquaintanceships. They are indispensable if the widely spread membership of The Institute is to act collectively as a Dominion-wide organization.

Each of The Institute's twenty-five branches actually functions as a local engineering society, with its appropriate local interests and activities. Quite properly our branches do not attempt any uniform or stereotyped line of action. Each is able to direct its efforts and arrange its programmes as may seem best for the interests of its members. To this extent our organization is a decentralized one, of a type which has been shown by experience, under Canadian conditions, to be the most effective and adaptable as regards branch activities.

There is, however, another equally important phase of The Institute's work, that of affording a common ground on which engineers all over the Dominion can meet from time to time, exchange experiences and promote the interchange of professional knowledge. The development of a broadly Canadian outlook among its members is, and should be, one of The Institute's major objects. This is particularly needed in a country of such vast extent, where such differences in environment and viewpoint naturally exist, and where it is therefore so difficult to settle problems of general interest without personal contact and round table discussion. Thus it is natural that the President on his journey should have spent his time, not so much in delivering set speeches, as in meeting branch officers, executive committees and branch members, answering their inquiries as to Institute problems, and outlining as far as possible the views of other sections of the membership in order to be able to build up a picture of The Institute as a whole. In this way more progress can be made in a few hours than would result from months of mere correspondence.

President Lefebvre's continuous intimate connection with the work of Council, dating from 1925, has given him a real knowledge of Institute affairs. He is equally familiar with the problems of engineering registration and the administrative work of the Provincial Associations of Professional Engineers. Thus he has been able to give to the branches he visited a broad view of the possibilities in regard to the future relations between the legally constituted Provincial Associations and the voluntary organization over which he presides. At this time especially it is important for members to understand the essential differences between the responsibilities of the Professional Associations and those of The Institute, and to realise that each performs a function which cannot and should not be undertaken by the other.

The programme of the development of The Institute is closely bound up with its relations to the Professional Associations. This subject, with other topics like the financial situation of The Institute, our activities as regards the unemployment of our members, and The Institute's publications formed the basis of discussion at many meetings and informal gatherings.

During his western journey Dr. Lefebvre visited successively Saskatoon, Edmonton, Victoria, Vancouver, Calgary, Lethbridge, Regina, Winnipeg and the Lakehead Branch at Fort William and Port Arthur. At these points he met students at the universities, the branch chairmen and branch executive committees and addressed gatherings of members. He was also able to confer with officers of the three western Professional Associations, and indeed was present by invitation at a Council meeting of the British Columbia Professional Association. He found our branches active and interested in The Institute's problems of the day. Difficult conditions exist but they are leading to increased effort as regards membership and the well being of The Institute.

The President desires to take advantage of the editorial columns of The Journal to express his thanks for the cordial manner in which he was received and welcomed everywhere, and his conviction that with members of the calibre to be found in The Institute's ranks to-day we may look forward to the future of The Institute with every confidence.

Progress in the National Construction Council of Canada

The Engineering Institute of Canada has officially become a member of the National Construction Council of Canada, which body is now well under way and making considerable progress in the work which it has undertaken. As has already been reported in these columns the Council is formed of representatives from practically all national associations engaged in or interested in construction work.

The Council has sent out questionnaires to fifty-one municipalities in Canada in an effort to obtain a true picture of the construction needs of the country. It is known that during the past three years a large reservoir of construction has been dammed up due to the financial situation, and it is the feeling of the Council that sooner or later this work will have to proceed. An effort is being made to ascertain just how much of this work would be self-liquidating; how much would be semi-self-liquidating, and how much would bring in no financial return whatever. It is not the intention of the Council to suggest in any way to individual municipalities that they should proceed with any such work, rather it is the hope that by co-operation of the Chambers of Commerce throughout the country with the construction interests, these questionnaires will be filled in accurately and completely, so that when capital expenditure is again possible in this country some definite guidance may be available for the Dominion government, for the provincial governments, and for the municipalities themselves.

A year or two ago an effort was made by the Dominion government, in co-operation with the provinces and the cities, to substitute relief work for direct relief, but at that time no proper survey had been made of the construction needs of the country; no proper study was given to the relative merits of various types of construction; unfortunately the work was seldom started under competitive conditions, and in a great many cases was not done under competent supervision. Under the excuse of providing the greatest number of jobs per dollar expended, antiquated methods were used, and the net result was that unit costs ran extravagantly high, and the whole endeavour was discredited. It is the hope of the Council that their activities will prevent a recurrence of such a situation.

The replies to the questionnaires are coming in in a very encouraging way, although in certain quarters some hesitation is apparent on the part of Chambers of Commerce on account of a misunderstanding of the situation. Certain municipalities have written to the Council stating that on account of the endorsation of the Canadian Chamber of Commerce resolution to the Finance Minister in Ottawa they would hesitate to co-operate with the National Construction Council in its work. This is based on an erroneous conception of what the Council is trying to do. The National Construction Council is heartily in sympathy with every effort that is being made to reduce administration costs, but it does wish clearly to emphasize the radical difference between administration costs and capital expenditures. The Council would also like to point out that no effort should be made at the moment in isolated centres to start individual operations. The benefits which might accrue from any such desultory action would very quickly be dissipated. The Council's view is that "if, as, and when," capital expenditures are resumed in this country a comprehensive construction programme must be available, will be extremely beneficial to the country, and will bring about a revival quicker than any other method.

At the last meeting of the Council three major committees were formed, the Publicity Committee under the chairmanship of Mr. H. P. Frid, B.Sc.; the Survey Committee under the chairmanship of Mr. J. B. Carswell, M.E.I.C., and the Research Committee under the chairmanship of Mr. W. L. Somerville, F.R.A.I.C. All of these committees have a comprehensive programme in front of them, and from time to time progress reports will go forward to the parent bodies represented in the Council.

J. B. C.

Meeting of Council

A meeting of Council was held at the Engineers' Club, Toronto, on Friday, April 28th, 1933, at seven forty-five p.m., with President O. O. Lefebvre, M.E.I.C., in the chair, and ten other members of Council present.

Following a request from the National Construction Council of Canada it was decided to forward that body's questionnaire regarding possible construction projects to each branch of The Institute with a request to place the matter in the hands of one or two active members in each branch who would be responsible for getting the necessary information.

The title of the Maritime Professional Meeting to be held in Liverpool, Nova Scotia, on July 13th, 14th and 15th, was approved.

In regard to the Plenary Meeting of Council, it was resolved that the branches be asked to contribute a portion of the expense to be assessed pro rata in accordance with the membership.

A letter was presented from the Quebec Branch urging the publication in full in The Journal of all comments on the work of the Committee on Development made by the various branches. It was pointed out that this material was at present under examination by a committee of Council and that progress statements as to the results were being published from time to time in The Journal for the information of members. To comply with the request of the Quebec Branch would result in the publication of a great deal of material which has already been summarized and considered by the committee, and would lead to confusing the issue rather than clarifying it. The Secretary was directed to explain the matter to the Quebec Branch Executive Committee along these lines.

It was unanimously resolved that the chairmen of the Past-Presidents' Prize, and the Gzowski, Leonard and Plummer Medal Committees, be appointed as follows, and that these members be asked to submit the names of the other members of their committees for approval at the next meeting of Council:

Past-Presidents' Prize Committee...Lesslie R. Thomson, M.E.I.C.
Gzowski Medal Committee.........C. J. Mackenzie, M.E.I.C.
Leonard Medal Committee.........C. V. Corless, M.E.I.C.
Plummer Medal Committee.........H. J. Roast, M.E.I.C.

The examiners for the Students' and Juniors' Prizes were appointed as follows:

H. N. Ruttan Prize—R. S. L. Wilson, M.E.I.C., Chairman, Edmonton; D. A. R. McCannel, M.E.I.C., Regina; J. W. Porter, M.E.I.C., Winnipeg.

Phelps Johnson Prize—Ernest Brown, M.E.I.C., Chairman, Montreal; J. A. McCrory, M.E.I.C., Montreal; F. Newell, M.E.I.C., Montreal.

Ernest Marceau Prize—A. B. Normandin, A.M.E.I.C., Chairman, Quebec; H. Cimon, M.E.I.C., Quebec; B. Grandmont, A.M.E.I.C., Three Rivers.

Martin Murphy Prize—Sydney C. Mifflen, M.E.I.C., Chairman, Sydney; A. F. Dyer, A.M.E.I.C., Halifax; W. J. Johnston, A.M.E.I.C., Saint John.

John Galbraith Prize—A. H. Harkness, M.E.I.C., Chairman, Toronto; C. S. L. Hertzberg, M.E.I.C., Toronto; T. Taylor, M.E.I.C., Toronto.

It was resolved that F. H. Peters, M.E.I.C., be asked to continue as chairman of the Committee on Biographies, together with G. J. Desbarats, M.E.I.C., and Colonel A. F. Duguid, A.M.E.I.C.

A letter from Professor T. R. Loudon, M.E.I.C., was noted, suggesting that an inquiry by The Institute into the economic commodity requirements of Canada would be very advantageous at this time, such an inquiry being particularly needed in view of existing conditions. Such an inquiry, however, to be effective, would involve considerable expenditure. After discussion, the Secretary was directed to thank Professor Loudon and point out that owing to financial conditions it is quite impossible for The Institute at this time to undertake the inquiry suggested.

Four resignations were accepted, one member was reinstated, two members were placed on the Life Membership List, eleven members were placed on the Suspended List, and a number of special cases were considered.

A number of applications for admission and for transfer were considered, and the following elections and transfers were effected:

Elections		*Transfers*	
Member	1	Assoc. Member to Member	2
Assoc. Members	8	Junior to Assoc. Member	3
Affiliates	2	Student to Junior	1
Students admitted	28		

Councillors present at this meeting were entertained at dinner by the Toronto Branch Executive Committee, and the thanks of Council were conveyed to the Executive Committee for the hospitality extended, and for the arrangements made to facilitate the holding of the Council meeting in Toronto.

The Council rose at ten forty p.m.

Rules Governing Award of Institute Prizes

Rules Governing the Award of the Sir John Kennedy Medal

A gold medal, to be called the "Sir John Kennedy Medal," may be struck and awarded under the following rules, 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 Engineering Institute of Canada.

(1) The medal shall be awarded by the council of The Institute, but 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.

(2) As a guide in making the award, the council of The Institute shall take into consideration the life, activities and standing in the community and profession of the late Sir John Kennedy.

(3) Awards shall be limited to corporate members.

(4) At the beginning of each year, every branch of The Institute shall be asked for its recommendation, supported by reasons, for the award of the medal, which must be submitted to council not later than May first. The council of The Institute shall then give consideration to the recommendations, but will not necessarily adopt any of them. If, in the opinion of the council, no corporate member of The Institute thus recommended is of sufficient merit or distinction, no award shall be made.

(5) The award shall be decided by letter ballot of the council in a form to be prescribed by the council. The ballot shall be mailed to each member of the council and shall state the date of the council meeting at which it is proposed to canvass the ballot, which shall not be less than twenty days after the issue of the ballot. At least twenty votes shall be cast to constitute an award. Three or more negative votes shall exclude from an award.

(6) Announcement of an award shall be made in The Engineering Journal and at the annual meeting, and, if possible, the presentation shall take place at that meeting.

Rules Governing the Award of the Past-Presidents' Prize

In recognition of the fund established in 1923 by the then living past-presidents and contributed to by subsequent past-presidents, a prize, to be called "The Past-Presidents' Prize," may be awarded annually according to the following rules:—

(1) 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 the council at the beginning of the prize year, which shall be July first to June thirtieth.

(2) In deciding on the subject to be specified, the council shall confer with the branches, and use its discretion, with the object of selecting a subject which may appear desirable in order to facilitate the acquirement and the interchange of professional knowledge among the members of The Institute.

(3) 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.

(4) The prize shall consist of a cash donation of the amount of one hundred dollars, or the winner may select books or instruments of no more than that value when suitably bound and printed, or engraved, as the case may be.

(5) 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.

(6) All papers to be entered for the competition must be received during the prize year by the general secretary of The Institute, either direct from the author or through a local branch.

(7) The award shall be announced in The Engineering Journal and at the annual meeting, and, if possible, the presentation shall take place at that meeting.

Rules Governing the Award of the Gzowski Medal

A gold medal, to be called "The Gzowski Medal," shall be struck each year and paid for from the annual proceeds of the fund provided for that purpose by Col. Sir Casimir Gzowski, A.D.C., K.C.M.G., late past-president of The Institute, which medal shall be awarded according to the following rules for papers presented to The Institute.

(1) Competition for the medal shall be open only to those who belong to The Institute.

(2) The award of medals shall not be made oftener than once a year, the medal year shall be the year ended June last previous to the annual meeting at which the award is to be made.

(3) The papers entered for competition shall be judged by a committee of five, to be called the Gzowski Medal 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.

(4) Papers to be eligible for competition must be the bona fide productions of those who contribute them, and must not have been previously made public, nor contributed to any other society in whole or in part.

(5) The medal shall be awarded for the best paper of the medal year, provided such paper shall be adjudged of sufficient merit as a contribution to the literature of the profession of civil engineering, but not otherwise.

(6) In the event of the committee not considering a paper in any one year of sufficient merit, no award shall be made; but in the following year or years, it shall be in the power of the committee to award the accumulated medals to the authors of different papers which may be deemed of sufficient merit.

(7) The medal shall be suitably engraved by The Institute, and shall be handed to the successful authors at the annual meeting, or be given to them as soon afterwards as possible.

Rules Governing the Award of the Leonard Medal

A gold medal, called "The Leonard Medal," shall be struck each year and paid for from the annual proceeds of the fund provided for that purpose by the late Lieut.-Col. R. W. Leonard, which medal shall be awarded in accordance with the following rules for papers on mining subjects presented either to The Canadian Institute of Mining and Metallurgy or to The Engineering Institute of Canada.

Maritime General Professional Meeting of The Engineering Institute of Canada
and
General Meeting of the Association of Professional Engineers of Nova Scotia

WHITE POINT BEACH, near LIVERPOOL, QUEENS COUNTY, N.S.
JULY 13th to 15th, 1933

Halifax Harbour from Dartmouth, N.S.

PROGRAMME

(*Subject to Minor Changes*)

Headquarters at White Point Beach Lodge (Six miles west of Liverpool on Route 3)

Thursday, July 13th.

11 a.m. Registration.

12 noon Informal Lunch and address of welcome.

3 p.m. Visit to plant of Mersey Paper Company.

7.30 p.m. Professional Papers:

(*a*) Use of the Back Pressure Turbine in a Modern News Print Mill, J. H. Mowbray Jones, A.M.E.I.C., chief engineer, Mersey Paper Company.

(*b*) Supervisory Control and Automatic Protection as Applicable to Hydro-Electric Development in the Maritimes, Howard Fellows, A.M.E.I.C., assistant chief engineer, N.S. Power Commission.

Friday, July 14th.

9 a.m. Visit to Power Developments on the Mersey River.

12 noon Luncheon at White Point Beach at which delegates will be the guests of Col. C. H. L. Jones of the Mersey Paper Company.

2 p.m. Professional Papers:

(*a*) Modern Practice in Highway Construction and Maintenance with particular reference to the Province of Nova Scotia, R. W. McColough, chief engineer, Department of Highways.

(*b*) Use of High-Ash Pulverized Coal in Steam Boilers with Special Reference to Results Obtained at Seaboard Plant, Glace Bay, N.S., K. H. Marsh, M.E.I.C., chief engineer, Dominion Steel and Coal Corp.

7.30 p.m. Banquet, Prominent Speakers.

Saturday, July 15th.

The morning will be available for golf, swimming, etc.

View from White Point Beach, N.S.

Mersey Paper Company Shipping Piers.

(1) Competition for the medal shall be open to those who belong to The Canadian Institute of Mining and Metallurgy or to The Engineering Institute of Canada.
(2) Award shall be made not oftener than once a year, and the medal year shall be the year ended June last previous to the year in which the award is made.
(3) The medal shall be presented at annual meetings of The Engineering Institute of Canada.
(4) A committee of five shall judge the papers entered for competition, all of whom shall be members both of The Canadian Institute of Mining and Metallurgy and The Engineering Institute of Canada, this committee to be appointed by the council of The Engineering Institute of Canada.
(5) All papers presented shall be the work of the author or authors and must not have previously been made public, except as part of the literature of The Canadian Institute of Mining and Metallurgy or The Engineering Institute of Canada.
(6) Should the committee not consider the papers presented in any one year of sufficient merit, no award shall be made, but in the following year, or years, the committee shall have power to award the accumulated medals or to award a second prize in the nature of a silver medal, or a third prize of books to be selected by the committee.
(7) The medal shall be suitably engraved, containing the name of The Engineering Institute of Canada, and the words, "The Leonard Medal" together with the adopted design, and on the reverse side the name of the recipient, the date and any other inscription that may be decided upon by the committee.

Rules Governing the Award of the Plummer Medal

A gold medal, to be called "The Plummer Medal," shall be struck each year and paid for from the annual proceeds of the fund provided for that purpose by Mr. J. H. Plummer, D.C.L., which medal shall be awarded according to the following rules for papers on chemical and metallurgical subjects presented to The Institute.

(1) Competition for the medal shall be open to those who belong to The Engineering Institute of Canada, and to non-members if their papers have been contributed to The Institute and presented at an Institute or Branch Meeting.
(2) Award shall be made not oftener than once a year, and the medal year shall be the year ended June last previous to the year in which the award is made.
(3) The medal shall be presented at annual meetings of The Engineering Institute of Canada.
(4) A committee of five shall judge the papers entered for competition, all of whom shall be members of The Engineering Institute of Canada, and shall be appointed by the council of The Institute.
(5) All papers presented shall be the work of the author or authors and must not have previously been made public, except as part of the literature of The Engineering Institute of Canada.
(6) Should the committee not consider the papers presented in any one year of sufficient merit, no award shall be made, but in the following year, or years, the committee shall have the power to award the accumulated medals or to award a second prize in the nature of a silver medal, or a third prize of books to be selected by the committee.
(7) The medal shall be suitably engraved, containing the name of The Engineering Institute of Canada, and the words, "The Plummer Medal," together with the adopted design, and on the reverse side the name of the recipient, the date and any other inscription that may be decided upon by the committee.

Rules Governing the Award of Prizes to Students and Juniors

(1) Five prizes may be awarded annually for the best papers presented by Students or Juniors of The Institute in the vice-presidential zones of The Institute, as follows:—
The H. N. Ruttan Prize,—
in Zone A—The four western provinces.
The John Galbraith Prize,—
in Zone B—The province of Ontario.
The Phelps Johnson Prize,—
for an English Student or Junior in Zone C—The province of Quebec.
The Ernest Marceau Prize,—
for a French Student or Junior in Zone C—The province of Quebec.
The Martin Murphy Prize,—
in Zone D—The Maritime provinces.
(2) Awards shall only be made if, in the opinion of the examiners for a zone, a paper of sufficient merit has been presented to a branch in that particular zone.
(3) The winner of a prize shall be required to specify such technical books or instruments as he may desire to the total value of approximately twenty-five dollars when suitably bound and printed or engraved, as the case may be.
(4) The award of prizes shall be for the year ending June thirtieth. On that date, each branch secretary shall forward to the examiners for his particular zone all papers presented to his branch by Students and Juniors during the prize year, regardless of whether they have been read before the branch or not.
(5) The prizes shall be awarded only to those who are in good standing as Students or Juniors of The Institute of June thirtieth following the presentation of the paper.
(6) The papers must be the bona fide production of those contributing them and must not have been previously made public or contributed to any other society in whole or in part. It is to be understood, however, that a paper which has won or been considered for a branch prize is nevertheless eligible for The Institute Prize. No paper shall be considered for more than one of the five prizes.
(7) The examiners for each zone shall consist of the vice-president of that zone and two councillors resident in the zone, appointed by council. In the case of Zone C, two groups of examiners shall be appointed under the two vice-presidents, one for the English award and one for the French award. The awards shall be reported to the annual meeting of The Institute next following the prize year, and the prizes presented as soon thereafter as is reasonably possible.

All members are again reminded that papers entered in competition for the Past-Presidents' Prize must be received previous to June 30th, 1933, by the General Secretary of The Institute.

Papers for the Students' and Juniors' Prizes must be received by the Branch Secretaries previous to June 30th, 1933.

ELECTIONS AND TRANSFERS

At the meeting of Council held on April 28th, 1933, the following elections and transfers were effected:

Member

PIERCE, John Wesley, (Univ. of Toronto), O.L.S., D.L.S., M.L.S., Room 14, Bank of Commerce Building, Peterborough, Ont.

Associate Members

BERRY, Effingham Deans, (Royal Tech. Coll., Glasgow), chief dftsman., E. B. Eddy Co. Ltd., Hull, Que.

DAVY, Arthur Cecil Montague, Lieut.-Commdr. (E), R.C.N., Asst. Director of Naval Engrg., Dept. of National Defence, Ottawa.

GRIFFITHS, George Ewart, B.A.Sc., (Univ. of Toronto), asst. meter engr., H.E.P.C. of Ontario, Niagara Falls District, Thorold, Ont.

HANSON, Ralph Ellis, B.Sc., (N.S. Tech. Coll.), Hydrographer, Grade 1, Hydrographic Survey, Hunter Bldg., Ottawa, Ont.

ROSS, Allan Crawford, B.Sc., (McGill Univ.), president and engr., Ross Meagher Ltd., 80 Elgin St., Ottawa, Ont.

SIRRS, Robert Raymond, B.A.Sc., (Univ. of Toronto), consltg. engr., 227 Dalhousie St., Ottawa, Ont.

TOOVEY, Thomas William, (Examination—Assn. of Prof. Engrs. of B.C.), chem. engr., The British Columbia Pulp and Paper Co. Ltd., Port Alice, B.C.

VILLENEUVE, Philippe A., B.A., B.A.Sc., (Ecole Polytech.), Villeneuve & Caiffiaux, consltg. engrs., Quebec, Que.

Affiliates

PARKER, Douglas Howard, chief engr., Montreal Star Co. Ltd., Montreal, Que.

SHUTER, Edwin, 55 Worsley Street, Barrie, Ont.

Transferred from the class of Associate Member to that of Member

ROSS-ROSS, Donald deCourcy, B.Sc., (McGill Univ.), chief industrial engr. in charge of depts. of industrial engrg., purchasing and cost accounting, Howard Smith Paper Mills Ltd., Cornwall, Ont.

WYNNE-ROBERTS, Lewis Wynne, B.Sc. (Hons. Engrg.), (Univ. of London, Eng.), member of firm, Wynne-Roberts, Son and McLean, 44 Victoria St., Toronto, Ont.

Transferred from the class of Junior to that of Associate Member

ELKINGTON, Gerald Erlam, B.Sc., (McGill Univ.), operating engr., East Kootenay Power Co. Ltd., Fernie, B.C.

FRANKS, Selwyn Thompson, B.A.Sc., (Univ. of Toronto), asst. to elect'l. engr., Canadian & General Finance Co., 25 King St. West, Toronto, Ont.

SHANLY, James, (McGill Univ.), asst. gen. supt., Kenogami paper mills, Price Bros. & Co. Ltd., Kenogami, Que.

Transferred from the class of Student to that of Junior

BENJAMIN, Archie, B.Sc., (McGill Univ.), distribution engrg. dept., Montreal Light Heat & Power Cons., Montreal, Que.

Students Admitted

ALEXANDER, Alwin Paul, (Univ. of Alta.), Monarch, Alta.

ARCHER, Maurice George, (Grad. R.M.C.), (McGill Univ.), 330 Grande Allee, Quebec, Que.

BERRINGER, Ormus Benjamin, B.Sc. (Mech.), (N.S. Tech. Coll.), Lunenburg, N.S.

BOURQUE, Louis Philippe, (McGill Univ.), 132—8th Ave. West, Calgary, Alta.

CHENNELL, Alwyn C., (McGill Univ.), 5831 Durocher Ave., Outremont, Que.

CRAIG, William Royce, (Univ. of Alta.), 639—12th St. So., Lethbridge, Alta.

EVANS, Philip Norton, (McGill Univ.), 352 Kitchener Ave., Westmount, Que.

FLEMING, Donald C., (Univ. of Alta.), 511-17th Ave. West, Calgary, Alta.

HEAVYSEGE, Bruce Reid, (McGill Univ.), 330-a St. Joseph St., Lachine, Que.

HOUGH, Ayton Lloyd, (McGill Univ.), 3609 University St., Montreal, Que.

HURDLE, Harold Lancelot, (Univ. of Alta.), 16 Tipton Block, Edmonton, Alta.

LAURIE, E. Stuart, (McGill Univ.), 653 Victoria Ave., Westmount.

LEMON, Marvin Reginald, (Univ. of Toronto), Stouffville, Ont.

MASON, Orley Batcheller, (McGill Univ.), Grand'Mere, Que.

MAYEROVITCH, Robert, (McGill Univ.), Rockland, Ont.

MITCHELL, Robert Walter, (McGill Univ.), 135 Balfour Road No., Town of Mount Royal, Que.

McCOLL, William Ross, (Univ. of Toronto), 16 Askin Ave., Sandwich, Ont.

McDUNNOUGH, Philip Nelson, (McGill Univ.), 86 Manrese St., Quebec, Que.

McGEE, Leonard Davidson, (McGill Univ.), 63 Bruce Ave., Westmount, Que.

McKNIGHT, Charles E. V., (Queen's Univ.), 707 King Edward Ave., Ottawa, Ont.

NESBITT, Arthur Deane, (McGill Univ.), 41 Forden Ave., Westmount, Que.

POTTS, James Edward, (McGill Univ.), Stirling, Ont.

RIVENOVICH, Israel R., (McGill Univ.), 446 Rigaud St., Montreal, Que.

ROBSON, William John, (Univ. of Alta.), 10631-106th St., Edmonton, Alta.

ROLBIN, Max, (McGill Univ.), 4632 Esplanade Ave., Montreal, Que.

SEYBOLD, Hugh Gordon, (McGill Univ.), 331 Lansdowne Ave., Westmount, Que.

SHARP, William Gray, (Univ. of Alta.), Didsbury, Alta.

WICKWIRE, Lawrence David, (N.S. Tech. Coll.), 39 Spring Garden Rd., Halifax, N.S.

Students Admitted

At the meeting of Council held on May 26th, 1933, the following Students were admitted:

BENJAFIELD, John Fordyce, B.Sc., (Queen's Univ.), 39 Wellington St., St. Thomas, Ont.

DUFF, Duncan Clemens Verr, B.Sc., (C.E.), (N.S. Tech. Coll.), Stellarton, N.S.

GAMBLE, Samuel Gill, (Grad. R.M.C.), B.Eng., (McGill Univ.), 269 Somerset, St. West., Ottawa, Ont.

HARTLEY, Eric Llewellyn, B.Sc., (Queen's Univ.), 239 Johnston St., Kingston, Ont.

HAYES, Gerald Joseph, B.Sc., (N.S. Tech. Coll.), Chatham, N.B.

KLOTZ, Carl Otto Paul, (Queen's Univ.), 20 River Road, Westboro, Ont.

LACKEY, Wesley James, B.Sc., (Queen's Univ.), 194 Humberside Ave., Toronto, Ont.

MENDELSOHN, Lewis, B.Eng., (McGill Univ.), 2086 Tupper St., Montreal, Que.

MULLEN, Thomas J., Jr., (McGill Univ.), 4338 Draper Ave., Montreal, Que.

QUIGLEY, Robert Webster, B.Eng. (McGill Univ.), 3483 Peel St., Montreal, Que.

WALTER, John, B.Sc., (Queen's Univ.), 16 William St. West, Kingston, Ont.

PERSONALS

Two members of The Institute are officers of the recently organized National Council of Canada: J. B. Carswell, M.E.I.C., managing director of the Burlington Steel Company, Ltd., Hamilton, representing The Engineering Institute of Canada on the Council, is second vice-president; and A. Ross Robertson, A.M.E.I.C., manager of the Ontario Division of the Dominion Bridge Company, Ltd., Toronto, who represents the Canadian Manufacturers Association, is Honorary Treasurer.

Dr. Charles Camsell, M.E.I.C., Deputy Minister of Mines, and Past-President of The Institute, is a member of the executive of the Pacific Science Congress which is to meet in Victoria and Vancouver in June, 1933. Among other members of The Institute with the Canadian party are Dr. R. W. Brock, M.E.I.C., Dean of the Faculty of Applied Science, University of British Columbia, Vancouver and Dr. A. Frigon, M.E.I.C., Director General of Technical Education of the Province of Quebec and Dean of the Ecole Polytechnique, Montreal.

W. A. Mather, M.E.I.C., formerly general superintendent of the Alberta District, Canadian Pacific Railway Company, with headquarters at Calgary, has been appointed assistant to the vice-president, Montreal. Mr. Mather, who graduated from McGill University in 1908 with the degree of B.Sc., has been with the Canadian Pacific Railway Company since that date, being attached for a time to the construction department, and later acting as resident engineer on maintenance of way in Winnipeg. From 1912 to 1915 he was superintendent at Kenora, Ont., and for a short time at Medicine Hat. In 1915 Mr. Mather was appointed assistant general superintendent at Vancouver, B.C., occupying that position until 1918 when he became general superintendent with headquarters at Moose Jaw, Sask., holding that appointment until 1932.

RECENT ADDITIONS TO THE LIBRARY

Proceedings, Transactions, Etc.

American Society of Civil Engineers: Proceedings, Year Book Number, 1933; Proceedings, April 1933.
Canadian Institute of Mining and Metallurgy: Transactions, 1932.
American Society of Mechanical Engineers: Volume 54, Transactions, 1932.
American Electrochemical Society: Advance copies of twelve papers to be presented at Sixty-third General Meeting, May 1933, Montreal.
The South Wales Institute of Engineers: Proceedings, 1933.
Cleveland Institution of Engineers: Proceedings, December 12th, 1932.
American Institute of Mining and Metallurgical Engineers: Directory Section, 1933.

Reports, Etc.

Department of Interior, Forest Service, Canada:
Bulletin 84: Cellulose-Water Relationship in Paper Making.
Air Ministry, Aeronautical Research Committee, Great Britain:
Reports and Memoranda:
No. 1501: Tests of Floating Ailerons on a Bristol Fighter Aeroplane.
No. 1497: The Influence of Wing Density upon Wing Flutter.
No. 1500: Resistance Derivatives of Flutter Theory.
No. 1498: Spinning Calculations on some Typical Cases.
No. 1499: Reversal of Aileron Control due to Wing Twist.
Department of Mines, Canada:
Investigations of Fuels and Fuel Testing, 1930 and 1931.
Department of Interior, National Development Bureau, Canada:
The Insulation of New and Old Houses.
Ohio State University Studies: Circular No. 29, A Method of Determining Values of Different Fuels for Power Plant Use. Bulletin No. 77, Performance of Propeller Fans.

Technical Books, etc., Received

Unemployment Relief in Ontario, by H. M. Cassidy, (*J. M. Dent and Sons, Toronto*), presented by Professor T. R. Loudon, M.E.I.C.
Industrial Piping, *Engineering Publications, Inc.*
Massachusetts Institute of Technology, The Graduate Schools of Science and Engineering.
Ten Years, a record of the progress and achievements of the *Electricity Supply Commission*, South Africa.

BOOK REVIEWS

Canadian Railway Development

By Norman Thompson and Major J. H. Edgar, M.E.I.C. MacMillan Company of Canada, Limited, Toronto, 1933. Cloth, 5½ by 8 in., 402 pp., Figs., Photos, $4.00.

It is rarely that one gets an historical work attempting to give dates and accurate chronology of any development, with the reasons leading up to the various component parts of the whole, which in itself is easy to read. This is, therefore, an unusual book, in that most of it is very readable, the human element being introduced to such an extent as to make it interesting from cover to cover for anyone who desires to follow the story of railway development in Canada.

The authors, Norman Thompson and Major J. H. Edgar, A.M.E.I.C., are both railway men with considerable experience, having spent many years in the railway service in western Canada and still being identified with the Canadian National Railways as officials on the Western Region of that system.

The contents of the book bear out the statement of the publishers that the authors in preparing their work, have "tapped every source of information known to them, including public and private libraries, and have also communicated with numerous railway officials, both in Canada and the United States." In fact they have endeavoured to give every section of the Dominion from the Atlantic to the Pacific its due share of attention, while at the same time treating the two great systems which now include most of Canada's railway mileage—the Canadian National and the Canadian Pacific—with impartiality.

The book appropriately commences with the early planning and construction of the first attempts at railroading in the Dominion, the most notable being Canada's first steam railway, the Champlain and St. Lawrence, on which the inaugural run between Laprairie and St. Johns, Quebec, was made on July 21st, 1836. It then passes on to the importation of three locomotives into Nova Scotia, two of which were the well-known "Samson" and "Albion" serving on a run connecting the Albion Mines, Nova Scotia, with the gulf of St. Lawrence by rail. Dealing with railway development up to 1858, reference is made to the "battle of the gauges" in which the broad gauge was favoured for a time in order to prevent diversion of traffic to other roads. There are chapters dealing with the Great Western Railway, the Grand Trunk Railway, the Intercolonial Railway, the Canadian Pacific Railway, the Canadian Northern Railway, the Grand Trunk Pacific and the National Transcontinental Railways, miscellaneous Dominion railways, United States railways operating in Canada and the Canadian National Railways.

It is not surprising that a book covering such a wide field and dealing with events occurring over such a long period of years, should contain some minor inaccuracies. It would seem as if the authors have not always had access to full documentary evidence. For example, the reference on page 197 to the "interprovincial bridge across the Ottawa, also known as the Alexandra bridge since its renewal in 1926" is not quite correct. The Interprovincial or Alexandra bridge was built in 1898-1899 in its present form and has not since been altered. The bridge over the Ottawa river which was renewed in the year 1926 was the old Prince of Wales bridge, over which the C.P.R. North Shore line entered Ottawa, a bridge originally constructed in the year 1880. Other examples might be cited, but they will no doubt receive correction in the next edition of this excellent book.

At the close of each chapter a summary of the dates of important events is given, and these are repeated with additions in the chronological tabulation of principal events with which the book closes. The authors have consulted an imposing list of books in obtaining their information, and these are mentioned in an appendix. The utility of the volume as a whole would have been greatly increased by the inclusion of an adequate index.

The book is well worth having, and the reader will be rewarded with many glimpses of the human side of railroading as well as its many-sided political and engineering problems.

C.E.S.A. Reports Receipt of Specifications

The following Specifications have been received during the past quarter.

1. From the British Standards Institution.

52-1933—Dimensions of Bayonet Lamp-Caps and Metal Cased Bayonet Lampholders for Voltages not Exceeding 250 Volts.
109-1933—Air-Break Knife Switches and Laminated Brush Switches.
124-1933—Totally-Enclosed Air-Break Switches for Voltages not Exceeding 660 Volts.
156-1932—Enamelled High-Conductivity Annealed Copper Wire.
159-1932—Bus-Bars and Bus-Bar Connection in Air, Oil or Compound.
279-1932—Flame-Proof Type Plug and Socket, Heavy Duty.
367-1932—Performance of Ceiling-Type Electric Fans (Medium-Speed Propeller Type).
376-Part 2-1933—Wiring Symbols and Written Circuits—Railway Signalling Symbols.
471-1932—Extra-Light Tubular Steel Poles for Telegraph and Telephone Purposes (Farmer's Poles).
477-1933—Wrought Light Aluminium Alloy Bars.
478-1933—Wrought Y-Alloy Bars.
479-1933—For Coal Tar Naphthas.
480-1933—Metal-Sheathed, Paper-Insulated Plain Annealed Copper Conductors.

2. From the Australian Standards Association.

B.8-1932—Marking and Colouring of Patterns.
S.P.R. 8-1931—Simplified Practice Recommendation—Fibrous Plaster Sheets.
B.35 to 38-1931—Brass Water Fittings (replacing tentative issue B. 1-1928).
C. 3 to 11-1932—Overhead Line Material for Telegraph and Telephone Purposes.
C34.—Electrical Performance of Industrial Electric Motors and Generators.
C35.—Electrical Performance of Large Electric Generators and Motors. Rating Permitting Overload.
C36.—Electrical Performance of Large Electric Generators and Motors. Continuous Maximum Rating.
C38.—Electrical Performance of Alternators of the Steam Turbine Drive Type.

3. From the American Standards Association.

A23-1932—Standards of School Lighting.
B6.1-1932—Spur Gear Tooth Form.
B49-1932—Shaft Couplings.
C48-1931—Electric Railway Control Apparatus.
Z11.26-1932—Standard Methods of Testing Gas Oils.
Z11.27-1932—Tentative Method of Test for Expressible Oil and Moisture in Paraffin Waxes.
Z11.28-1932—Tentative Definitions of Terms Relating to Petroleum.
Z11.29-1932—Tentative Method of Test for Dilution of Crankcase Oils.
Z11.30-1932—Tentative Method of Test for Precipitation Number of Lubricating Oils.
Z21.2-1932—Approval Requirements for Flexible Gas Tubing.
Z21.3-1932—Approval Requirements for Hotel and Restaurant Ranges.
Z21.4-1932—Approval Requirements for Private Garage Heaters.
Z21.5-1932—Approval Requirements for Clothes Dryers.
Z21.6-1932—Approval Requirements for Incinerators.
Z21.7-1932—Approval Requirements for the Gas Heated Ironers.
Z21.8-1932—Requirements for Installation of Conversion Burners in House Heating and Water Heating Appliances.

CENTURY OF PROGRESS EXPOSITION
CHICAGO

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ENGINEERING WEEK
June 25th to July 1st, 1933

BULLETINS

Road surfacing—The Barrett Company Limited has recently published a forty-eight-page booklet containing useful tables and information on the use of Tarvia and "Tarvia-Lithic" for highway engineers, contractors and road builders. The publication contains instructions for proper handling and unloading of BMX tank cars, and a section on Tarvia surface treatments.

Welding—Dominion Oxwelding Tips, a bi-monthly review, has been received from the Dominion Oxygen Company Ltd., Toronto and Montreal. This bulletin contains information on welding, and the present issue features welding of brass and bronze, marine repairs and salvage and information regarding tests for identifying metals in chart form.

Concrete Piles—A twenty-page bulletin has been received from the Franki Compressed Pile Company of Canada Ltd., Montreal, and contains information on the method of driving, characteristics, uses, and tests on Franki concrete piles.

Conveyors—Link-Belt Limited, Toronto, have recently issued a twenty-four-page booklet entitled "Transmitting and Conveying Ideas" which illustrates in some detail the application of modern conveying machinery to various industrial uses, and points of interest concerning the equipment so used.

Road-servicing—A four-page folder has been received from The Barrett Company Limited, on the maintenance of highways with Tarvia.

Insulation and Brake-Linings—A twenty-four-page booklet has been received from the Canadian Johns-Manville Co. Ltd., Toronto, Ont., entitled "The Power Specialist" which contains a number of articles on the use and adaptation of brake-linings and insulation in commerce and industry.

Agenda for World Economic Conference

The agenda for the World Economic Conference deals with both financial and economic questions in detail. It is a broad plan for the restoration of prices and a resuscitation of world trade. The official representatives of those governments which have participated in the formulation of this programme have commented upon the scope of their plan in the following words: "It will not, in our judgment, be possible to make progress by piecemeal measures. A policy of 'nibbling' will not solve the crisis. We believe that the governments of the world must make up their minds to a broad solution by concerted action along the whole front. Action in the field of economic relations depends largely upon monetary and financial action and vice versa. Concerted measures in both fields are essential if progress is to be made in either." The official position of those who make this comment lends these forceful words peculiar importance.

The following excerpts from the annotated agenda for the Conference constitute an outline of the material which is to be studied.

1. "In the field of monetary and credit policy, the objective must be the restoration of an effective international monetary standard to which the countries which have abandoned the gold standard can wisely adhere. The notes appended clearly show that there are a great number of economic as well as financial conditions which must be fulfilled before the restoration of an international gold standard can be a practical possibility. Moreover, it will be necessary to provide effective safeguards against such a restoration of the gold standard leading to a fresh breakdown.

2. "The unprecedented fall of commodity prices in recent years has caused a growing disequilibrium between costs and prices, has immensely increased the real burden of all debts and fixed charges, has made business more and more unprofitable, and has resulted in a continuous and disastrous increase of unemployment throughout the world. Some increase in the level of world prices is highly desirable and would be the first sign of world recovery. The Conference will no doubt wish to explore all possibilities of counteracting this fall in prices. One of the methods that should be considered is the continuation and development, where monetary conditions permit, of a general policy of easy money designed to promote a healthy expansion of business.

3. "The restoration of free exchanges is so essential to the recovery of financial confidence and to the resumption of the normal flow of international credit that the governments should consider whether they cannot expedite the process. In order to do this, some means might be organized by which resources at present immobilized would be put into active circulation, and stabilization credits would be provided under appropriate conditions for the countries which require such assistance.

4. "Finally, there must be greater freedom of international trade. It has already been pointed out that one of the most significant features of the present crisis is the fall which has taken place, not only in the value, but in the quantum of world trade. This fall has been partly caused, and has certainly been intensified, by the growing network of restrictions which have been imposed on trade during recent years. Every country seeks to defend its economy by imposing restrictions on imports, which in the end involve a contraction in its exports. All seek to sell but not to buy. Such a policy must inevitably lead to an increasing paralysis of international trade. Governments should set themselves to re-establish the normal interchange of commodities."—*From the May issue of the Royal Bank of Canada Monthly letter.*

The Trevithick Memorial Lecture

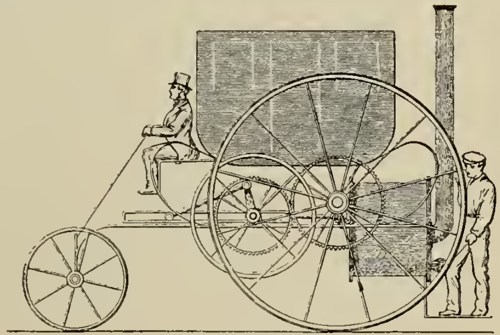
At the invitation of the Trevithick Centenary Commemoration Committee, Professor C. E. Inglis, F.R.S., on April 24, delivered a Trevithick Memorial Lecture, the meeting taking place in the theatre of the Institution of Civil Engineers, by kind permission of the Council. The chair was taken by Sir Murdoch MacDonald, the President of the Institution and the chairman of the Commemoration Committee.

When Trevithick died, said Professor Inglis, no obituary notices proclaimed that the nation had lost a mechanical genius of the first order of magnitude, and his memory passed into an oblivion which for many years was almost complete. But the greatness of the man and the impetus he had given to engineering science was such that his fame could not suffer permanent eclipse. Fifty years ago the name of Richard Trevithick had won an honoured position throughout the engineering world, and now posterity, more discerning than his own generation, deems him not unworthy to be enthroned on the same plane with his predecessor and one-time rival, the illustrious James Watt.

Trevithick's work as an inventor really commenced when he was about 26. From 1797 onwards, until he left England in 1816. He was a veritable volcano of inventions, though some, because they antedated engineering progress by many years, failed to come to fruition; others—notably the high-pressure semi-portable steam engine—gave an immediate impetus to mechanical science for which his successors mainly reaped the honour and financial reward. The rapidity with which Trevithick turned an idea into an actuality was quite astounding. To book learning, past or present, he paid little or no heed, and in the course he steered he never stopped to sound the depths for possible anticipations.

Speaking of the large hydraulic pumping engine of Trevithick, erected in 1803 in Derbyshire, Professor Inglis said: This simple and powerful type of engine was verily the mechanical embodiment of its creator's mental and physical characteristics, and Trevithick's creations invariably inherited his own personal attributes—strength and energy. Watt, in comparison, was a timorous spirit; steam, in his mental vision, was merely an agent for forming a vacuum, and the potentialities of danger he envisaged from the use of high-pressure steam outweighed the possible advantages which could be gained thereby. Trevithick, on the other hand, never counted that particular cost; he never permitted potentialities of danger to obscure his horizon, and it was this entire absence of fear which, perhaps more than any other mental characteristic, impelled him forward to win renown as the originator of the high-pressure engine, at any rate as far as this country was concerned.

One great landmark in Trevithick's life was the enrolment by him and his cousin, Andrew Vivian, of the patent of 1802, for "improvements in the construction and application of steam engines." In drawings for this patent, the small size of boiler, was a noticeable feature. while the suggestion of the use of two cranks at right angles was certainly a novelty in design. The small size of boiler could only have been rendered practicable by the employment of a steam blast, the advantage of which Trevithick had discovered in his Camborne road-carriage experiments; but, strangely enough, this all-important feature is neither illustrated nor claimed verbally in the specification. Trevithick was most certainly the originator of the steam blast.



Road-Carriage, 1803.

Professor Inglis was not able to add much to our knowledge of the actual details of Trevithick's locomotives or throw any light on the personality of the "not over-scrupulous individual," Robert Dickinson, who apparently made his living by exploiting other peoples' inventions, and whose name figures in Trevithick's patents of 1808 and 1809. Neither did he attempt to review at length the latter part of Trevithick's career. Trevithick, he said, was at his zenith during the ten years between 1798 and 1808, and although into his remaining 25 years were crowded sufficient achievement and adventures to fill the lives of two ordinary mortals, the latter phases should not be allowed to protrude too prominently into the picture. Of his work in Cornwall between the time he left London and when he sailed for America, one result was the introduction of his Cornish boiler, which gave Trevithick a claim to our respect and admiration, as the leading pioneer in the construction of boilers designed in accordance with scientific principles.—*Engineering.*

BRANCH NEWS

Calgary Branch

J. Dow, M.E.I.C., Secretary-Treasurer.
W. H. Broughton, A.M.E.I.C., Branch News Editor.

On Monday, April 17th, a dinner meeting was held at the Renfrew Club in honour of the President, Dr. O. O. Lefebvre, M.E.I.C., at which some forty members and guests were present. The President's address was preceded by a musical selection and community singing, from which much amusement was derived. The chairman, H. J. McLean, A.M.E.I.C., introduced the President, who, in his opening remarks, congratulated the Branch on the atmosphere of good fellowship which prevailed.

Dr. Lefebvre spoke on the principal events in the history of The Institute since the days of the Canadian Society of Civil Engineers, and referred to the great strides which had been made in engineering since that time, and the change for the better in public opinion regarding the engineering profession. He referred to the attempt in 1880 to form an engineering society in Canada in which Sir Sanford Fleming, Mr. Plunkett and others took the matter in hand, so that as a result the Society was formed in 1887. At the very outset efforts began looking to the improvement of the profession by enforcing proper conditions for admission.

The Calgary Branch had been formed in 1913 and The Institute had now twenty-five branches, an arrangement which led to closer contact between members in the various localities, and had been of great service to the membership at large. In 1918 the name of the Society was changed to The Engineering Institute of Canada and in 1919, a model act was drafted for Professional Associations in the different provinces. The speaker pointed out that there are now eight provinces where the control of the engineering profession is legally exercised by Provincial Professional Associations. These associations were really the children of The Institute, and the fullest possible measure of co-operation with them was desired.

Speaking of present conditions Dr. Lefebvre outlined the various measures taken by the Council in connection with members who, owing to financial reasons, were unable to pay their fees. A Suspended List had been established so that members in difficulty, upon resuming active membership, could do so without unnecessary formality. He believed that an effort should now be made to bring into The Institute those engineers in charge of responsible work and young graduates leaving the engineering colleges. This could be done if every branch would endeavour to interest young engineers and help them to come in contact with the older members.

Dr. Lefebvre referred to a number of other points in connection with Institute policy and pointed out that for financial reasons it had been necessary to discontinue the E-I-C News, and that it was unlikely that the funds available would permit the publishing of the Year Book or Transactions during the present year. Every effort had been made to limit The Institute expenditure, the salaries of the staff having been reduced and all expenditures carefully scrutinized, the Finance Committee having felt that at this time a balanced budget was a necessity. For this reason it was hoped that as Headquarters would not be able to finance a Plenary Meeting of Council the branches would contribute a part of the funds needed for this purpose.

Dr. Lefebvre referred to the various activities of The Institute, particularly its connection with the National Construction Council of Canada, and its relations with the Provincial Associations.

Following the President's address, Past-President S. G. Porter, M.E.I.C., expressed his pleasure in welcoming the President to Calgary, and commented upon the importance to The Institute of such visits as Dr. Lefebvre was making. For many reasons it was especially desirable that the President should visit the western branches, and he felt sure that Dr. Lefebvre would pilot The Institute through these strenuous times. Mr. Porter drew attention to the importance of holding a Plenary Meeting of Council this year in order to discuss the development and progress of The Institute, and the problems now confronting us.

Immediately following the dinner, and at the request of Dr. Lefebvre, a meeting of the executive committee was held at which Institute affairs were discussed in further detail.

Lethbridge Branch

E. A. Lawrence, S.E.I.C., Secretary-Treasurer.
Wm. Meldrum, A.M.E.I.C., Branch News Editor.

The Lethbridge Branch of The Engineering Institute of Canada held a meeting in the Marquis hotel on Tuesday, April 18th, at which Dr. O. O. Lefebvre, M.E.I.C., President of The Engineering Institute of Canada, was the guest of the evening. George Brown's orchestra presented an enjoyable programme of dinner music and later accompanied the community singing under the able leadership of R. S. Lawrence. Vocal selections by Mrs. L. A. Roy and Mr. G. Evans were heartily appreciated, a point of special interest to the President being a French-Canadian song rendered by Mrs. Roy. The thanks of the Branch was tendered by the chairman, J. Haimes, A.M.E.I.C. Following a brief intermission, Dr. Lefebvre dealt with the problems at present facing The Institute.

He discussed these various problems in detail, suggesting possible improvements and remedies for the ills of the prevailing times. He invited criticisms and suggestions from a western view point. Several ideas were propounded by various members at the close of the Doctor's address and these were later discussed at a meeting of the local executive which the President attended.

London Branch

W. R. Smith, 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 April 19th in the city hall auditorium, presided over by V. A. McKillop, A.M.E.I.C., chairman of the Branch.

By the courtesy of the Otis Fensom Company their representative, Mr. Burgess, gave a talk on the construction of the Empire State building in New York and the Washington bridge over the Hudson river which was illustrated by moving pictures.

Views of the Empire State building, 1,250 feet in height, comprising 80 storeys, showed the erection of the steel and various stages of construction progress. An interesting feature of this was the manner in which the central crane was successively raised after the placement of the steel surrounding it. Instances were shown of the intrepid daring of the erectors who seemed to be as much at home 1,200 feet up in the air as on terra firma. The erection of the steelwork was completed in about six months and well inside the contract time. Views were also shown of the elevator equipment which occupies about one third of the ground floor area. There are fifty-seven elevators installed to meet the transportation requirements of the people using the building—about 15,000. Some of these elevators are for freight purposes only and others for passenger traffic travel at different speeds, the faster only stopping at certain floors.

The Washington suspension bridge films demonstrated the construction activities, beginning with the foundations and anchorage tunnels, then the erection of the towers and the slinging of the temporary cables and the suspension from these of the temporary workmen's footbridge. Next the spinning of the main cables built up to three feet diameter with straight single wire units about ¼-inch diameter. Further views illustrated the hydraulic presses acting in a ring for compacting the wires and the process of annealing the wire by cold pressure. The slinging of the bridge trusses and flooring was also clearly shown and finally the ceremonial opening of the bridge with lanes of traffic passing in either direction.

After the showing of these a film was run showing the construction of the airship Akron which recently met with disaster.

In proposing a vote of thanks to Mr. Burgess, Jno. R. Rostron, A.M.E.I.C., compared the speedy erection methods of modern engineering with the erection of the pyramids in Egypt where only man power was employed aided by the "pry" and inclined plane.

About fifty members and guests were present.

Moncton Branch

V. C. Blackett, A.M.E.I.C., Secretary-Treasurer.

On February 23rd, at a meeting held in the city hall, members of the Branch listened to an interesting illustrated address by W. J. Wright, Ph.D., F.R.S.C., Provincial Geologist, Fredericton, on the subject "Present Development and Future Possibilities of the Mining Industry in New Brunswick."

The Mining Industry in New Brunswick

Dr. Wright commented on the general lack of knowledge as to the value of minerals in the province. As far back as 1861 the mineral production in that year was valued at $300,000., while last year it was over $1,000,000.

Minto coal has hitherto been considered too high in sulphur for commercial coke, but a new process is being tried out in England for the removal of the sulphur and the results are awaited with interest. The coal industry in New Brunswick is flourishing and last year more coal was mined than in any year since 1923. Oil deposits are of a high grade, particularly for lubricating purposes.

Other mining industries in the province have suffered severely from depression, foreign tariffs and lack of protection. For instance, the United States market for gypsum is practically closed on account of the tariff.

Iron and copper have been mined but the ore is of too low grade to compete with foreign ores. Only traces of gold have been found in New Brunswick but the area in the vicinity of the junction of Victoria and Northumberland counties was the best prospecting ground. Tungsten was mined, during the war years at Burnt Hill on the south west Miramichi.

T. H. Dickson, A.M.E.I.C., chairman of the Branch, presided and extended a warm vote of thanks to the speaker.

The Sphere of Influence of the Engineer

On February 27th, before a combined meeting of Moncton Branch and the Engineering Society of Mount Allison, E. G. Evans, M.E.I.C., retired engineer of right-of-way, Canadian National Railways, gave an instructive address on "The Sphere of Influence of the Engineer today in the Business World and what it was 50 years ago." The meeting was held at Sackville in the Science building of the University. D. H. Hayman, president of the Engineering Society, presided and at the close of the address extended the cordial thanks of the gathering to the speaker of the evening.

Fifty years ago, stated Mr. Evans, engineering work was confined mostly to government departments, large railway systems and the construction of large bridges. Construction work, in general, outside these spheres, included, in part, minor railway enterprises, industrial buildings and city water and sewer projects.

Few engineers were university trained. What education they had was obtained in the public schools and from general experience found in engineering offices, in work shops and in field work.

During that period there were but two principal classes or branches of engineering, civil and mechanical, even mining engineering then was not the special branch it is today.

There has also been a great change in recent years in the attitude to and the appreciation of the engineer in contrast with the position he generally occupied in that regard fifty years ago. Not only is the business world dependent on the engineer for the design and execution of all important work of construction, but also for the preliminary investigation that determines whether or not a project will prove a commercial success.

In conclusion, Mr. Evans urged that development of character and personality should accompany efforts to reach a high standard of mental attainment and technical efficiency.

Following Mr. Evans' address, Professor H. W. McKiel, M.E.I.C., spoke briefly, making a strong plea for the upholding of engineering ethics.

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 inspection trip through the Ontario Paper Mill was made on April 26th, the main object in view being an examination of the new thermo-electric boilers.

Some fifty members took part in the expedition and thirty-five remained for dinner at Trinity United Church in Thorold and heard an excellent review of the installation presented by Mr. W. L. Eliason, electrical engineer for the Paper Company. Mr. E. J. Calnan, steam control engineer, assisted Mr. Eliason and by means of diagrams gave a very clear conception of this intricate apparatus.

The yearly electoral meeting was held on May 10th at the Fonthill Golf Club, members of the old and new Executives being the guests of Chairman E. P. Murphy, A.M.E.I.C.

During and after an excellent luncheon, the general business of the Branch was discussed. Plans for the Annual Meeting were approved and the scrutineers announced the result of the recent election. Following this the new Executive went into committee and appointed their officers for the year commencing June 1st, 1933.

The results are as follows:

Chairman	W. R. Manock, A.M.E.I.C.
Vice-Chairman	P. E. Buss, A.M.E.I.C.
Secretary-Treasurer	P. A. Dewey, A.M.E.I.C.
St. Catharines District	L. P. Rundle, M.E.I.C.*
Niagara Falls District	G. C. Mountford, A.M.E.I.C.*
	W. D. Bracken, A.M.E.I.C.
Welland District	J. C. Street, M.E.I.C.
	F. L. Haviland, M.E.I.C.
Port Colborne District	E. P. Murphy, A.M.E.I.C.
	C. N. Geale, A.M.E.I.C.
Fort Erie District	C. S. Boyd, A.M.E.I.C.*
Councillor	E. G. Cameron, A.M.E.I.C.

During the afternoon most of the guests took advantage of a sudden clearing of the weather and played that noble game which, like the bagpipes, came to us via Scotland and causes about the same amount of unrest.

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*New members of the Executive Committee.

Ottawa Branch

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

John Murphy, M.E.I.C., F.A. I.E.E., electrical engineer of the Railway Commission and the Department of Railways and Canals, spoke at the noon luncheon, April 6th, the subject of his address being "Frazil—from 1883 to 1933." The address included personal reminiscences on the speaker's part from the time when he was a small boy to the latest approved methods of the present day for combatting this evil and was illustrated by motion pictures taken during the course of Mr. Murphy's own experiments by the Department of Trade and Commerce, and by lantern slides.

Group Captain E. W. Stedman, M.E.I.C., local chairman, presided, and head table guests, in addition to the chairman and the speaker, included: Hon. C. P. Fullerton, R. H. Coats, Maj. J. G. Parmelee, A. J. Hazelgrove, Col. A. E. Dubuc, M.E.I.C., H. E. M. Chisolm, G. Gordon Gale, M.E.I.C., C. A. Bowman, A.M.E.I.C., R. J. C. Stead, Dr. R. W. Boyle, M.E.I.C., F. C. Badgley, Lieut-Col. W. A. Steel, A.M.E.I.C., and C. McL. Pitts, A.M.E.I.C.

Frazil Ice

Frazil ice, before methods were evolved to overcome it, cost the citizens of this country universal inconvenience with inevitable monetary loss, stated Mr. Murphy. It was often responsible for the cessation of our city waterworks plant, the failure of the electric lighting, and the stopping of our street cars.

The sudden formation of the long, needle-like ice crystals during periods of cold weather, first caused trouble at the Chaudiere Falls, stated Mr. Murphy, shortly after 1800 when settler Wright started to grind his corn and saw his logs with water power. For the next hundred years such inconveniences were accepted as a part of the normal routine of our winter seasons. Now, however, due to persistent study despite much discouragement, the problem of overcoming frazil ice has been solved and this menace need no longer be of public concern.

When water is in the neighborhood of the freezing point, investigation has revealed the fact that a drop of one or two thousandths of a degree (or even less under certain conditions) in its temperature may result in tremendous physical changes. Under such conditions anchor ice will cling to solids and frazil ice will float upon the surface. On the other hand, in combatting this ice formation a raising of the water temperature above the freezing point by a like infinitesmal amount is all that is required to prevent this ice formation.

Working upon this basis heating units may be designed for raising the temperature of the vital parts that are likely to be incommoded by the ice formation. Such heating units may employ either steam or electric current. Since the raise in temperature required is extremely small the amount of heat required is likewise not great and the method is one of economy.

A variation of this, used frequently in front of the head gates of power plants, is what is known as the "bubble system" wherein, by means of a small-diameter pipe, a jet of compressed air is introduced below the surface of the water in front of the gates.

At the conclusion of the address, A. J. Hazelgrove, chairman of the Ottawa chapter of the Ontario Association of Architects, acting on behalf of that organization, extended an invitation to the local members of The Institute to be present at a motion picture screening of the construction of the Empire State building and also of the new George Washington bridge over the Hudson river.

"Forerunners of Modern Chemistry"

L'Abbe Alexandre Vachon, Dean of the Department of Chemistry, Laval University, Quebec, addressed the noon luncheon meeting of the local Branch on Thursday, May 11th, the subject of his address being "Forerunners of Modern Chemistry." Group Captain E. W. Stedman, M.E.I.C., chairman, presided at the luncheon, and in addition to the chairman and speaker the head table guests, who were all graduates of Laval University, were as follows: Honourable Alfred Duranleau; Honourable Maurice Dupre; Onesime Gagnon, M.P.; Georges Bouchard, M.P.; Oscar Boulanger, M.P.; E. R. Faribault; Jules Desrochers; T. Maher; R. Blais; G. J. Desbarats, M.E.I.C.; J. E. St. Laurent, M.E.I.C.; A. Lafleche, A.M.E.I.C.; and A. Langlois, A.M.E.I.C.

Abbe Vachon in his address, which was illustrated by lantern slides, described the work of the early alchemists whose discoveries eventually led up to the modern science of chemistry.

Animated by a diversity of interests varying from lust for wealth to a detached passion for science, stated the speaker, the alchemists of old, balked in their search for the philosopher's stone that would transmute base metals into gold, came at last into their own, with the changing of time that brought forth modern science.

Alchemy, from the same root as the modern word chemistry—Chemia, sacred name for Egypt, plus the particle "al"—he said was not altogether trickery. Modern science has discovered that all elements were transmutable, although the feat of transmuting them was still a matter of obscurity.

The old alchemy recognized four elements: fire, which in point of fact is an accident; earth, which happens to contain all the elements; air, which is a mixture of several elements; and water, which is a compound of two elements. They recognized four states in which elements could exist: hot or cold, wet or dry. Gold which resisted acids, fire and time, was the most noble of metals and lead was the basest.

But their work was not wasted for they founded that school of science that makes experiments and proceeds by way of observation and inference. Their discoveries, hidden often enough in cabalistic formulae, found fruit in the introduction of gun-powder, dyeing and many other early chemical successes. They filled with gold the coffers of the princes who kept them, if they did not actually discover the way of making gold. Even though accused of trafficking with the supernatural, they included in their ranks such deeply religious men as St. Albert and Roger Bacon.

Modern chemistry does not consider transmutation of metals to be an idle dream. It is recognized that nature, under God's law of nature, accomplishes the change of elements to each other by radio-active processes though, so far, those changes cannot be initiated or controlled in the laboratory. It is recognized that any transmutation would cost many times the value of the product. Perhaps a catalyst, a modern philosopher's stone, will be discovered and if once the stores of atomic energy are unlocked there is no limit to the possibility of the future.

The laboratories of the research workers of today differ somewhat from those of the alchemists of the 16th century, but the spirit of the workers is the same: they desire to extend the limits of human knowledge. Some there are, as in the past, who have a desire to get rich: they are not the real men of science. Remuneration, as the world understands it, for work done or results obtained is the last thought of the true scientific research worker.

That was the spirit that animated the great alchemists of the school of St. Albert the Great and Leonardo da Vinci. They worked diligently to know what was the constitution of matter and to extend the limits of knowledge.

Quebec Branch

Jules Joyal, A.M.E.I.C., Secrétaire-Trésorier.

TROIS CAUSERIES

Lundi soir, le 24 avril 1933, la Section de Québec réunissait ses membres dans l'une des vastes salles du Palais Montcalm, le but de cette assemblée était de mettre en vedette le groupe des jeunes ingénieurs locaux et le programme comportait trois brièves causeries à cet effet.

Les conférenciers furent présentés par le président de la Section, M. Hector Cimon, M.E.I.C.

DU CONTRÔLE DES SERVICES PUBLICS ET L'INGÉNIEUR

Dans une première causerie intitulée "Du contrôle des services publics et l'ingénieur", M. J.-U. Archambault, A.M.E.I.C., ingénieur de la Commission des services publics de Québec, exposa que la compétition, l'une des premières formes de contrôle auxquelles furent soumises les entreprises d'utilité publique, tout en étant d'une excellence incontestable dans la plupart des opérations économiques, n'a généralement pas donné satisfaction dans le domaine des services publics.

La multiplicité des systèmes a bientôt fait périr ceux-ci pour faire place aux monopoles, ce qui a amené nos législateurs à créer des corps compétents pour entendre et régler les controverses qui s'élèvent entre les services publics et le public lui-même.

"Dans la province de Québec", nous dit M. Archambault, "le contrôle sur les services publics est exercé par la Commission des services publics de Québec".

Le conférencier fit alors un bref historique de cette commission puis en arriva à expliquer le rôle qu'y joue l'ingénieur.

"Les requêtes pour services électrique, téléphonique, d'aqueduc, d'autobus, etc., sont soumises à des ingénieurs chargés de s'assurer que les appareils, outillages ou matériaux employés sont propres à assurer la sécurité publique de même qu'un service aussi bon et efficace que possible."

"Les ingénieurs sont aussi appelés à faire des recherches et à suggérer les moyens de remédier aux causes de mauvais services."

Le conférencier termine en disant que la profession a raison d'être fière du rôle qu'elle joue dans ce domaine, rôle qui est destiné à s'accroitre de plus en plus.

"GENERAL ECONOMICS OF TELEPHONE BUSINESS"

Vint ensuite M. G. D. Moon, Jr.E.I.C., du Bell Telephone Co. of Canada dont la conférence avait pour titre "General Economics of Telephone Business".

M. Moon a commencé par dire quelques mots sur l'utilité, la quasi-nécessité générale du téléphone puis il a montré ce que les grandes organisations du genre cherchent à réaliser pour donner satisfaction à leur clientèle; il a ensuite fait ressortir les avantages d'un monopole pour ce genre de service en disant qu'autrement un client devrait avoir un appareil pour chaque système établi.

Le conférencier a aussi démontré que la valeur du service rendu à un abonné par son appareil téléphonique est proportionnelle au nombre d'appareils avec lesquels il peut être raccordé directement, et il a signalé en particulier que les taux sont forcément plus élevés dans les villes que dans les campagnes parce que chaque appareil est utilisé plus souvent, et que les raccordements centraux exigent plus de frais de même que l'installation extérieure.

LA CONSTRUCTION DU RÉSERVOIR DES CHAMPS DE BATAILLE

Le troisième conférencier fut M. Ludger Gagnon, assistant-ingénieur de la cité de Québec, qui nous parla de "La construction du Réservoir des Champs de Bataille".

M. Gagnon commença par un bref historique des faits qui ont amené la construction de ce réservoir puis nous fit voir le soin avec lequel on a procédé à la confection des plans et devis; il a attiré particulièrement l'attention sur les préoccupations d'économie qui ont présidé à la conception de ces travaux.

Le conférencier a exposé que le réservoir a été recouvert pour des raisons d'hygiène et d'économie d'abord et en outre pour se conformer à la décision rendue par la Commission des Champs de Bataille. Il a expliqué que le même soin d'économie a guidé les ingénieurs dans la préparation des plans pour toutes les parties des travaux: Murs, colonnes, planchers, couverture, mur de division, etc. . . .

Le conférencier termine en disant que tout en économisant on n'a rien épargné pour obtenir un réservoir au fonctionnement efficace et en même temps simple et adéquat.

M. Gagnon a ensuite produit les plans complets du réservoir et tous ont pu les consulter à leur gré et obtenir des renseignements supplémentaires.

Les conférenciers furent très applaudis et quelques mots de remerciements leur furent adressés par le secrétaire de la Section, J. Joyal, A.M.E.I.C.

Assistance: 42.

Saint John Branch

Sidney Hogg, A.M.E.I.C., Secretary-Treasurer.
C. Gordon Clark, S.E.I.C., Branch News Editor.

The annual meeting of the Saint John Branch of The Engineering Institute of Canada was held on May 14th, 1933, at the Riverside Golf and Country Club. A. A. Turnbull, A.M.E.I.C., retiring chairman of the Branch, presided.

During the banquet following the toast to the King, the toast to The Engineering Institute of Canada was proposed by H. R. Montgomery, A.M.E.I.C., who stressed the value of The Institute to its members and said he looked to an even more successful year for the Branch next year. S. R. Weston, M.E.I.C., in responding, delivered an amusing address on ornithology.

A. A. Turnbull, A.M.E.I.C., addressed the meeting on the "Great Pyramid of Egypt." He said that a study of the pyramid showed the engineers of those days had in many ways as much scientific knowledge at their command as those of the present. Mr. Turnbull announced that a Maritime General Professional Meeting of The Engineering Institute of Canada would be held in Liverpool, N.S., during July.

Officers elected for the coming season were as follows:

Chairman	G. A. Vandervoort, A.M.E.I.C.
Vice-Chairman	E. J. Owens, A.M.E.I.C.
Secretary-Treasurer	Sidney Hogg, A.M.E.I.C.
Executive	F. M. Barnes, A.M.E.I.C.
	Captain W. H. Blake, A.M.E.I.C.

Reports were presented from the following committees:

Audit	E. J. Owens, A.M.E.I.C.
Entertainment	S. Hogg, A.M.E.I.C.
Publicity	C. G. Clark, S.E.I.C.
Salaries	S. R. Weston, M.E.I.C.
Employment	J. A. W. Waring, A.M.E.I.C.

The reports presented showed that the Branch had enjoyed a highly successful year, ending the season with an increased credit balance. An increase in membership was reported.

Feeling reference was made to the memory of the late George H. Waring, A.M.E.I.C., and Stanley C. Webb, A.M.E.I.C., who had died during the year.

Saskatchewan Branch

Stewart Young, A.M.E.I.C., Secretary-Treasurer.

A special meeting of the Branch was held in the Parliament Buildings, Regina, on Thursday evening, April 20th, 1933, being preceded by a dinner at which thirty-three were in attendance.

The purpose of the meeting was to meet the President of The Institute, Dr. O. O. Lefebvre, M.E.I.C., and he was introduced by D. A. R. McCannel, M.E.I.C. P. C. Perry, A.M.E.I.C., acted as chairman.

THE PRESENT STATUS OF THE ENGINEERING INSTITUTE OF CANADA

In introducing his subject "The Present Status of The Engineering Institute of Canada," Dr. Lefebvre pointed out that, due to present economic conditions The Institute was obliged to devise ways and means of offsetting loss of revenue through decreased membership. He pointed out that where engineers are obliged to withdraw from The Institute for financial reasons it is the policy of the Council to suggest the advisability of their being placed on the suspended list rather than that they resign. By so doing, resumption of membership when times become normal is facilitated.

In order to balance its budget The Institute has been obliged to reduce salaries to the extent, approximately, of twenty-five per cent.

Consideration is being given to the non-publication of the Year Book, experience having shown that after the lapse of six months from publication twenty per cent. of the addresses are out-of-date.

Dr. Lefebvre mentioned that normally the transactions should be published this year. However, the publication of the transactions may have to be allowed to stand.

Up to the present time the Journal has been self-supporting but through decreased advertising it may show a deficit for the coming year.

With respect to this year's Plenary Meeting of Council, the same can only be held on financial support being given by the Branches.

After briefly recounting the financial problems of The Institute, Dr. Lefebvre dealt with several items of criticism levelled at the administrative body, the Council. He pointed out that criticism was frequently aimed at the Journal. At the same time it must not be forgotten that the contents of the Journal depend entirely on the contributions of the members.

With respect to the relations of The Institute with the several Associations of Professional Engineers, the President briefly outlined the history and the growth of The Institute, leading ultimately to the organization of the several Provincial Professional Associations. These bodies are, therefore, the offspring of The Institute. The function of the individual Professional Association is to control the legal aspects of the engineering profession while The Institute aims to raise the professional status of the individual engineer. A Committee of Eight, representative of the provincial associations has reported along certain lines while The Institute, through its Committee on Development, has reported along other lines. These two points of view must be brought together.

Dr. Lefebvre dealt more particularly with the report of the Committee on Development, pointing out that while the report before being finally adopted must undergo many changes, the fact remained that even though it is not finally adopted, the discussion created across Canada by the preliminary report has been most beneficial to The Institute generally. In closing Dr. Lefebvre requested the greatest cooperation from the individual members of The Institute towards determining the contents of the final report.

Immediately before adjourning J. M. Campbell, A.M.E.I.C., Moose Jaw, congratulated Dr. Lefebvre on the excellency of his address, moving a vote of thanks. This was seconded by H. S. Carpenter, M.E.I.C., and carried unanimously.

The meeting adjourned at 10.30 p.m.

Sault Ste. Marie Branch

G. H. E. Dennison, A.M.E.I.C., Secretary-Treasurer.

The regular monthly meeting of the Sault Ste. Marie Branch was held on April 28th 1933, at the Windsor Hotel, being preceded by a dinner. About thirty-five members attended the meeting.

A committee consisting of Carl Stenbol, M.E.I.C., L. R. Brown, A.M.E.I.C., and E. M. MacQuarrie, A.M.E.I.C., which had been appointed by the Executive to study and report on the question of Development of The Institute, brought in a report whose principal recommendations were:—

1. That the class of Honorary Member be retained and a new classification called Patrons be instituted to provide for distinguished persons, not members of The Institute.
2. That the Student and Affiliate classifications be retained as at present but that a more suitable name should be substituted for Associate Members.
3. Qualifications for membership should be retained as at present.
4. Fees should not be increased.
5. The President of The Institute should be nominated on the advice of the three previous Presidents.
6. The existing code of ethics should be retained.

After an extended discussion the report was adopted.

The decision of the Ontario government to abandon all road maintenance in Northern Ontario this year was brought to the attention of the meeting through a resolution submitted to the Executive by E. M. MacQuarrie, A.M.E.I.C., and a resolution sponsored by R. H. Burns, Jr.E.I.C., and L. R. Brown, A.M.E.I.C., pointed out the loss which must result from neglecting maintenance work on clay and gravel roads and the necessity of maintaining the highways from the agricultural and tourist point of view, and urged the Department to reconsider their decision. Some of the members present thought that it would be inconsistent to demand a continuance of government expense in the face of a general demand for economy in government, but after some debate an amendment embodying the text of the original resolution was adopted unanimously.

Forest Conservation in Ontario

At the conclusion of the business meeting a paper was presented by Mr. Nagel Kensit, district forester for the Department of Lands and Forests. Mr. Kensit's talk dealt with "Some Aspects of Forest Conservation in Ontario" and was amplified by maps and an exhibit of some of the equipment used in fighting forest fires. A very interesting discussion followed the paper.

Vancouver Branch

A. I. E. Gordon, Jr.E.I.C., Secretary-Treasurer.

The Petroleum Industry in Canada

On March 13th, an evening meeting of the Vancouver Branch was held in the auditorium of the Medical Dental building when about thirty-five members and friends were present.

Mr. A. D. Grant, superintendent of the Imperial Oil Refineries Ltd., Ioco, B.C., spoke on various phases of the petroleum industry in Canada. He touched briefly on production and refining methods and dealt in some detail with transportation and marketing. He concluded by giving a well-considered analysis of the public attitude to the oil industry and the oil companies' attitude to the public.

In answer to questions the speaker explained the manufacture of lubricating oils, waxes and greases as carried on at the Imperial Oil Refinery at Sarnia. In this connection the "cracking" process of refining gasoline by heating certain grades of crude oil to temperatures around 700 degrees C. when over 20 per cent gasoline may be obtained was dealt with in some detail. The use of ethyl fluid in gasoline and the use of the "octane rating" as a measure of the anti-knock effect was also explained and was of great interest.

A vote of thanks was moved by W. O. Scott, A.M.E.I.C.

The meeting was held as a sequel to the inspection trip of the Vancouver Branch to Ioco refinery on March 4th, and in his closing remarks the chairman paid tribute to Chas. Hamilton, A.M.E.I.C., for arranging with Mr. Grant for both affairs.

Open House at the University of British Columbia

An open house sponsored by the University of British Columbia Engineering Society was held on March 11th, 1933, and was attended by nearly six thousand persons.

Visitors were conducted through the various laboratories where processes illustrating phases of industry in British Columbia were on exhibition. For example, in the Forest Products laboratory, a department operated by the Federal government, telephone poles were broken in a 100-ton hydraulic press. In the mining building a complete process for converting ore into smelted metal was demonstrated. Demonstrations were also given in the electrical engineering and geological laboratories and in a number of mechanical engineering departments.

Joint Meeting with A.I.E.E.

On Monday, April 3rd, a joint meeting with the local branch of the A.I.E.E. was held in the auditorium of the Medical Dental building with Mr. G. R. Wright, A.M.E.I.C., chairman of that body, presiding. An enthusiastic audience heard Professor E. G. Cullwick, Jr.E.I.C., deliver a most interesting address on "Electronic Valves and Their Application."

This paper received honorable mention in competition for The Engineering Institute of Canada Past-Presidents' Prize in 1932.

Electronic Valves and Their Application

The Speaker stated "a true electronic valve is a two-electrode tube, with photo-emissive cathode, vacuum or gas-filled, and is of ever-increasing importance." He then discussed the general principles, use and applications of electronic valves in some detail.

If two electrodes only are used the tube is called a diode. Applications of the diode are as rectifiers in wireless and telephone circuits, to obtain d.c. from mains for radio sets, to obtain high voltage d.c. from low power for x-rays, etc. A 400,000-volt x-ray tube has been built using four 100,000-volt diodes in series.

When a grid or control electrode is added the tube is called a triode. Applications are as a detector of radio signals, as an amplifier, etc. The triode has made radio, and has made possible radio telephone, radio direction finders, etc.

Other applications of electronic valves are the mercury-arc rectifier, photo electric cell, the gas-filled photo-cell which has made possible the talkies, photo-telegraphy, television, light measurement and analysis, and the control of apparatus by light.

Professor Cullwick concluded by stating that the electronic valve is essentially a device which gives as great and sensitive control over electric current as one would have if by placing a finger in Niagara he would stop the stream. When we deal with the electron we are very close to the fundamental basis of our universe and in the increase in our control over it lies our hope of increasing our mastery over the physical world.

After some discussion a vote of thanks was moved to the speaker and the meeting adjourned.

Winnipeg Branch

E. W. M. James, A.M.E.I.C., Secretary-Treasurer.
E. V. Caton, M.E.I.C., Branch News Editor.

On Thursday, April 6th, at the regular meeting of the Branch presided over by Professor G. H. Herriot, M.E.I.C., chairman, a paper was read by Professor E. P. Fetherstonhaugh, B.Sc., M.E.I.C., Dean of the Faculty of Engineering and Architecture, University of Manitoba, on "The Photoelectric Tube."

The Photoelectric Tube

The speaker dealt first with the fundamental ideas of electron physics as a background for the study of the phenomena of photoelectricity. The historical development of the cell or tube was outlined from the time of Hertz's first discovery of the photoelectric effect up to the present time. The amplifier as an auxiliary device in photoelectric circuits was explained and various relays of both the electronic and electromagnetic types were referred to. In the second part of the paper numerous industrial applications of the photoelectric tube were mentioned and its use in talking-movie apparatus and in television systems was explained in some detail. The lecture was illustrated with lantern slides and at its conclusion some demonstrations were given of the action of light beams in operating various devices through the medium of the photoelectric tube, amplifier and relay.

A large number of visitors were present and the discussion which followed the paper indicated the interest of the meeting in the subject.

Ferranti Surge Absorber

On Friday, April 21st, a meeting was addressed by A. B. Cooper, M.E.I.C., his subject being the "Ferranti Surge Absorber." Mr. Cooper dealt with the problem of protection of transformer equipment from lightning and other causes and indicated lines along which such protection should be carried out. He described a device which has been developed to give the necessary protection and discussed in detail its advantages. He also showed in moving pictures an hydraulic analogy, which was extremely interesting and which in the speaker's opinion represented what occurred in the apparatus. In the discussion which took place after the paper several of the members questioned Mr. Cooper and the resulting debate was of value and interest to all concerned.

INSTITUTE AFFAIRS

At the same meeting the Branch had the honour of being addressed by Dr. O. O. Lefebvre, M.E.I.C., President of The Institute, on Institute affairs, particularly with reference to retaining present members and increasing membership among those eligible wherever possible.

On Saturday noon, April 22nd, a luncheon was tendered to the President by the local Branch at the Fort Garry hotel. Professor G. H. Herriot, M.E.I.C., was in the chair. Some forty members were present. Dr. Lefebvre first gave a short talk on the Quebec Streams' Commission, and after the talk discussed the relations of The Institute to the Professional Associations. The interest of the Branch in the matter is best indicated by the fact that the meeting did not break up until after 5 p.m.

DEVELOPMENT OF PORT CHURCHILL

A special luncheon meeting was held on Tuesday, April 25th, at the Hudson's Bay Store to meet Geo. Kydd, A.M.E.I.C., engineer in charge of the development of Port Churchill. Mr. Kydd was introduced to the members by the chairman, Professor G. H. Herriot, M.E.I.C., and after the luncheon addressed the Branch on the Development of Port Churchill, showing a number of lantern slides describing the work in detail. A large number of members were present and the appreciation of the Branch was expressed to Mr. Kydd by H. A. Dixon, A.M.E.I.C.

Department of Mines, Ottawa

Among the Departments of the Civil Service in Ottawa concerned with engineering work the Department of Mines is one of the most important. It was established to further the development of the mining and metallurgical industries of the Dominion, and its activities cover all phases of mineral development from geological exploration to the marketing and utilization of finished mineral products. The present organization of the Department includes the Geological Survey, the Mines Branch, the National Museum, and the Explosives Division.

GEOLOGICAL SURVEY

The Geological Survey was organized in 1842 under the leadership of Sir William Logan, and its chief function is the collection and correlation of information regarding the geology of Canada. For this purpose, it carries out geological investigations in the field, the results of which, when worked up in the office and laboratory, are published and made available to prospectors, mining engineers, and others concerned in the development of our mineral resources. Incidentally, the Geological Survey prepares and publishes the maps necessary for geological work.

The Survey's attention is mainly directed to the regions of Canada whose geological history is such as to make them promising from a mining and metallurgical standpoint. An outstanding example of the investigations carried out in such an area is the work of the Survey since 1930 in connection with the radium and silver deposits of the Great Bear Lake district, the development of which is based directly on information made available by the Geological Survey.

The Geological Survey also investigates problems met with in the more specialized branches of geology, such as palæontology.

MINES BRANCH

The Mines Branch of the Department of Mines is devoted to the productive side of the industry as distinguished from the discovery and investigation of mineral resources.

Its work has to do with methods of treatment of ores, smelting of metals, and the industries connected with non-metallic mineral products. Its functions are of a highly technical character, and have for their main object the collection and distribution of information available to the mining, metallurgical and allied industries. The tests and investigations of the Mines Branch are made in its laboratories by the various divisions of mineral resources, fuels and fuel testing, ore dressing and metallurgy, ceramics, and road materials and chemistry. As an example of the researches may be taken the work of the Division of Fuels and Fuel Testing in the investigation of all grades of domestic coals, with a view to determining their character and usefulness.

THE NATIONAL MUSEUM

The National Museum is the repository for specimens and objects of scientific value of all kinds, and contains public exhibits representative of the natural resources of the country. Its scope, therefore, includes, in addition to geology and its related sciences, many specimens of interest in connection with geology, biology, anthropology and archæology.

EXPLOSIVES DIVISION

The functions of the Explosives Division deal rather with administration than with technical research. This Division has the duty of administering the Explosives Act, under which the manufacturing, testing, storage and importation of explosives are regulated. The arrangement and operation of explosives factories, the storage of explosives and their transportation, are all subject to regulations which are enforced by the Explosives Division, with the assistance of the Royal Canadian Mounted Police. The Division is, of course, responsible for investigations in respect to accidents in explosives factories or where explosives have been concerned.

DOMINION FUEL BOARD

Allied to the Mines Branch organization is the Dominion Fuel Board, created in 1922 and composed of eight officials of the Mines Branch and the Department of the Interior. Under this Board a comprehensive programme has been carried out, largely by the technical branches of the two Departments concerned, dealing with such problems as the possibility of central and district heating in Canada; house insulation, house heating, the possibility of providing substitute fuels for the normal consumption of American anthracite in central Canada, and similar problems of this nature.

Employment of Heat-Insulating Materials in Residential Buildings

Investigations by the Dominion Fuel Board into the employment of heat-insulating materials in residential buildings have disclosed undoubted benefits to home owners in the wider use of such materials; the construction industries would benefit if the merits of these materials were more generally understood. Insulation is now known as an efficient means of preventing excessive heat leakage in winter and its use results in large economies in fuel. It is not so generally appreciated that the same treatment of buildings helps greatly to alleviate the scorching heat of summer. Insulating practices are not only applicable in the building of new homes but many of the materials can be applied at moderate cost to the improvement of homes already built.

The Board has issued a new publication, the third of an insulation series, entitled "The Insulation of New and Old Houses" and believes that present low costs should greatly encourage the use of the class of materials known as heat insulators. These include products both vegetable and mineral in composition, derived from forest, farm and mine, and their manufacture in many cases renders products valuable that would otherwise be waste.

The utilization of coarse fibre screenings and waste paper increases efficiency in pulp and paper industries; mill edgings, slabs and saw-mill waste provide material for secondary manufacturing plants in the production of rigid insulating fibre boards; fishermen in the Maritimes find profitable part time employment in collecting eel grass; and cattle hair, scrap gypsum board, fibrous peat and flax straw are other waste or semi-waste materials that find profitable uses in the manufacture of building insulation. It is expected that certain deposits of Canadian limestone of suitable composition will come into use for the manufacture of rock wool.

The author of the booklet, G. D. Mallory of the National Development Bureau, Department of the Interior, describes the various avenues of heat escape and deals with the methods of applying insulation in dwellings. Nineteen pages are devoted to the problems of the owner of the home built before modern insulating practices came into vogue as a means of attaining fuel economy. Mr. Mallory points out that unavoidable losses amount to about 30 per cent of the total heat escape from uninsulated houses. Of the remaining 70 per cent—the so-called avoidable losses—from 40 to 60 per cent, or 28 to 42 per cent of the total loss, may be economically prevented in the average new house by employing an adequate thickness of insulation.

What remedy is in sight for the owner of an old house? The author states that results from insulating unfinished attics of many old houses of medium size indicate fuel savings of one-half to two tons of coal per year. Further fuel savings are possible if it is feasible to insulate the walls and there is the added consideration of greater comfort enjoyed in both summer and winter, not to mention increased fireproofness, decreased noise and enhanced property value.

Copies of this publication may be obtained from the National Development Bureau, Department of the Interior, or the Dominion Fuel Board at Ottawa. A charge of 15 cents per copy is made to cover cost of printing.

World Power Conference—Sweden

The World Power Conference, a permanent international organization, has decided through its international executive committee in London that a sectional meeting will be held in Stockholm, Sweden, from the 26th of June to the 10th of July this year. At this meeting the energy problems of large-scale industry and transport will be considered.

Official invitations have been sent by the Swedish National Committee to corresponding committees in the countries which have joined the World Power Conference.

In connection with this sectional meeting, opportunities will be given to the participants to make excursions to industrial plants in and near Stockholm and plans have also been made for a number of alternative excursions to important industrial districts in Sweden, Denmark, Finland and Norway.

The secretary of the Canadian National Committee is Norman Marr, M.E.I.C., Norlite Building, Ottawa, Ontario, from whom further particulars can be obtained.

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

Capital Wanted

Small investment required by engineer to manufacture and market newly perfected radio interference eliminating device. A number now in successful operation. Apply to Box No. 991-W.

Situations Wanted

ELECTRICAL AND RADIO ENGINEER, B.Sc., '28. Experience in the design and testing of broadcast radio receivers, including latest superheterodyne practice, and capable of constructing apparatus for testing same Also familiar with telephone and telephone repeater engineering. Thorough experience in design, and construction and inspection of municipal power conduits. Apply to Box No. 12-W.

MECHANICAL ENGINEER, Canadian, with technical training and executive experience in both Canadian and American industries, particularly plant layout, equipment, planning and production control methods, is open for employment with company desirous of improving manufacturing methods, lowering costs and preparing for business expansion. Apply to Box No. 35-W.

MECHANICAL ENGINEER, A.M.E.I.C. Married. Experience in machine shops, erection and maintenance of industrial plant mechanical and structural design. Reads German, French, Dutch and Spanish. Seeks any suitable position. Apply to Box No. 84-W.

YOUNG ENGINEER, B.A., B.Sc., A.M.E.I.C., R.P.E., Ont. Competent draughtsman and surveyor. Eight years experience including design, superintendence and layout of pulp and paper mills, hydro-electric projects and general construction. Limited experience in mechanical design and industrial plant maintenance. Apply to Box No. 150-W.

PURCHASING ENGINEER, graduate mechanical engineer, Canadian, married, 34 years of age, with 13 years' experience in the industrial field, including design, construction and operation, 8 years of which had to do with the development of specifications and ordering of equipment and materials for plant extensions and maintenance; one year engaged on sale of surplus construction equipment. Full details upon request. Apply to Box No. 161-W.

STRUCTURAL ENGINEER, B.A.Sc., '15, A.M.E.I.C., R.P.E., (Ont.) Married. Experience in structural steel and concrete includes ten years design, five years sales, two years shop practice and erection, and one year advertising. Available at two weeks notice. Apply to Box No. 193-W.

CIVIL ENGINEER, age 44, open for employment anywhere, experience covers about 20 years' active work, including 7 years on municipal engineering, 2 years as Town Manager, 3 years on railway construction, 3 years on the staff of a provincial highway department, 2 years as contractor's superintendent on pavement construction. Apply to Box No. 216-W.

REINFORCED CONCRETE ENGINEER, B.Sc., P.E.Q., eight years experience in construction design of industrial buildings, office buildings, apartment houses, etc. Age 30. Married. Apply to Box No. 257-W.

MECHANICAL ENGINEER, B.Sc., McGill '19. Twelve years experience including oil refining power plant, structural and reinforced concrete design, factory maintenance, steam generation and distribution problems, heating and ventilating. Available at once. Location immaterial. Apply to Box No. 265-W.

ELECTRICAL ENGINEER, B.Sc., '28, Canadian. Age 25. Experience includes two summers with power company; thirteen months test course with C.G.E. Co.; telephone engineering, and the past thirty months with a large power company in operation and maintenance engineering. Location immaterial and available immediately. Sales or industrial engineering desirable. Apply to Box No. 266-W.

PLANE-TABLE TOPOGRAPHER, B.Sc., in C.E. Thoroughly experienced in modern field mapping methods including ground control for aerial surveys. Fast and efficient in surveys for construction, hydro-electric and geological investigations. Apply to Box No. 431-W.

ELECTRICAL ENGINEER, B.Sc., A.M.E.I.C., Am.A.I.E.E., age 30, single. Eight years experience H.E. and steam power plants, substations, etc., shop layouts, steel and concrete design. Location immaterial. Available immediately. Apply to Box No. 435-W.

Situations Wanted

CIVIL ENGINEER, B.A.Sc., A.M.E.I.C., Jr.A.S.C.E., age 28, married. Experience: construction, design, cost estimating on hydro-electric and storage work, also railway. Desires work in engineering, industrial or commercial fields. Available at once. Apply to Box No. 447-W.

CIVIL ENGINEER, B.Sc., A.M.E.I.C., with six years experience in paper mill and hydro-electric work, desires position in western Canada. Capable of handling reinforced concrete and steel design, paper mill equipment and piping layout, estimates, field surveys, or acting as resident engineer on construction. Now on west coast and available at once. Apply to Box No. 482-W.

MECHANICAL ENGINEER, B.Sc. Age 28, married. Four and a half years on industrial plant maintenance and construction, including shop production work and pulp and paper mill control. Also two and a half years on structural steel and reinforced concrete design. Located in Toronto. Available at once. Apply to Box No. 521-W.

CIVIL ENGINEER, Canadian, married, twenty-five years' technical and executive experience, specialized knowledge of industrial housing problems and the administration of industrial towns, also town planning and municipal engineering, desires new connection. Available on reasonable notice. Personal interview sought. Apply to Box No. 544-W.

Minor Repairs then—More Extensive Plant Alterations

As illustrating the advantages at times to be gained through unemployed engineers locating and accepting work of a very minor character, the following may be cited.

Through the kindness of a member of The Institute it was brought to the attention of the Employment Service Bureau that a small soap manufacturing company wished to make a few alterations in a piece of their equipment. An unemployed mechanical engineer was placed in touch with the firm and he found that by redesigning the equipment in question at very small expense it could be made to function much more effectively. He submitted the sketches of the new design which were accepted, and the work proceeded under his supervision. His remuneration for the four or five days he was occupied amounted to $25.00.

A month or so later the same firm, pleased with the altered equipment, decided to make fairly extensive alterations in several other machines, with the idea of improving their product and increasing production. They therefore asked the same engineer to undertake this work and submit sketches. This eventually resulted in his receiving about $150.00, with the prospect of further work of a similar nature in the near future.

ELECTRICAL AND MECHANICAL ENGINEER, B.Sc., A.M.E.I.C. Experience includes C.G.E. Students Test Course and six years in engrg. dept. of same company on design of electrical equipment. Four summers as instrumentman on surveying and highway construction. Recently completed course in mechanical engineering. Available at once. Location preferred Ontario, Quebec, or Maritimes. Apply to Box No. 564-W.

MECHANICAL ENGINEER, A.M.E.I.C., with twenty years experience on mechanical and structural design, desires connection. Available at once. Apply to Box No. 571-W.

MECHANICAL ENGINEER, B.A.Sc., '30, desires position to gain experience, and which offers opportunity for advancement. Experience in pulp and paper mill and one year in mechanical department of large electrical company. Location immaterial. Available immediately Apply to Box No. 577-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.

MECHANICAL ENGINEER, Canadian, technically trained; eighteen years experience as foreman, superintendent and engineer in manufacturing, repair work of all kinds, maintenance and special machinery building. Location immaterial. Available at once. Apply to Box No. 601-W.

Situations Wanted

CHEMICAL ENGINEER, S.E.I.C., B.Sc., University of Alberta, '30. Age 31. Single. Six seasons' practical laboratory experience, three as chief chemist and three as assistant chemist in cement plant; one year's p.g. work in physical chemistry; three years' experience teaching. Desires position in any industry with chemical control. Available immediately. Apply to Box No. 609-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.

CIVIL ENGINEER, A.M.E.I.C., R.P.E., Ontario; three years construction engineer on industrial plants; fourteen years in charge of construction of hydraulic power developments, tower lines, sub-stations, etc.; four years as executive in charge of construction and development of harbours, including railways, docks, warehouses, hydraulic dredging, land reclamation, etc. Apply to Box No. 647-W.

MECHANICAL ENGINEER, A.M.E.I.C., Canadian, technically trained; six years drawing office. Office experience, including general design and plant layout. Also two years general shop work, including machine, pattern and foundry experience, desires position with industrial firm in capacity of production engineer or estimator. Available on short notice. Apply to Box No. 676-W.

ELECTRICAL ENGINEER, B.Sc., '29, Jr.E.I.C. Age 26. Undergraduate experience in surveying and concrete foundations; also four months with Canadian General Electric Co. Thirty-three months in engineering office of a large electrical manufacturing company since graduation. Good experience in layouts, switching diagrams, specifications and pricing. Best of references. Available immediately. Apply to Box No. 693-W.

MECHANICAL ENGINEER, B.Sc., '27, Jr.E.I.C. Four years maintenance of high speed Diesel engines units, 200 to 1,300 h.p. Also maintenance of D.C. and A.C. electrical systems and machinery. Draughting experience. Westinghouse apprenticeship course. Practical mechanical and electrical engineer with a special study of high speed Diesel engine design, application and operation. Location in western or eastern Canada immaterial. Apply to Box No. 703-W.

COMBUSTION ENGINEER, R.P.E., Manitoba. A.M.E.I.C. Wide experience with all classes of fuels. Expert designer and draughtsman on modern steam power plants. Experienced in publicity work. Well known throughout the west. Location, Winnipeg or the west. Available at once. Apply to Box No. 713-W.

YOUNG ENGINEER, B.A.Sc., (Univ. Toronto '27), Jr.E.I.C. Four years practical experience, buildings, bridges, roadways, as inspector and instrumentman. Available at once. Present location, Montreal. Apply to Box No. 714-W.

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

MECHANICAL ENGINEER, age 41, married. Eleven years designing experience with project of outstanding magnitude. Machinery layouts, checking, estimating and inspecting. Twelve years previous engineering, including draughting, machine shop and two years chemical laboratory. Highest references. Apply to Box No. 723-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.

DESIGNING ENGINEER, M.Sc. (McGill Univ.), D.L.S., A.M.E.I.C., P.E.Q. Experience in design and construction of water power plants, transmission lines, field investigations of storage, hydraulic calculations and reports. Also paper mill construction, railways, highways, and in design and construction of bridges and buildings. Available at once. Apply to Box No. 729-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.

CIVIL ENGINEER, M.Sc., 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.

ELECTRICAL AND RADIO ENGINEER, B.Sc. '31, S.E.I.C. Age 25. Nine months experience on installation of power and lighting equipment. Eight months on extensive survey layouts. Two summers installing telephone equipment. Specialized in radio servicing and merchandising. Available at once. Location immaterial. Apply to Box No. 740-W

CIVIL ENGINEER, graduate '29. Married. One year building construction, one year hydro-electric construction in South America, fourteen months resident engineer on road construction. Working knowledge of Spanish. Apply to Box No. 744-W.

Situations Wanted

SALES ENGINEER, B.Sc., McGill, 1923, A.M.E.I.C. Age 33. Married. Extensive experience in building construction. Thoroughly familiar with steel building products; last five years in charge of structural and reinforcing steel sales for company in New York state. Available at once. Located in Canada. Apply to Box No. 749-W.

DESIGNING ENGINEER, graduate Univ. Toronto '26. Thoroughly experienced in the design of a broad range of structures, desires responsible position. Apply to Box No. 761-W.

MECHANICAL ENGINEER, graduate, '23, A.M.E.I.C., P.E.Q., age 32, married. (English and French.) Two years shop, foundry and draughting experience; one year mechanical supt. on construction; six years designing draughtsman in consulting engineers' offices (mechanical equipment of buildings, heating, sanitation, ventilation, power plant equipment, etc.). Present location Montreal. Available immediately. Montreal or Toronto preferred. Apply to Box No. 766-W.

CIVIL ENGINEER, S.E.I.C., B.Sc. Queen's Univ. '29. Age 25. Married. Three years experience as construction supt. and estimator for contracting firm. Experience includes general building, bridges, sewer work, concrete, boiler settings, sand blasting of bridges and spray painting. Available at once. Apply to Box No. 767-W.

ELECTRICAL ENGINEER, B.Sc. (McGill Univ. '29), S.E.I.C. Married. Experience in pulp and paper mill mechanical maintenance, estimates and costs and machine shop practice. Desires position with industrial or manufacturing concern. Location immaterial. Available on short notice. References. Apply to Box No. 770-W.

ELECTRICAL ENGINEER, Queen's Univ. '24, Jr.E.I.C., age 32, married. Experience includes, student Test Course, Can. Gen. Elec. Co., four years dial system telephone engineering with large manufacturing company. Available at once. Apply to Box No. 772-W.

CIVIL ENGINEER, B.Sc., '25, Jr.E.I.C., P.E.Q., married. Desires position, preferably with construction firm. Experience includes railway, monument and mill building construction. Available immediately. Apply to Box No. 780-W.

DRAUGHTSMAN, experience in civil engineering, forestry engineering, land surveying and house construction. Good references. Apply to Box No. 781-W.

ELECTRICAL AND SALES ENGINEER, S.E.I.C., grad. '28. Experience includes one year test course, one year switchboard design and two years switchboard and switching equipment sales with large electrical manufacturing company. Three summers Pilot Officer with R.C.A.F. Available at once. Apply to Box No. 788-W.

SALES REPRESENTATIVE. Electrical engineer with ten years experience in power field interested in representing established firm for electrical or mechanical product in Montreal territory. Excellent connections. Apply to Box No. 795-W.

CIVIL ENGINEER, S.E.I.C., graduate '30, age 23, single. Experience includes mining surveys, assistant on highway location and construction, and assistant on large construction work. Steel and concrete layout and design. Apply to Box No. 809-W.

CIVIL ENGINEER, college graduate, age 27, single. Experience includes surveying, draughting concrete construction and design, street paving both asphalt and concrete. Available at once; will consider anything and go anywhere. Apply to Box No. 816-W.

CIVIL ENGINEER, B.E. (Sask. Univ. '32), S.E.I.C. Single. Experience in city street improvements; sewer and water extensions. Good draughtsman. References. Available at once. Location immaterial. Apply to Box No. 818-W.

CIVIL ENGINEER, S.E.I.C., B.Sc. (Queen's '32), age 21. Three summers surveying in northern Quebec. Interested in hydraulics and reinforced concrete. Available at once. Location immaterial. Apply to Box No. 822-W.

CIVIL ENGINEER, B.Sc., A.M.E.I.C., with fifteen years experience mostly in pulp and paper mill work, reinforced concrete and structural steel design, field surveys, layout of mechanical equipment, piping. Available at once. Apply to Box No. 825-W.

ELECTRICAL ENGINEER. S.E.I.C., grad. '29, age 24, married; experience includes one year Students Test Course, sixteen months in distribution transformer design and eight months as assistant foreman in charge of industrial control and switchgear tests. Location immaterial. Available at once. Apply to Box No. 828-W.

SALES ENGINEER, M.E.I.C., graduate civil engineer with twenty years experience in the structural, sales, and municipal engineering fields, and as manager of engineering sales office. Available at once. Apply to Box No. 830-W.

Situations Wanted

CIVIL ENGINEER, B.A.Sc., D.L.S., O.L.S., A.M.E.I.C., age 46, married. Twelve years experience in charge of legal field surveys. Owns own surveying equipment. Eight years on technical, administrative, and editorial office work. Experienced in writing. Desires position on survey work, assisting in or in charge of preparation of house organ, on staff of technical or semi-technical magazine, or on publicity, editorial or administrative office work. Available at once. Will consider any salary, and any location. Apply to Box No. 831-W.

AERONAUTICAL ENGINEER, B.Sc. (McGill), M.Sc. (Mass. Inst. Tech.). Canadian. Age 26, recent graduate. Capable of aeroplane design and stress analysis. Apply to Box No. 838-W.

CIVIL ENGINEER, M.Sc., R.P.E. (Sask.). Age 27. Experience in location and drainage surveys, highways and paving, bridge design and construction city and municipal developments, power and telephone construction work. Available on short notice. Apply to Box No. 839-W.

CIVIL ENGINEER, S.E.I.C., B.Sc. '32 (Univ. of N.B.). Age 25, married. Two years experience in power line construction and maintenance; one year of highway construction; one summer surveying for power plant site, location and spur railway line construction. Available at once. Location immaterial. Apply to Box No. 840-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.

CIVIL ENGINEER, B.Sc. (Alta. '31), S.E.I.C., age 24. Experience, three summers on railroad maintenance, and seven months on highway location as instrumentman. Willing to do anything, anywhere, but would prefer connection with designing or construction firm on structural works. Available immediately. Apply to Box No. 846-W.

MECHANICAL ENGINEER, Jr.E.I.C., technical graduate, bilingual, age 30. Two years as designing heating draughtsman with one of the largest firms of its kind on this continent handling heating materials; three years designing draughtsman in consulting engineers' office, mechanical equipment of buildings, heating, ventilation, sanitation, power plant equipment, writing of specifications, etc. Present location Montreal. Available at once. Apply to Box No. 850-W.

BRIDGE AND STRUCTURAL ENGINEER, A.M.E.I.C., McGill. Twenty-five years' experience on bridge and structural staffs. Until recently employed. Familiar with all late designs, construction, and practices in all Canadian fabricating plants. Desirous of employment in any responsible position, sales, fabrication or construction. Apply to Box No. 851-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.

MECHANICAL ENGINEER, B.Sc. '32, S.E.I.C. Good draughtsman. Undergraduate experience:—One year moulding shop practice; two years pipe fitting and sheet metal work; one year draughting and tracing on paper mill layout; six months machine shop practice; and eight months fuel investigation and power heating plant testing. Desires position offering experience in steam power plants or heating and ventilating design. Will go anywhere. Apply to Box No. 858-W.

MECHANICAL ENGINEER, age 31, graduate Sheffield (England) 1921; apprenticeship with firm manufacturing steam turbine generators and auxiliaries and subsequent experience in design, erection, operation and inspection of same. Marine experience B.O.T. certificate thoroughly conversant with Canadian plants and equipment. Available on short notice. Any location. Box No. 860-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.

ENGINEER, McGill Sci. '21-'25, S.E.I.C., aerial mapping, stereoscopic contour work; lumber classification; highway, railway and transmission line locations; estimates; water storage investigations, etc. Five years ground surveys; three years aerial mapping. Bilingual. Available on short notice. Apply to Box No. 872-W.

CONSTRUCTION ENGINEER (Toronto Univ. of '07). Experience includes hydro-electric, municipal and railroad work. Available immediately. Location immaterial. Apply to Box No. 886-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.

Situations Wanted

CIVIL ENGINEER, B.Sc., Montreal 1930, age 26, single, French and English, desires position technical or non-technical in engineering, industrial or commercial fields, sales or promotion work. Experience includes three years in municipal engineering on paving, sewage, waterworks, filter plant equipment, layout of buildings, etc. Available immediately. Apply to Box No. 891-W.

ELECTRICAL ENGINEER, grad. Univ. of N.B. '31. Experienced in surveying and draughting, requires position. Available at once Will go anywhere. Apply to Box No. 893-W.

CIVIL ENGINEER, B.A.Sc., Jr.E.I.C., age 29, single. Experience includes two years in pulp mill as draughtsman and designer on additions, maintenance and plant layout. Three and a half years in the Toronto Buildings Department checking steel, reinforced concrete, and architectural plans. Available at once. Location immaterial. At present in Toronto. Apply to Box No. 899-W.

ENGINEER, Jr.E.I.C., specializing in reconnaissance and preliminary surveys in connection with hydro-electric and storage projects. Expert on location and construction of transmission lines, railways and highways. Capable of taking charge. Location immaterial. Apply to Box No. 901-W.

MECHANICAL ENGINEER, Canadian, age 25, B.Sc. (Queen's '32). Since graduation on supervision of large building construction. Undergraduate experience in electrical, plumbing and heating, and locomotive trades. Available at once. Apply to Box No. 903-W.

DESIGNING ENGINEER, A.M.E.I.C. Permanent and executive position preferred but not essential. Fifteen years experience in designing power plants, engine and fan rooms, kitchens and laundries. Thoroughly familiar with plumbing and ventilating work, pneumatic tubes, and refrigeration, also heating, electrical work, and specifications. Apply to Box No. 913-W.

INDUSTRIAL ENGINEER, B.Sc. in M.E., age 25, married, is open for a position of a permanent nature with an industrial concern. Experience includes three years in various divisions of a paper mill and two years in an electrical company. Apply to Box No. 917-W.

ENGINEER, B.Sc., A.M.E.I.C., R.P.E. (N.B.), age 35, married. Seven years' mining experience as sampler, assayer, surveyor, field work, and foreman in charge of underground development; two years as assistant engineer on highway construction and maintenance. Available on short notice. Apply to Box No. 932-W.

CIVIL ENGINEER, B.Sc., '25, McGill Univ., Jr.E.I.C., P.E.Q., age 32, married. Experience as rodman and instrumentman on track maintenance. Seven and one-half years with Canadian paper company, as assistant office engineer handling all classes of engineering problems in connection with woods operations, i.e., road buildings, piers, booms, timber bridges, depots, dams, etc. Apply to Box No. 933-W.

ELECTRICAL ENGINEER, Dipl. of Eng., B.Sc. (Dalhousie Univ.), S.B. and S.M. in E.E. (Mass. Inst. of Tech.), Canadian. Married. Seven and a half years' experience in design, construction and operation of hydro, steam and industrial plants. For past sixteen months field office electrical engineer on 510,000 H.P. hydro-electric project. Available at once. Apply to Box No. 936-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.

ELECTRICAL ENGINEER, twenty years experience, desires position, either temporary or permanent. Experienced in design, construction, and operation of power and industrial plants, and supt. of construction. Apply to Box No. 974-W.

INDUSTRIAL ENGINEER, B.Sc., in C.E. (McGill Univ. '30), graduate student in industrial engineering '33 session, age 27, single, available for a position of temporary or permanent nature with industrial concern. Has theoretical knowledge of latest methods of market analysis, production control, management and cost accounting. Also experience in the design and construction of industrial buildings. Location immaterial. Apply to Box No. 981-W.

CIVIL ENGINEER, B.Sc. (Univ. of Sask. '33), S.E.I.C., age 28, single. Experience in testing hydro-electric equipment, draughting, surveying, city street, improvements, technical photography. Available at once. Location immaterial. Apply to Box No. 986-W.

MECHANICAL ENGINEER, S.E.I.C., B.Sc., Queen's University '33. Age 24, desires position on power plant and power distribution problems, factory maintenance, heating and ventilation or refrigeration design. Willing to work for living expenses in order to gain experience. Apply to Box No. 999-W.

Purchasers' Classified Directory

A Selected List of Equipment, Apparatus and Supplies

For Alphabetical List of Advertisers see page 18.

A

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Bars, Steel and Iron:
Bethlehem Steel Export Corp.
U.S. Steel Products Co.
Bearings, Ball and Roller:
Can. S.K.F. Co. Ltd.
Billets, Blooms, Slabs:
Bethlehem Steel Export Corp.
U.S. Steel Products Co.
Bins:
Canada Cement Co. Ltd.
Blasting Materials:
Canadian Industries Limited.
Blowers, Centrifugal:
Can. Ingersoll-Rand Co. Ltd.
Blue Print Machinery:
Montreal Blue Print Co.
Boilers:
Babcock-Wilcox & Goldie-McCulloch Ltd.
Combustion Engineering Corp. Ltd.
Foster Wheeler Limited.
Wm. Hamilton Ltd.
E. Leonard & Sons Ltd.
Vulcan Iron Wks. Ltd.
Boilers, Electric:
Can. General Electric Co. Ltd.
Dominion Engineering Works Limited.
Northern Electric Co. Ltd.
Boilers, Portable:
E. Leonard & Sons Ltd.
Boxes, Cable Junction:
Northern Electric Co. Ltd.
Braces, Cross Arm, Steel, Plain or Galvanized:
Northern Electric Co. Ltd.
Brackets, Ball Bearing:
Can. S.K.F. Co. Ltd.
Brakes, Air:
Can. General Elec. Co. Ltd.
Brakes, Magnetic Clutch:
Northern Electric Co. Ltd.
Bridge-Meggers:
Northern Electric Co. Ltd.
Bridges:
Canada Cement Co. Ltd.
Dominion Bridge Co. Ltd.
Bucket Elevators:
Jeffrey Mfg. Co. Ltd.
Plessisville Foundry.
Buildings, Steel:
Dominion Bridge Co. Ltd.

C

Cables, Copper and Galvanized:
Northern Electric Co. Ltd.
Cables, Electric, Bare and Insulated:
Can. Westinghouse Co. Ltd.
Can. General Electric Co. Ltd.
Northern Electric Co. Ltd.
U.S. Steel Products Co.
Caissons, Barges:
Dominion Bridge Co. Ltd.
Cameras:
Associated Screen News Ltd.
Capacitors:
Bepco Canada Ltd.
Can. Westinghouse Co. Ltd.
Lancashire Dynamo & Crypto Co. of Can. Ltd.
Cars, Dump:
E. Long Ltd.
Castings, Brass:
The Superheater Co. Ltd.
Castings, Iron:
Babcock-Wilcox & Goldie-McCulloch Ltd.
Dominion Engineering Works.
Wm. Hamilton Ltd.
E. Leonard & Sons Ltd.
E. Long Ltd.
The Superheater Co. Ltd.
Vulcan Iron Wks. Ltd.
Castings, Steel:
Sorel Steel Foundries Ltd.
Vulcan Iron Wks. Ltd.
Catenary Materials:
Can. Ohio Brass Co. Ltd.
Cement Manufacturers:
Canada Cement Co. Ltd.
Chains, Silent and Roller:
The Hamilton Gear & Machine Co. Ltd.
Jeffrey Mfg. Co. Ltd.
Chains, Steel:
Sorel Steel Foundries Ltd.
Channels:
Bethlehem Steel Export Corp.
Hamilton Bridge Co. Ltd.
U.S. Steel Products Co.
Chemicals:
Canadian Industries Limited.
Chemists:
Milton Hersey Co. Ltd.
Chippers, Pneumatic:
Canadian Ingersoll-Rand Company, Limited.
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Ferranti Electric Co.
Circuit Breakers:
Can. General Elec. Co. Ltd.
Can. Westinghouse Co. Ltd.
Northern Electric Co. Ltd.
Clarifiers, Filter:
Bepco Canada Ltd.
Crompton Parkinson (Canada) Ltd.
Clutches, Ball Bearing Friction:
Can. S.K.F. Co. Ltd.
Clutches, Magnetic
Northern Electric Co. Ltd.
Coal Handling Equipment:
Babcock-Wilcox & Goldie-McCulloch Ltd.
Combustion Engineering Corp. Ltd.
E. Long Ltd.
Combustion Control Equipment:
Bailey Meter Co. Ltd.
Compressors, Air and Gas:
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Canadian Ingersoll-Rand Company, Limited.
Foster Wheeler Co.
Concrete:
Canada Cement Co. Ltd.
Condensers, Steam:
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Canadian Ingersoll-Rand Company, Limited.
Foster Wheeler Limited.
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Can. General Elec. Co. Ltd.
Can. Westinghouse Co. Ltd.
Crompton Parkinson (Canada) Ltd.
Harland Eng. Co. of Can. Ltd.
Lancashire Dynamo & Crypto Co. of Can. Ltd.
Northern Electric Co. Ltd.
Bruce Peebles (Canada) Ltd.
Conduit:
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Can. Westinghouse Co. Ltd.
Northern Electric Co Ltd.
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Northern Electric Co. Ltd.
Conduit Fittings:
Northern Electric Co. Ltd.
Conduits, Wood Pressure Creosoted:
Canadian Wood Pipe & Tanks Ltd.
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Can. Westinghouse Co. Ltd.
Northern Electric Co. Ltd.
Couplings:
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Dresser Mfg. Co. Ltd.
Couplings, Flexible:
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Dresser Mfg. Co. Ltd.
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Cranes, Hand and Power:
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Cranes, Locomotive:
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Cranes, Shovel, Gasoline Crawler, Pillar:
Dominion Hoist & Shovel Co. Ltd.
Crowbars:
B. J. Coghlin Co. Ltd.
Crushers, Coal and Stone:
Canadian Ingersoll-Rand Company, Limited.
Jeffrey Mfg. Co. Ltd.

D

Dimmers:
Northern Electric Co. Ltd.
Disposal Plants, Sewage:
W. J. Westaway Co. Ltd.
Ditchers:
Dominion Hoist & Shovel Co. Ltd.
Drills, Pneumatic:
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Dynamite:
Canadian Industries Limited.

E

Economizers, Fuel:
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Foster Wheeler Limited.
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Darling Bros. Ltd.
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Dart Union Co. Ltd.
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Can. Ohio Brass Co Ltd.
Can. Westinghouse Co. Ltd.
Northern Electric Co. Ltd.
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Plessisville Foundry.
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Canadian Ingersoll-Rand Company, Limited.
Harland Eng. Co. of Can. Ltd
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Harland Eng. Co. of Can. Ltd.
E. Leonard & Sons Ltd.
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Foster Wheeler Limited.
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Darling Bros. Ltd.
Foster Wheeler Limited.
Explosives:
Canadian Industries Limited.

F

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The Superheater Co. Ltd.
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Forcite:
Canadian Industries Limited.
Forgings:
Bethlehem Steel Export Corp.
Foundations:
Canada Cement Co. Ltd.

G

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Dominion Engineering Works Limited.
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Can. Westinghouse Co. Ltd.
Crompton Parkinson (Canada) Ltd.
Harland Eng. Co. of Can. Ltd.
Lancashire Dynamo & Crypto Co. of Can. Ltd.
Northern Electric Co. Ltd.
Bruce Peebles (Canada) Ltd.
Governors, Pump:
Bailey Meter Co. Ltd.
Governors, Turbine:
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Gratings, M. & M. Safety:
Dominion Bridge Co. Ltd.

H

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Can. Ohio Brass Co. Ltd.
Can. Westinghouse Co. Ltd.
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Dominion Hoist & Shove Co. Ltd.
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- Switchboards
- Motor Driven Pumps
- Motors of all kinds
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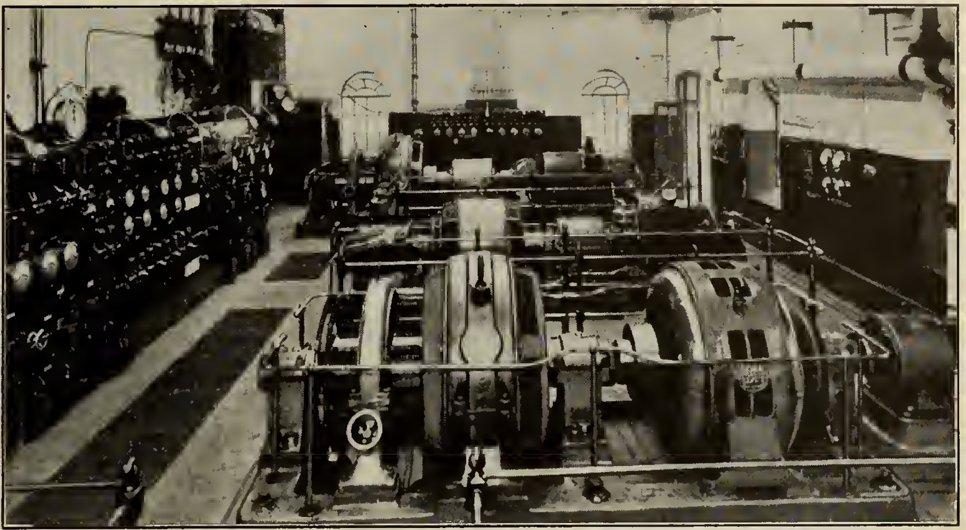

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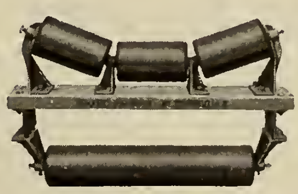

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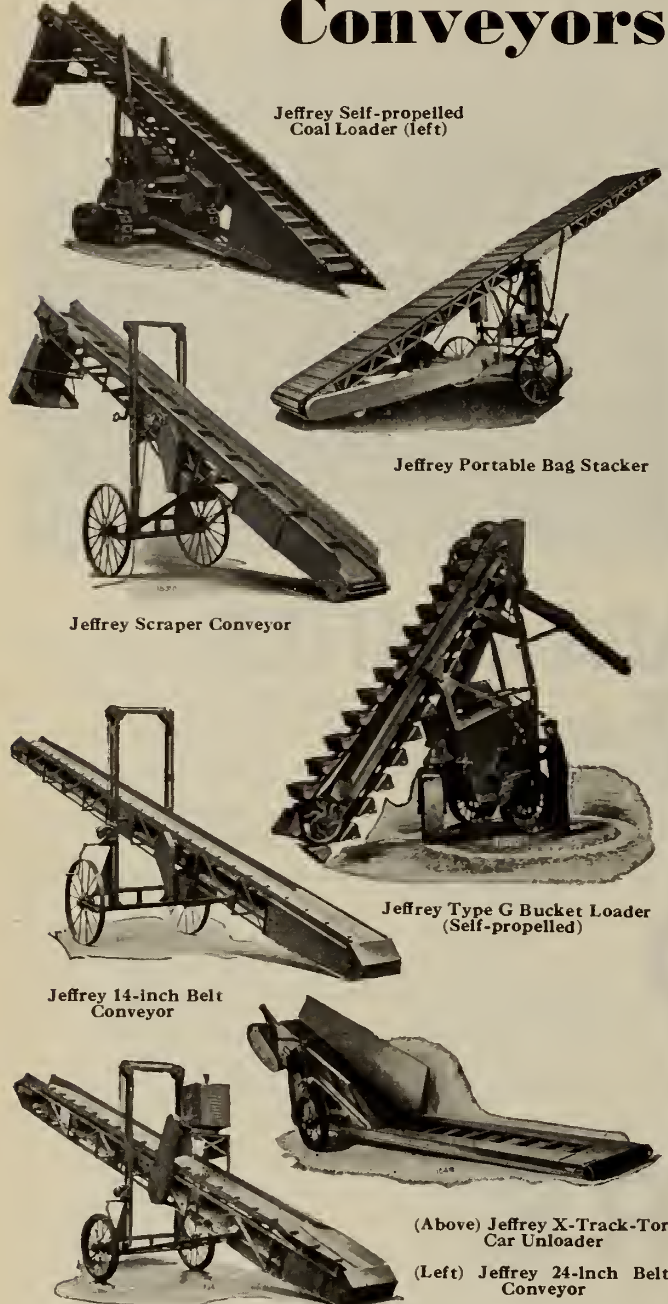

Jeffrey Self-propelled Coal Loader (left)

Jeffrey Portable Bag Stacker

Jeffrey Scraper Conveyor

Jeffrey Type G Bucket Loader (Self-propelled)

Jeffrey 14-inch Belt Conveyor

(Above) Jeffrey X-Track-Tor Car Unloader

(Left) Jeffrey 24-inch Belt Conveyor

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Jeffrey has built a complete line of Portable Conveying Machinery to assist the industrial plant in handling bulk materials in the yard and the engineer with his particular project — whether it is Buildings, Roads, Bridges, Airports, Waterways, Railroads, Sewerage, Refuse Plants, Power Developments, etc.

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Northern Electric Co. Ltd.

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Can. General Elec. Co. Ltd.
Can. Westinghouse Co. Ltd.
Crompton Parkinson (Canada) Ltd.
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Moloney Electric Co. of Canada, Ltd.
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Insulating Materials:
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Northern Electric Co. Ltd.

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J

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L

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M

Machinery, Hydraulic:
Dominion Engineering Works Limited.

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Dominion Engineering Works Limited.

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Dominion Engineering Works Limited.

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E. Long Ltd.
Plessisville Foundry.

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Can. Westinghouse Co. Ltd.
Ferranti Electric Ltd.
Northern Electric Co. Ltd.

Meters, Flow:
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Neptune Meter Co. Ltd.

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Neptune Meter Co. Ltd.

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N

Nickel, Chrome Steel:
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O

Oil Burning Equipment:
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P

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Plessisville Foundry.

Pipe, Wood Stave:
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Pipe Couplings and Nipples:
Dart Union Co. Ltd.

Plates, Steel:
Bethlehem Steel Export Corp
U.S. Steel Products Co.

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Canadian Ingersoll-Rand Company Ltd.

Pole Line Hardware:
Can. Ohio Brass Co. Ltd.
Northern Electric Co. Ltd.

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Canadian Industries Limited.

Powder, Black and Sporting:
Canadian Industries Limited

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Can. Westinghouse Co. Ltd.
Crompton Parkinson (Canada) Ltd.
Harland Eng. Co. of Can. Ltd.
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Foster Wheeler Limited.

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Bethlehem Steel Export Corpn.
Combustion Engineering Corp. Ltd.
Foster Wheeler Limited.

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R

Radiator Air Vents and Traps:
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Bailey Meter Co. Ltd.

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Riveted Pipe:
Dominion Bridge Co. Ltd.

Roads:
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Road Machinery:
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Rods:
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Rod Mill Liners:
Sorel Steel Foundries Ltd.

Rolls, Paper Machine:
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Rope, Wire:
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U.S. Steel Products Co.

S

Saw Mill Machinery:
Wm. Hamilton Ltd.
E. Long Ltd.

Scales:
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Screening Equipment:
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Separators, Electric:
Northern Electric Co. Ltd.

Sewers:
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Harland Eng. Co. of Can. Ltd.
Northern Electric Co. Ltd.

T

Tanks:
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Darling Bros. Ltd.
Dominion Bridge Co. Ltd.
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E. Leonard & Sons Ltd.
Vulcan Iron Wks. Ltd.

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Tees:
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Telegraph Line Material:
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National Sewer Pipe Co. Ltd.

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Ferranti Electric Ltd.
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Can. Westinghouse Co. Ltd.
Crompton Parkinson (Canada) Ltd.
Ferranti Electric Ltd.
Moloney Electric Co. of Can., Ltd.
Northern Electric Co. Ltd.
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Can. Westinghouse Co. Ltd.
Lancashire Dynamo & Crypto Co. of Can. Ltd.

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U

Unions:
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V

Valve Controls:
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Dominion Engineering Works Limited.
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Ventube:
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W

Washers, Air:
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Babcock-Wilcox & Goldie-McCulloch Ltd.
Combustion Engineering Corp. Ltd.
Foster Wheeler Limited.

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Can. Ohio Brass Co. Ltd.
Can. Westinghouse Co. Ltd.
Northern Electric Co. Ltd.

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Winches, Stop-log and Headgate:
Wm. Hamilton Ltd.

Wire:
Bethlehem Steel Export Corp.
U.S. Steel Products Co.

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Northern Electric Co. Ltd.
U.S. Steel Products Co.

Wire Rope:
Dom. Wire Rope Co. Ltd.

Wire Springs:
B. J. Coghlin Co. Ltd.

Worm Gears:
The Hamilton Gear & Machine Co. Ltd.

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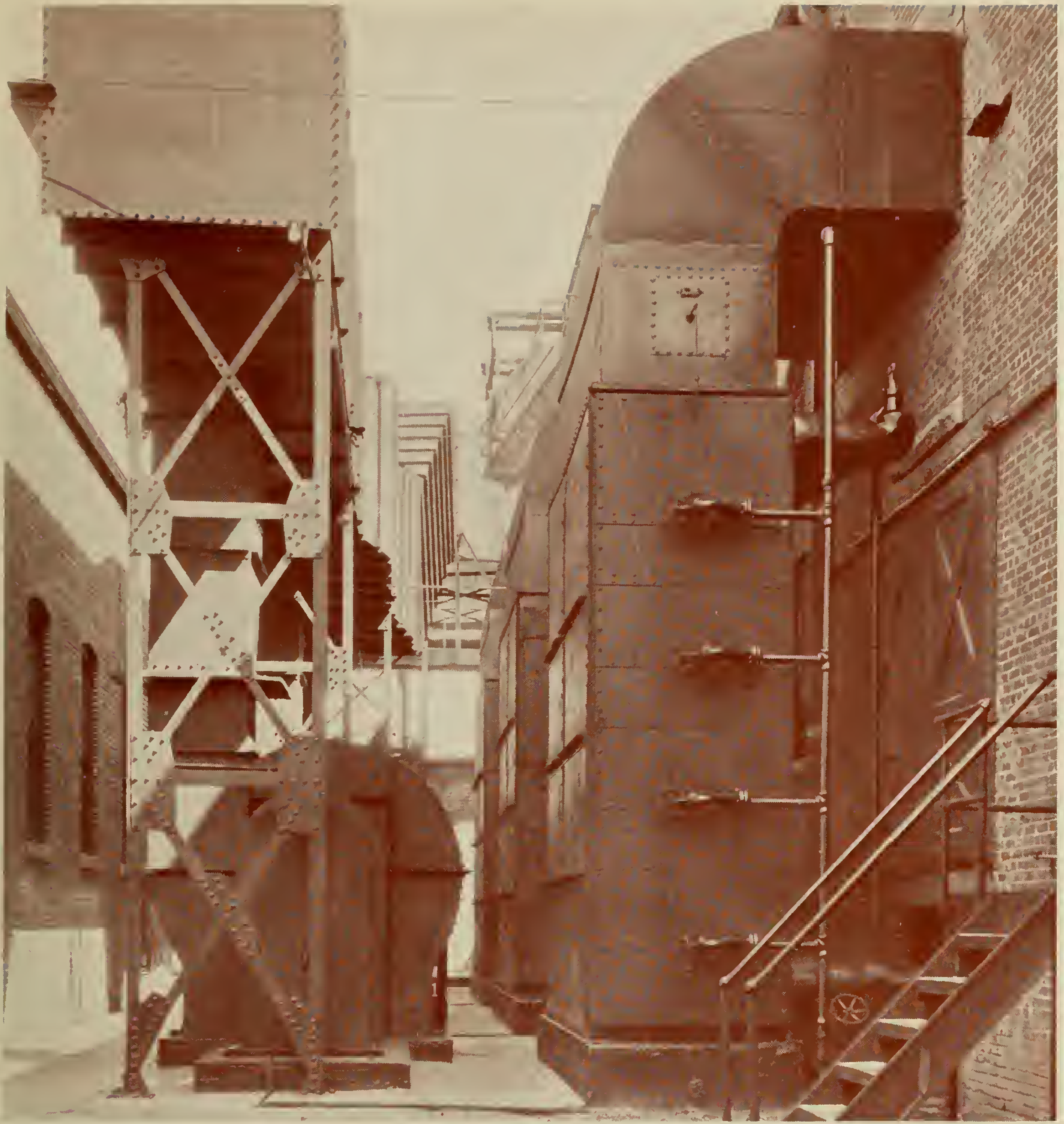

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Extended surface type armored economizers as installed by Foster Wheeler increase steam generating efficiencies as much as 15 percent, depending upon the relative size of the economizer. Economizers have increased capacities of steam generating units as much as 50 percent.

The extended surface construction of the Foster Wheeler economizer permits its installation in a small space, but when there is insufficient space in the boiler room, the economizer may be placed out-of-doors, as shown above. In this instance a fuel saving of $10\frac{1}{2}$ percent has been effected and the economizer cost will be saved in less than two years.

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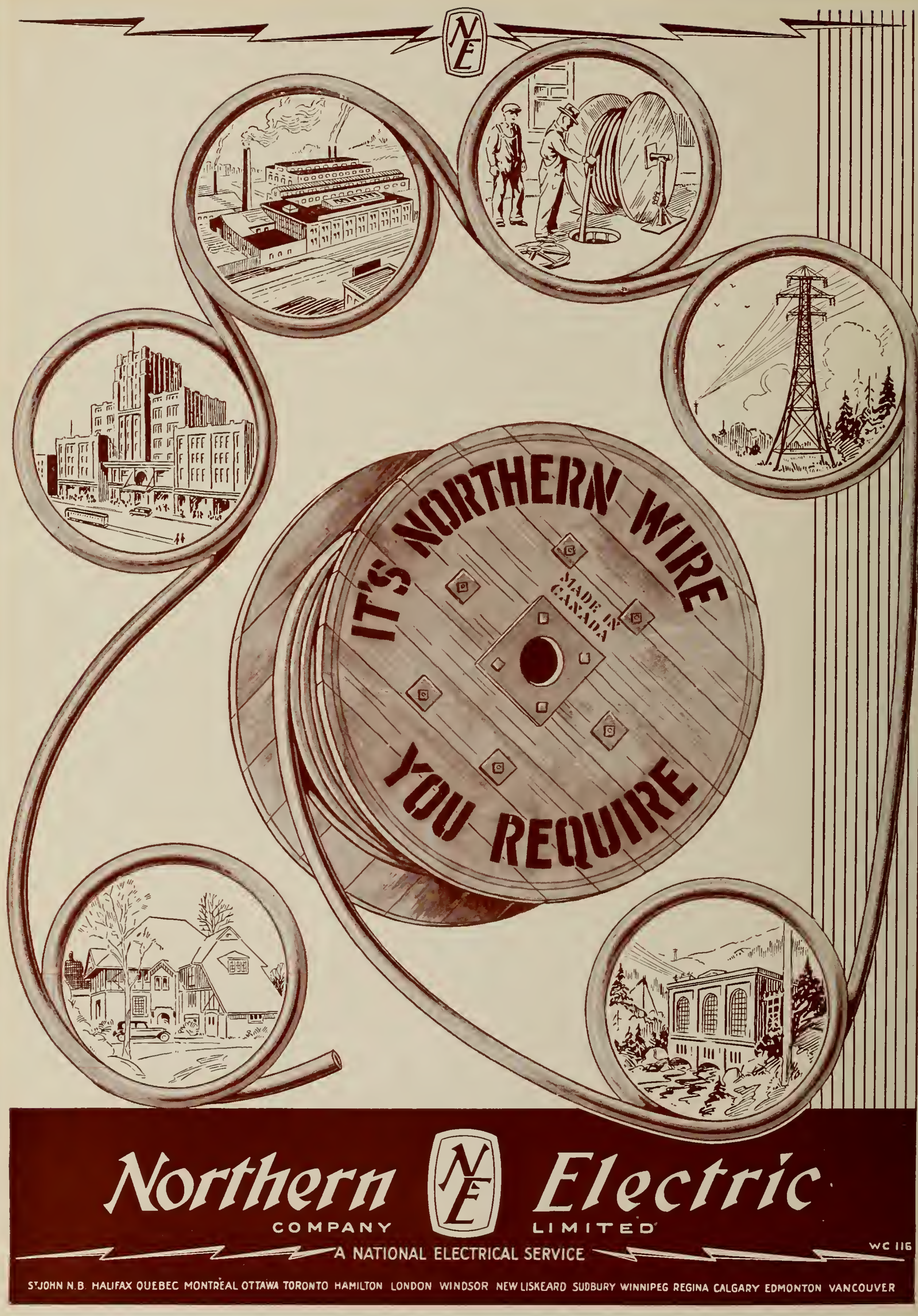
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VOL. XVI
No. 7

JULY
1933

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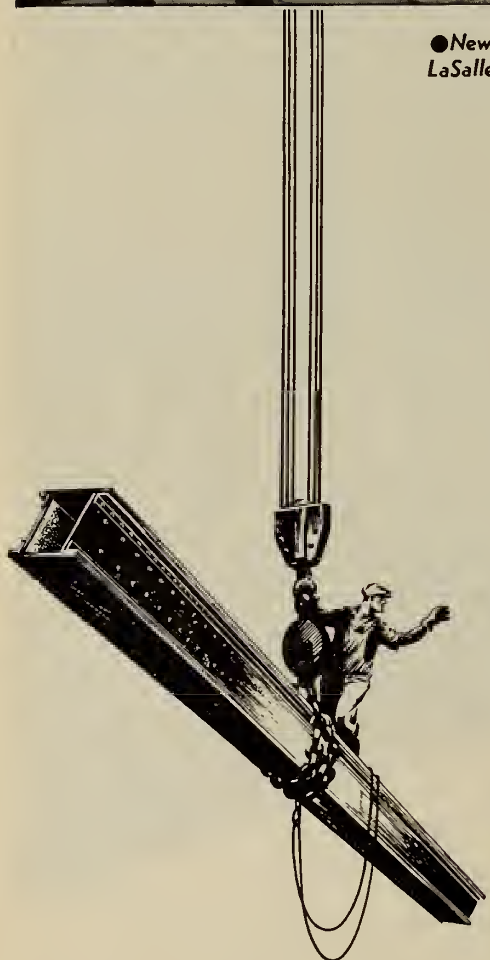

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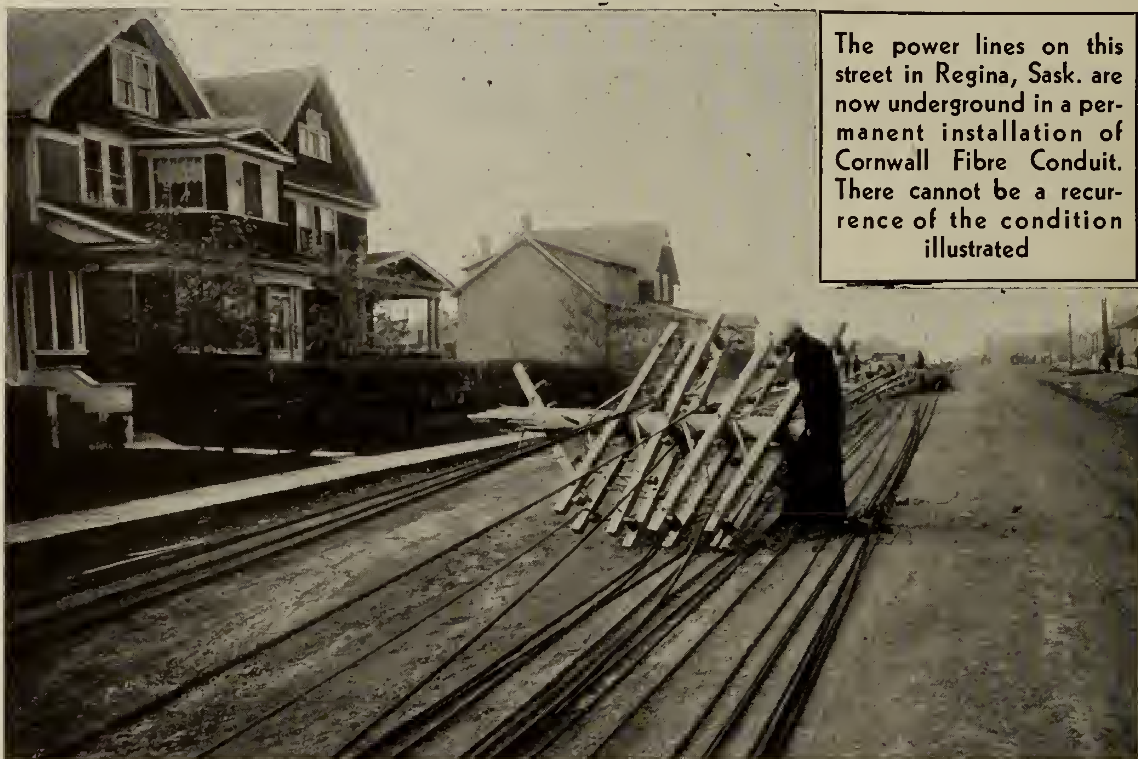

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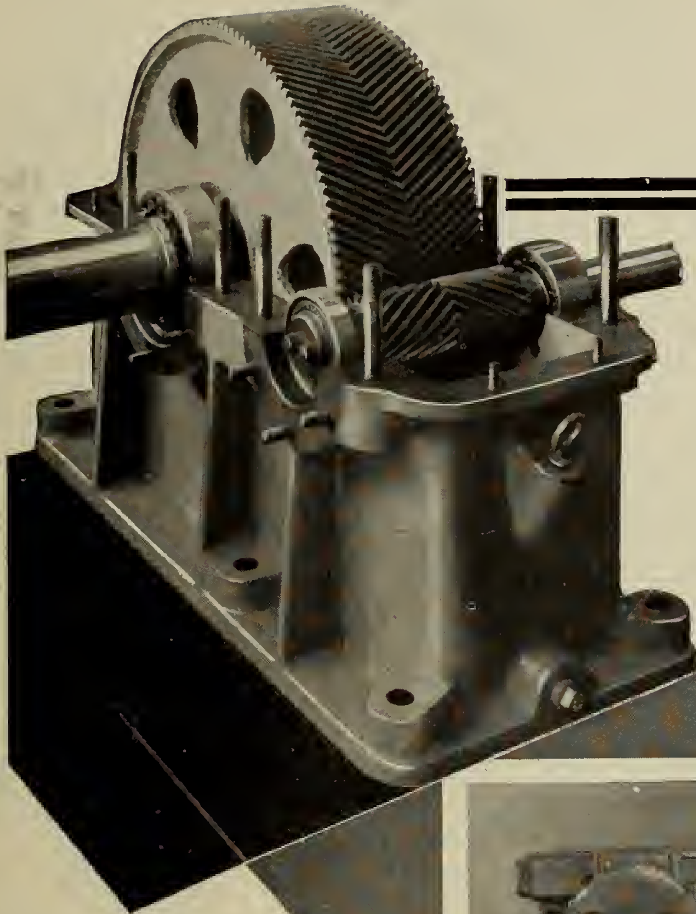

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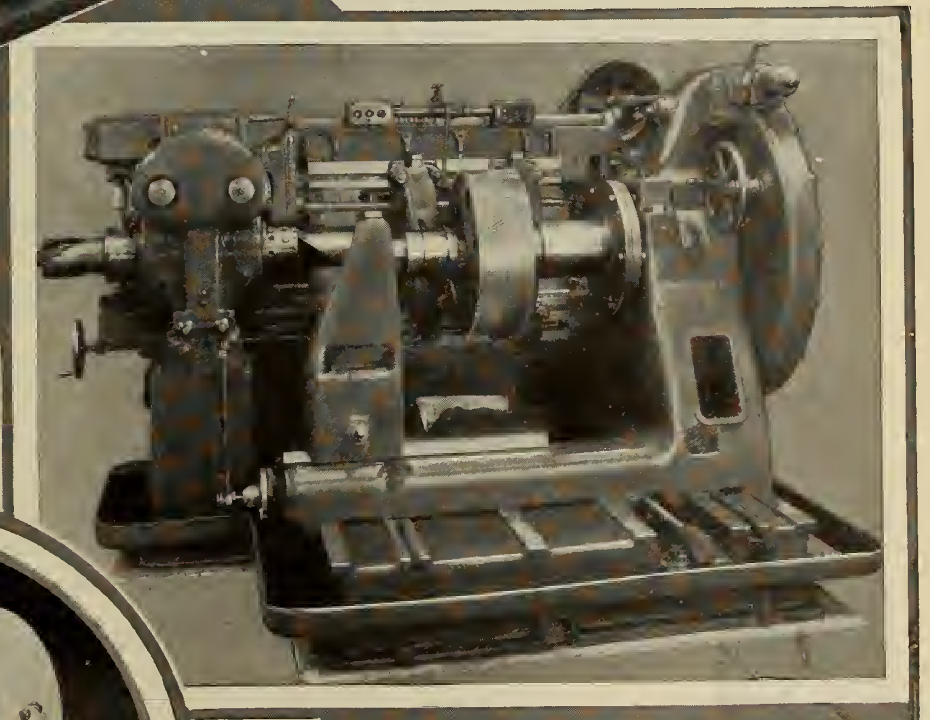

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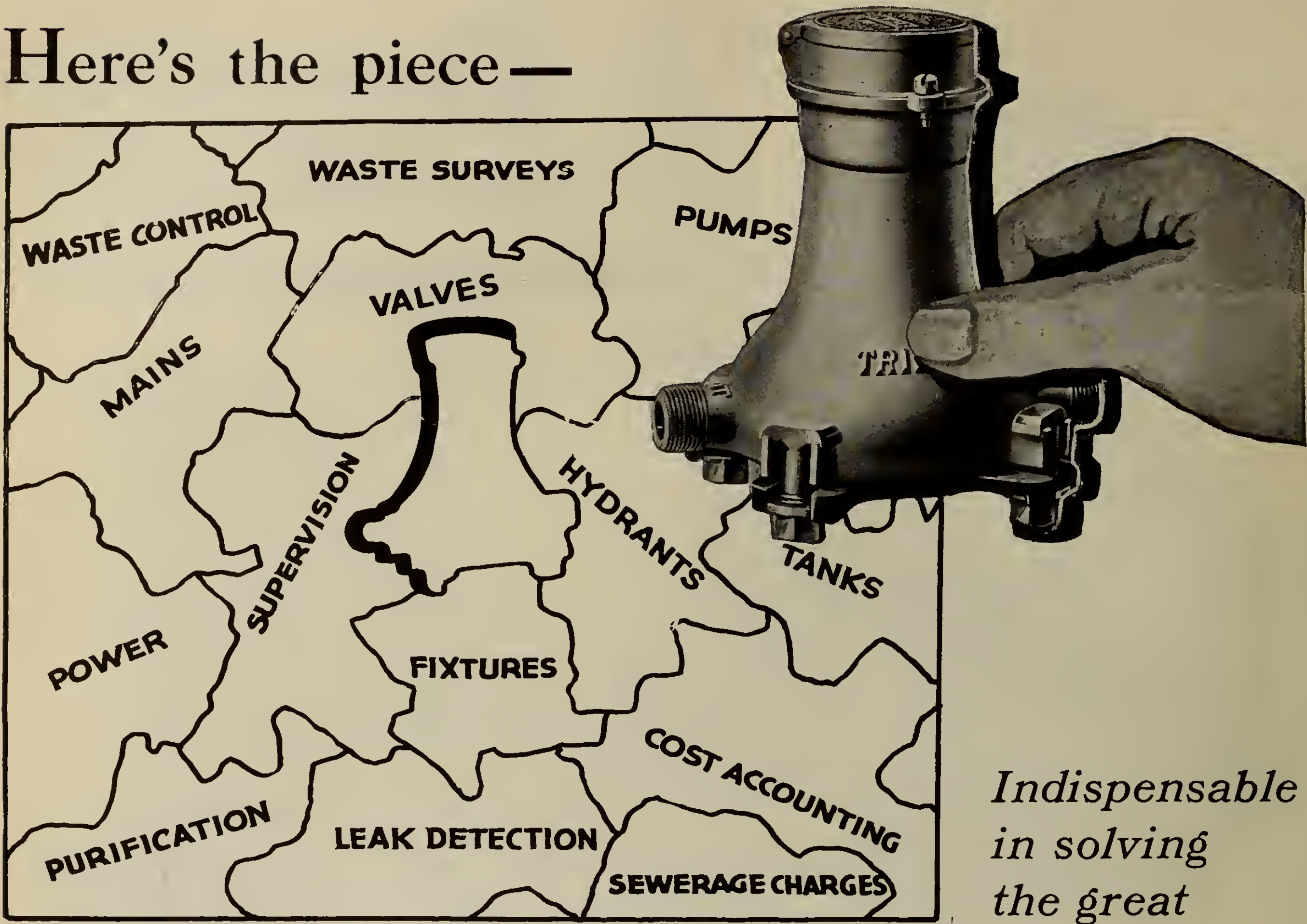

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Considerations Governing the Location of Hydro-Electric Developments on the Upper St. Maurice River

C. R. Lindsey, A.M.E.I.C.,
Power Engineering Company, Montreal.

Paper presented before the Montreal Branch of The Engineering Institute of Canada, April 13th, 1933.

SUMMARY.—This paper deals with a study of the hydro-electric possibilities in a stretch of the St. Maurice river on which a difference of level of 630 feet exists in 78 miles. The geological history and characteristics of the river and its drainage basin are discussed. Extensive reconnaissance and preliminary surveys were necessary, with investigations in regard to the measurement and recording of water levels, stream flow and ice conditions. Photographic methods of topographic surveying were employed and electrical methods were used for determining the depth to bed-rock on prospective dam sites. As a result of the whole study, plans for six possible developments were prepared with a total possible installed capacity of over one million horse power.

The St. Maurice river is the second largest tributary of the St. Lawrence with its water shed wholly within the province of Quebec. The area of its drainage basin is approximately 16,000 square miles and its physical characteristics are similar to those of other tributary streams of the St. Lawrence which have their sources in the Laurentian highlands. A small part of the drainage area near the outlet is a part of the St. Lawrence plain, therefore being suitable for agricultural and grazing purposes, while the greater portion is extremely rugged and is generally important for its timber, fur and game as well as its potential water power. The water surface elevation of the upper part of the St. Maurice is 1,325 and its outlet is at tide water so that this gives an average slope of 5.6 feet per mile. Of the 1,325 feet difference in elevation between headwater and the outlet, 636 feet is comprised in ten distinct falls, leaving 689 feet to be accounted for by various types of rapids, making the average slope of the river between falls slightly more than three feet per mile.

The following quotation is from a report on the "General Geology of the St. Maurice Drainage Basin" by Irving B. Crosby.

"The St. Maurice valley is almost entirely in the Laurentian highlands, and the river flows through this region from its headwaters to Grandes Piles where it leaves the highlands and flows across the St. Lawrence plain. The old rocks of the Laurentian region extend out under the plain, however, and the river has cut down through the sedimentary deposits and flows on the Laurentian rocks as far downstream as La Gabelle where these old rocks become completely buried.

The Laurentian region was reduced by long erosion to a peneplain or region of little relief. This was subsequently uplifted and dissected by streams, the amount of the dissection being very marked near the borders of the region and much less near the centre. The St. Maurice has its source in the central and little dissected part of the peneplain and flows in a general south-easterly direction through valleys of increasing depth. The deep dissection of the border of the peneplain gives it a mountainous appearance and justifies the use of the term "Laurentian Mountains," while the interior of this region is best described as a plateau.

The rocks of the Laurentian highlands are among the oldest, if not the oldest, on the American continent. They consist of granites and gneisses, and the latter are of two types, one of which had a sedimentary origin and the other an igneous origin.

The formation of the rocks was followed by a very long period of erosion during which the land was reduced to a peneplain or surface of low relief. This was finally uplifted, allowing the streams to cut deeper and dissect the old surface. The streams had extensively and deeply dissected the peneplain and had begun to widen their valleys when another uplift caused them to deepen the channels in the floors of their valleys.

Thus the hills and mountains of the Laurentian highlands were formed, and, since they were carved from a nearly flat plain, the highest summits are of approximately the same elevation. From the higher hills in the region the sky line appears nearly flat and marks the level of the old peneplain. There is, therefore, a great contrast in the appearance of the country when seen from a mountain top and when seen from a valley.

This long period of erosion was brought to an abrupt end by the advance of the great ice sheet which covered the region for many thousand years and finally disappeared some ten thousand or more years ago. The ice streamed across the region for thousands of years and greatly modified the topography. It smoothed off the north slope of hills, steepened the south slopes and widened the north-south valleys. When the ice finally melted a vast amount of debris was deposited. This debris or glacial drift is of two general types: the unwashed and unstratified drift which was dropped directly from the ice and is known as till, and the washed and stratified deposits which were laid down in water. Glacial till consists of a heterogeneous mixture of clay, rock flour, sand, gravel, cobbles and boulders. When the proportions of clay and boulders are considerable, it is known as boulder clay. The stratified deposits consist of clay, rock flour, sand and gravel. Sand predominates in the upper St. Maurice valley.

Fig. 1—St. Maurice River Drainage Basin.

The glacial drift forms an incomplete and uneven blanket over the country.

Thus the post-glacial streams took new courses through the clogged valleys, and when passage was completely blocked, they sought the paths of least resistance through low gaps in the hills, and along two lines they were turned to the east by zones of glacial deposits. The result was a drainage system completely different from that of pre-glacial times."

Hydrology of The St. Maurice River as it Pertains to Rainfall and Run-Off

There have been some meteorological records available from this area since about 1900, and from these it is determined that the minimum annual rainfall is 26 inches and the maximum 46 inches, while the average annual rainfall is about 36 inches.

Records of the water surface elevations of the river have been recorded at Shawinigan Falls since 1901 and a rating curve of river flow in c.f.s. has been made, based upon a series of meter flow measurements over a wide range of discharges. From these records it is evident that the minimum flow before any storage was available was about 5,800 c.f.s. and the maximum flow 172,000 c.f.s. and the mean average flow 25,600 c.f.s. This means that the average annual run-off is equal to about 22 inches of rainfall, or in other words, the average annual run-off is about 61 per cent of the average rainfall.

There are now eight meteorological stations established in different parts of the drainage area from which precipitation records are available.

Between the years 1900 and 1928 four hydro-electric developments had been made on the lower reaches of the St. Maurice, converting 380 feet of head into hydro-electric and hydraulic power. The Shawinigan Water and Power Company had control of 285 feet of this head, which was comprised in three developments, namely: Gabelle, Shawinigan Falls and Grand'Mere with an installed capacity of 674,000 h.p.

As the demand for hydro-electric energy had shown a fairly steady ratio of increase in the years preceding 1928, and it was apparent that the potential power on the lower reaches of the river would soon be completely developed, it was logical that serious consideration should be given to the potential power resources on the upper reaches of the river.

The Quebec Streams Commission had done valuable preliminary field work along certain sections of the upper river, which consisted of water surface profiles from the outlet to the Gouin dam storage, a distance of 237 miles by river. They had also established benchmarks and certain gauges (the records of which were available) and made topographic surveys of certain rapids and falls, together with preliminary plans and general schemes of developments at three locations on that section of the river between La Tuque and the junction of the Manouan and the St. Maurice, a river distance of 84 miles.

Early in 1928 the Shawinigan Water and Power Company made application to the Quebec government for the power rights on that section of the upper St. Maurice as outlined above. At a public auction held at the provincial buildings on May 23rd, 1928, the company secured a lease to develop the potential power on that section of the river from the division line between the townships of Vallieres and Dumoulin at river mileage 110 to the junction of the Manouan and St. Maurice at river mileage 188, constituting a section about 78 miles in length. (See Fig. 1).

The normal water surface elevation at the lower limit is 508 while the normal water surface elevation at the junction of the St. Maurice and Manouan is 1,138, being a difference of 630 feet, which is the theoretical head available in the 78 miles of river. Of this total, only 150 feet were concentrated in two major falls.

The determining of what part of this head could be made economically available in the form of hydro-electric power, forms the subject of this paper.

A condition of the lease as regards development was, that in order to carry out the entire constructive programme as outlined in certain clauses of the lease, further surveys and data additional to those which were then available would be necessary and the lessee would be under obligation to make these additional surveys and obtain additional data at his own expense. The lease also provided that plans and specifications as well as a constructive programme should be finished by January 1st, 1930, for submission to the minister, as his approval of the complete scheme was necessary before any actual construction work could be started on the first development. It was also specified in the lease that the lessee should commence actual construction work on the first concentration within the above section of the river, not later than July 1st, 1930.

In order to meet the above conditions, immediate action had to be taken in preparing a comprehensive plan for the various necessary field operations.

Early in the spring of 1928, S. Svenningson, M.E.I.C., and the author made an extensive reconnaissance trip along this section of the river, utilizing such plans and data as were then available. Fortunately there were vertical aerial photographs of a strip about one mile wide along this section of the river from which a form line plan was made which was found to be extremely useful. There were also a profile of the water surface and topographic plans of

Rapide Allard, Rapide des Coeurs and a portion of the White Rapids, (which plans had been made by the Quebec Streams Commission), and a profile of that part of the Transcontinental Railway between La Tuque and Weymontachingue.

About three weeks were spent on this general reconnaissance, and as a result it was evident that the topographical, hydrological and geological features of this section of the river were such that it would be necessary to obtain much additional information before a complete scheme of development could be worked up which would utilize as much of the 630 feet theoretical head as should be found economically feasible. It also became obvious that no one single development could be definitely located until a sufficient study had been made to determine its effect on the ultimate scheme.

In the investigation of any hydro-electric development scheme, the field engineering features can be classified in three general divisions, namely, hydrological, topographical and geological. Hydrology should be placed first, because without water there can be no hydro-electric problems. As regards topography and geology, while they are somewhat related, it is apparent that the general topography of the St. Maurice is more important than its geological features, although one can easily think of conditions where this order might be reversed.

Hydrology as Related to Stream Flow

The data dealing with rainfall and run-off as already mentioned had reference to the lower part of the St. Maurice and therefore included practically the whole of the water shed. It was now necessary to deal with a section of the river which has at the lower limit a drainage area of 10,600 square miles, and at the upper limit 6,560 square miles.

On the 78 miles of river records of water elevations only existed for one location, Manouan, which is near the upper limit, and therefore no rating curves of flow were available.

The installing of water surface gauges at various points was given careful consideration, because it was known from experience that the value of an elaborate and costly series of gauge readings is greatly reduced by the presence of errors or even by uncertainty as to some essential part of the work. This is especially true when gauge readings are studied or repeated years later. It is essential that field observations should be based upon the general principle that sufficient information be included in the notes to enable one not familiar with the details to apply the data with confidence, and that old and new observations should be strictly comparable.

Some of the most common errors occurring in water gauge readings may be listed as follows:—

1. errors due to poor choice of gauge location;
2. errors in benchmark elevations;
3. settlement or disturbance of the gauge;
4. moving a gauge or resetting it some distance from its original location, and then using the old number;
5. "guessed" readings;
6. carelessness in referencing the zero of the gauge to a properly described benchmark.

The information given by correct water gauge readings is applicable to determining:—

(*a*) the water surface slopes;
(*b*) backwater curves;
(*c*) river discharge;
(*d*) design of coffer dams;
(*e*) certain features of power plant design;

Due to the general water surface profile and the inflow of various tributaries it was necessary to install about sixty gauges. These were of various kinds selected to meet the local conditions, but in general included non-recording gauges of three types:—

direct reading tripod gauges;
direct reading staff gauges, and
indirect reading cantilever or chain gauges.

This latter type proved very satisfactory. The boom and its supports were made up of local timber and the scale consisted of flexible levelling tapes which were coated with white shellac. The pulley was of the clothes-line variety, having a 10-pound sash weight, with a one-quarter inch cable. Add to the above a few nails, some friction tape and wire, a little labour, and a reasonable amount of experience and care, and the result was a satisfactory gauge at reasonable cost. The real merit of this type of gauge is that it is not damaged by the action of floating ice, logs, etc. The time and frequency of reading the various gauges depended upon what use was to be made of the data, and varied from several readings daily to an occasional reading at various stages of flow.

Measurements of Stream Flow

As an aid in determining the head and tailrace elevations as well as the range of fluctuations for various flows, together with the ultimate plant capacity to be installed at the various sites which would be selected, and also to enable reasonable estimates of unwatering costs during construction to be made, it was deemed advisable to meter the river flow at two separate sections, so that rating curves of flow could be made. The first section metered was at river mileage 148 having a drainage basin of 8,255 square miles. The second section metered was at river mileage 119, having a drainage basin of 10,440 square miles.

Current meter measurements are usually done under one of the three following conditions:

Firstly, where extreme accuracy of results is of prime importance; secondly, where time and expense are important factors, and thirdly, where a balance between the first two is desired.

The determination of the best hydraulic section for metering is of utmost importance, otherwise the value of the best of equipment and methods is largely nullified. Therefore, it may be well to mention some of the essential characteristics:

(*a*) 200-foot length of channel through which the cross-section and velocity is reasonably uniform;
(*b*) bed and banks permanent for all stages of flow;
(*c*) permanent control of section for all stages;
(*d*) minimum mean velocity not less than 0.6 foot per second for low stages and not in excess of 9 feet per second for high stages.

It has been found that the accuracy of current meter flow measurements varies rather widely, depending on the characteristics of section, equipment, and methods used.

If an accuracy of within 15 to 20 per cent is satisfactory, this can of course be obtained by various types of floats. If 7 to 10 per cent error is permissible, this can be obtained by metering at 0.6 depth without giving too much attention to the selection of panel sections. If, however, a greater accuracy than 4 to 5 per cent is to be obtained, great care must be taken in selecting the equipment and in the method of actual meter operation.

The equipment and field operations on the upper St. Maurice may be briefly described as follows:—

One "Ott" direct acting, and one "Price" differential acting current meter were employed. Two Vercheres type square stern boats, 16 feet in length were used, because their shape is well adapted for use in swift water without affecting the current at the point of metering, also allowing beaching, running aground or the meeting of obstacles without damage. They were equipped with struts, decking, cleats, etc. to form a working platform. A small winch which carried the meter cable was clamped to the deck. The decking was built in sections bolted together so that it could be easily and quickly dismantled. The motive power was either one or two 7-h.p. "Super-Elto" outboard motors and their use during unfavourable conditions, such as rain, snow, frazil and floating ice, was quite satisfactory. (Fig. 2.)

A messenger cable, three-eighths-inch diameter, to which these boats were attached, was placed across the river

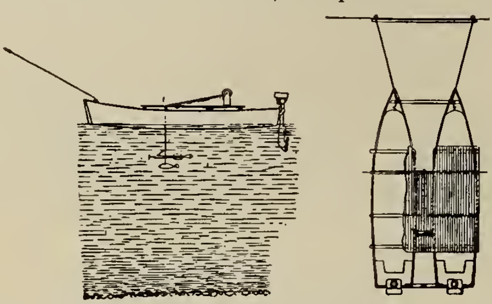

Fig. 2—Equipment Used in Stream Flow Metering.

in a manner which will be illustrated later, together with a one-quarter inch cable calibrated at ten-foot intervals.

Preliminary cross sections having been taken and a profile of the metering section made, panel points were chosen where a change of velocity was indicated by the profile. Fourteen panel points were selected in this way in a width of 600 feet of river, the smallest panel being 20 feet in width, and the largest being 80 feet in width. It has been found that where panel points have been well selected it reduces the number of meter readings necessary for accuracy, thereby reducing the time, which is an important element, as this reduces to a minimum the variations in gauge heights.

In general, each panel point was metered at 2/10 and 8/10 of its depth, but at shallow depths 6/10 of the depth was metered. In order to determine if there were surges, and if so, what the time element was, the meter was suspended at about a three-foot depth at three different points, the total number of revolutions being read every 15 seconds. From a graph of these results it was evident that the surge cycle was about 165 seconds and this time was used for any one determination of velocity. As a check on the 2/10 and 8/10 method, vertical velocity curves were measured; one meter measured velocities at the following percentages of total depth: surface, 5, 20, 40, 60, 80, 95, bottom, and 90, 70, 50, 30, 10, 5, surface.

A second meter, termed the index meter remained at a fixed point, 45 per cent of the total depth and about four feet horizontally from the traversing meter. The index and traverse meters were operated simultaneously and in the calculations the separate velocities were worked out for each meter and a mean index velocity was determined as well as a coefficient of correction to be applied to the various readings of the traverse meter readings. From the corrected velocities a vertical velocity curve was constructed and it was found that the mean of the 2/10 and 8/10 depth velocities was 2¾ per cent in excess of the true mean in the vertical. The discharges were first calculated as uncorrected and then reduced by 2¾ per cent as determined by the vertical velocity curves.

The section was metered thirty-four times over a range of 7 feet rise in elevation, which means an increase of about 24,500 c.f.s. in flow. From the resulting data a rating curve was made for a range of flow between 10,000 and 60,000 c.f.s. which is believed to be accurate within the range of one per cent.

A second section was metered at river mileage 119 with the same equipment and methods and a rating curve established there also.

Ice Conditions

The winter weather conditions for this district are severe: minimum temperatures of from 50 to 60 degrees below zero F. have been recorded, and this condition, together with the long stretches of rapid water, such as that part of the river between mileage 129 and 138 known as Rapide Blanc, in which the average slope is about 26 feet per mile, is ideal for the formation of frazil ice. It was evident that careful consideration should be given to the general ice conditions of the river, if serious trouble was to be avoided in plant operation and efficiency.

During the winter of 1929 there was a patrol of the river and daily reports as to air temperatures, water temperatures, wind velocities, ice formation, and ice movement were recorded. From these observations it would appear that frazil ice forms in the rapids under favourable conditions in quantities of many thousands of tons per hour; that frazil ice is far in excess of anchor ice; that shore ice will form until the stream velocity reaches a little more than 3 feet per second. It is evident that the practical way to eliminate ice troubles would be to completely drown out the various rapids, or allow sufficient forebay capacity to take care of enormous quantities of ice.

Topographical Features

A study of the topographical features revealed the necessity of obtaining a large amount of topographic data in a relatively short time and therefore it was decided to divide this part of the work into three parts, namely: aerial photographic form line and contour surveys; preliminary ground field reconnaissance by means of aneroid barometers, hand levels and compasses; and the usual detail ground surveys.

By the use of aerial survey methods comparatively large areas can be mapped in a short time and much valuable information obtained with regard to the general topography, width of river valley, location and elevation of the height of land between the various tributaries, type.

Fig. 3—Looking Downstream Mile 112.

and extent of any proposed flooded areas, also types and density of timber which might be affected.

The important part of the specification for the taking of aerial photographs was as follows:—

(1) That aerial photographs be taken with a camera the lens of which had been calibrated at the National Physical Testing Laboratory at Ottawa and having the points designating the optical centre of the lens marked, so as to be reproduced on each print;

(2) that the lens used be either 8-inch or 12-inch focal length at any altitude up to 9,000 feet;

(3) that aerial photographs be taken in parallel strips in an easterly and westerly direction, maintaining a forward overlap of 55 per cent and a lateral overlap of 20 per cent or more;
(4) that a constant altitude above the ground in excess of 7,000 feet but not exceeding 11,000 feet, be maintained throughout the entire area;
(5) that the average tilt of the photographs should not exceed one degree from the vertical and the maximum tilt 3 degrees from the vertical;
(6) that the long side of the picture be perpendicular to the line of flight, due allowance being made for "crab."
(7) One set of contact prints on semi-matte paper from each negative to be supplied.

Photographs as specified above were taken over an area where the only ground control, either horizontal or vertical was a plan and profile of the river, and therefore, upon receipt of the photographs it was necessary to examine them under the stereoscope so that ground control could be done at the points where it would be the most useful, thereby reducing the amount of ground control to the minimum.

Certain features were selected from the photographs which could be identified in the field, such as a stream outlet or bend in stream, a bare hill top or an old lumber camp, and the elevation of these selected points was determined. The amount of ground control necessary depends upon the general topographical features and the accuracy desired in the final map. In this case extreme accuracy was not required, so the vertical control points were as much as four or five miles apart and the horizontal control about fourteen miles. After this control was made, the process of transferring the data from individual photographs to map form was begun and the radial line method used. The process can be roughly summarized as follows:—

(1) transferring the principal and minor control points;
(2) plotting skeleton strips to an undetermined scale;
(3) stereoscopic determination of topography;
(4) changing this topography to the strip plot;
(5) determination of the actual scale of strip plots;
(6) assembly of the reduced strip plots to projection of finished map.

As a net result of this work, plans were produced on which approximately 1,200 miles of contours were shown to an accuracy sufficient for the purpose and within a minimum time interval, and at a cost which could not be approached by any other method. It might be of interest to know that there was an opportunity to check a portion of the aerial-determined contours by ground survey methods, and it was found that the total area included by the aerial method was in error by about 3½ per cent. Considering the small amount of ground control used, this result was quite satisfactory.

As the study progressed various places were found which were not included within the photographed area and where preliminary data were needed, and in such cases, a reconnaissance party was sent out equipped with the usual aneroid barometer, hand levels, compasses, etc.

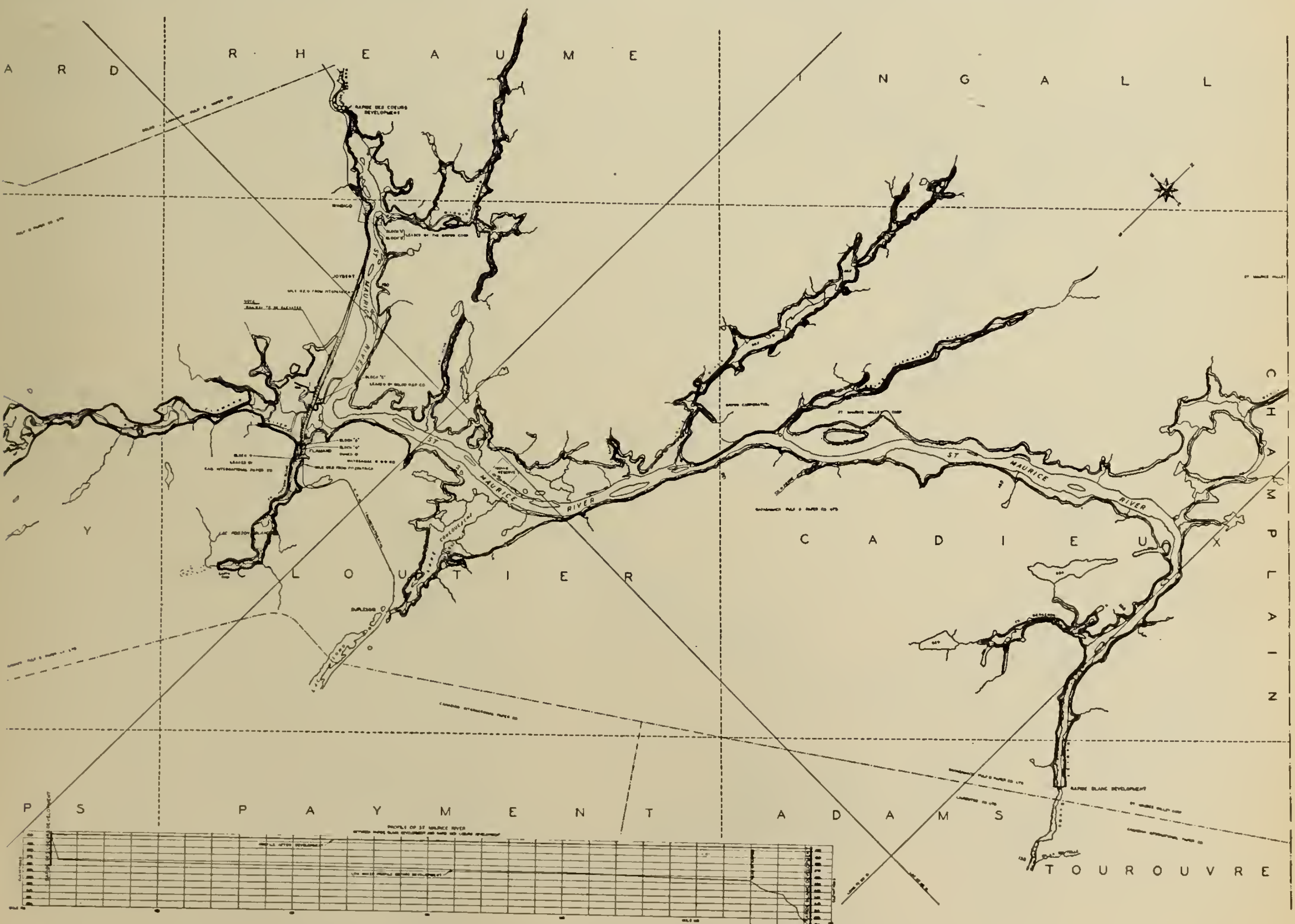

Fig. 4—Rapide Blanc Development, Major portion of Lands Affected and Profile.

As regards the detailed ground surveys the equipment was of the usual type familiar to all field engineers and the personnel of the parties included the chief of party and the necessary transitmen, levelmen, chainmen, rodmen, axemen, and last but not least the chef.

Some of the more important instructions issued to each chief of party follow:—Camp equipment and sites to be kept in a sanitary condition; be familiar with first aid so that the first aid equipment furnished would be of practical use; extreme care to be used in handling boats and canoes; base lines to be established and monumented with concrete monuments; benchmarks to be established and checked with the records of the Quebec Streams Commission; both benchmarks and base lines to be referenced so that they could be easily identified after a period of years. All field notes to be plotted and checked in the field.

As a result of reconnaissance and study it was found necessary to make a detailed topographic survey of portions of the river at the following mileages; 112, 118, 129, 133, 135, 136, 138, 164, 176½, 179, 181, 182 and 183. River mileage 112 is about one mile upstream from the lower limit of the section under lease. At that point the topography is such that it offered possibilities for a development with a range of head up to 200 feet and therefore data were secured to work out three schemes, comprising the following range for developed heads, 60, 110 and 200 feet.

These various heads were selected for the reason that each one would drown out the rapids to a point where the topography was favourable for the location of another development.

The 60-foot head would give a forebay length of 6 miles; the 110-foot head 17 miles, and the 200-foot head 21 miles.

The Transcontinental Railway parallels the river at this location and is only 40 feet above the normal water level of the river. This entailed extensive relocation surveys for each of the three schemes, totalling in all about 20 miles.

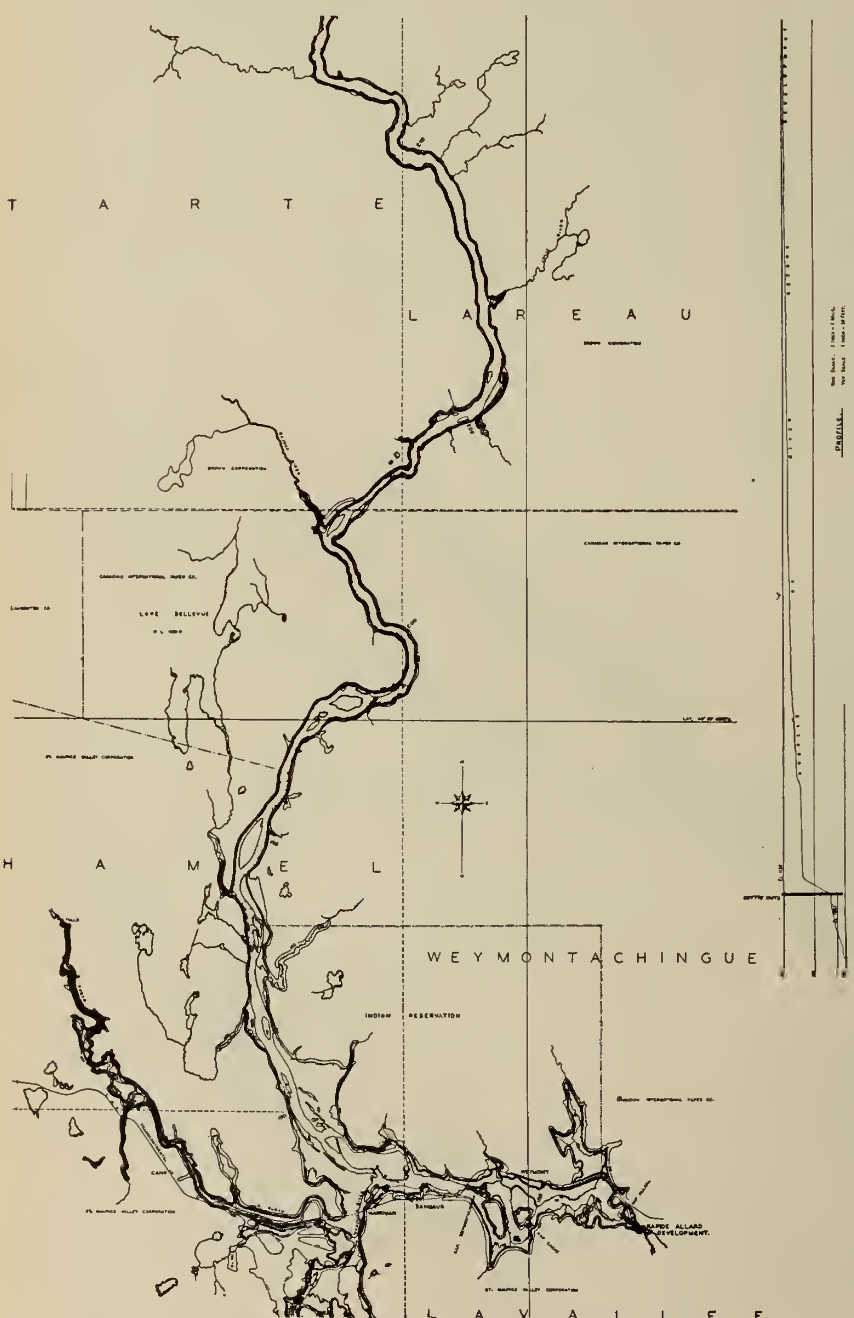

Fig. 5—Rapide Allard Development, Lands Affected and Profile.

At mileage 118 there was a possible location for a developed head up to 210 feet and for the same reasons as previously mentioned, the following heads were considered, 50, 88, 108, 138 and 210 feet.

At mileage 129 sufficient data were obtained to make a study of the following heads, 90, 160, 172 and 238 feet.

At mileage 133 three different heads were considered, viz.: 148, 183 and 243 feet.

At mileage 135½ four heads of 78, 93, 113 and 178 feet.

At mileage 136, four heads of 70, 85, 105 and 165 feet.

At mileage 138, two heads of 45 and 105 feet.

At Rapide des Cœurs, mileage 164, two heads of 80 and 90 feet.

At mileage 177 (Rapide du Lievre), three heads of 45, 65 and 83 feet.

At Rapide La Graisse, mileage 179, one head of 45 feet.

At Iroquois Rapids, mileage 180, one head of 38 feet.

At Rapide Petit Rocher, mileage 181, one head of 45 feet.

At Rapide Allard, mileage 183, four heads of 40, 55, 65 and 83 feet.

The above-mentioned locations were those at which detailed surveys were made as well as the necessary railroad relocation surveys. In addition to the above there were five other locations where cross-sections were made and other preliminary work done, but where further detail study was not thought necessary.

During the progress of the field work it was discovered that the height of land between the St. Maurice watershed and watershed of the Vermillion, which is one of its tributaries, was at elevation 895 and therefore if the normal water surface of the St. Maurice above Rapide Blanc was raised by a development in that section above this elevation, the flow of the St. Maurice at Flamand (or river mileage 158½) would be diverted through Creek Poisson Blanc and Creek Auger into the Vermillion entering the St. Maurice again at mileage 121. The normal water elevation of the St. Maurice at Flamand is about 866, while at the outlet of the Vermillion it is 605, a difference of 261 feet. This condition presented the possibility of diverting the St. Maurice into the Vermillion and therefore the feasibility of locating plants on the Vermillion to develop a head of 280 feet. Some of the major advantages to be gained by this diversion would be that no spillway capacity would need to be provided at the various plants; there would be a much smaller flow to be taken care of during construction; transportation facilities could be provided at less cost and approximately 15 miles of transmission lines could be saved.

It was therefore determined to make a profile of the Vermillion river and to ascertain on what parts of the river, if any, the topography might be suitable for such purpose. Cross-sections, soundings, etc. were taken, and three fairly suitable sites were located at which heads of 90, 100 and 90 feet could be developed. The next step was to trace out the high contours, with the aid of aerial photographs, ground reconnaissance and an inspection of the geological features. It was then found that the height of land between the Vermillion and Rat river watersheds was at a comparatively low elevation with sand formation to a great depth forming the divide. A cut-off dam therefore would be necessary, and this proved to be too expensive, which sounded the death knell of this scheme.

Geological Features

Two lines of geological investigation were followed. The first study was that of the general geological features of the district especially as to the relationship, if any, between the preglacial and the present drainage systems, and secondly, a more detailed study of various sites which might be considered as suitable for final development. As an aid in this work all available information from maps and aerial photographs was first studied and then extensive reconnaissance trips were taken and later this information was supplemented by flying over portions of the district. When the study had advanced to the point where it was found advisable to determine the depth to rock at certain key places, the method of electrical prospecting was suggested by the geologist and was used at six locations to determine the depth to rock in order to prepare a contour map of the bed rock surface and outline the buried gorge in the vicinity of proposed dam sites.

As a result of the first part of these studies, the geologist reported that the present irregular course of the St. Maurice river is due to the fact that it is not now in its old preglacial valley, but now occupies parts of five preglacial streams and flows over old divides at Rapide Allard, Rapide des Cœurs and at the head of Rapide Blanc, and as a result of this, the valleys at these locations are narrow and the rock is at or near the surface. Also no structural faulting is evident and these sites are favourable for dams. The geologist's idea of the preglacial drainage and its relation to the present is shown in Fig. 7. After the general geological features had been outlined a more detailed geological study was made of twenty possible dam sites and at four of these an electrical prospecting method was employed in order to determine the depth to bed rock and the location of the preglacial valley.

The system adopted involves causing an electrical current to flow through the ground, and then studying the

Fig. 6—Rapide Allard Development, General Plan.

distribution of the resultant electric field.* The accuracy of this method depends upon the well defined difference in the resistivities of the various strata of overburden encountered.

The bedrock along the St. Maurice valley consists chiefly of granite and is covered by an unconsolidated sedimentary overburden. The granite is so compact that it contains but little water and has a resistivity which is always very high, usually varying between 5,000 and

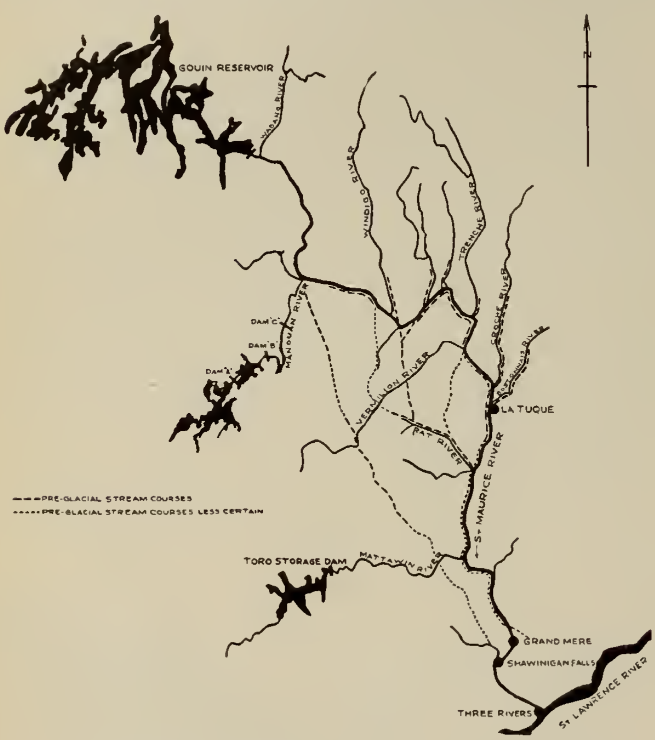

Fig. 7—Preglacial Drainage of the St. Maurice Valley.

25,000 ohms per cubic meter and is quite regular over limited areas. On the contrary the unconsolidated sedimentary overburden usually has a high porosity and high water content. Its resistivity is, therefore, quite different from that of granite and much more variable. The following figures are characteristic; the resistivity of wet clays usually lies between 30 and 200 ohms per cubic meter, material of a silicious nature shows from 250 to 1,000 ohms, and more or less dry compact sands give from 1,000 to 2,000 ohms and up.

From these summary indications, it appeared that the thickness of the overburden could be measured by electrical exploration with very reasonable chances of success. In all, 95 determinations to bed rock were made. As yet, there has been no occasion to check these results with actual core drillings, but it is known that where this method has been checked under somewhat similar conditions, there was a resulting error of about six per cent where the depth of overburden varied from 27 to 157 feet. While this method does not supplant geology or core drilling it can be made to supplement them and permits the obtaining of data rapidly, which gives a perspective of the situation and enables the planning of subsequent drilling or exploration to be done more economically. Fig. 8 illustrates the cross-section of a river bottom as shown by electrical prospecting methods.

As a result of the geological study it was possible to locate certain dam sites at points where the least trouble would be experienced with foundations; in other cases it gave an indication of the foundation problems to be met and therefore was an aid in the preliminary design and estimate of cost.

Conclusion

The various field operations which have been briefly outlined and which extended over the period from July 1st 1928 to December 1929 made surveys for possible hydro-electric developments at nineteen locations, comprising thirty-nine possible heads, and obtained data relative to such parts of railway location, timber limits, and depots, Indian reservations and fish and game clubs as would eventually come within the flooded areas.

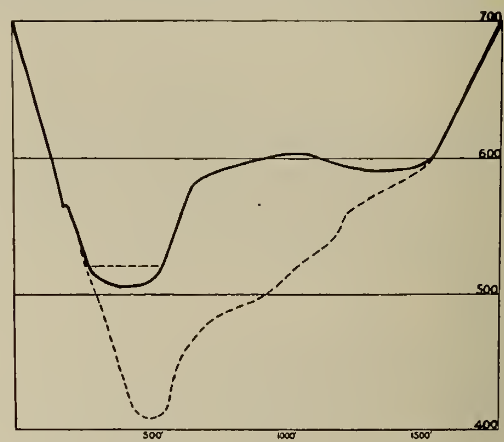

Fig. 8—Bedrock Level in River Bottom.

In the study of this information fifty-one various schemes were given consideration and comparative estimates made, and as a result, plans for six developments were submitted to the government and given approval. The locations finally selected and the tentative installed capacities are as follows:—

River Mileage	Name of Section	Head	Tentative Installed Capacity in h.p.
112	Sans Nom	110	252,000
129	Trenche	160	348,000
135	Rapide Blanc	113	240,000
164	Rapide des Cœurs	70	112,000
177	Rapide du Lievre	83	124,000
183	Rapide Allard	87	132,000

The foregoing heads total 623 feet out of a total theoretical head of 630 feet on this 78 mile section of the upper St. Maurice, making a total tentative installed capacity of 1,208,000 h.p. which can be economically developed and transmitted to industrial centres.

*See Leonardon, "Topographical Study of a Hidden Bedrock Surface by Resistivity Measurements," Engineering Journal, June 1931, pp. 331-335.

The Purification of Water Supplies

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Paper presented before the London Branch of The Engineering Institute of Canada, December 15th, 1932.

SUMMARY.—The author reviews modern practices in water purification, dealing first with preliminary sedimentation, mixing and coagulation. He discusses briefly the difficulties in the conditioning of floc and in the design of mixing chambers and other equipment. Filtration, aeration and sterilization are also considered, with particular reference to bacterial contamination and the improvement of the taste of the finished water.

It is the purpose of the present paper to present a brief resume of the outstanding features in the modern practice of water purification, without going into any great technical detail. The various processes will be outlined in such a manner as to supplement the information that may be acquired in an inspection trip through any modern filter plant, in the hope that having seen a modern plant, embodying the latest thought in the art, it may be possible to carry away some permanent conception of the multitude of factors that are involved in the work of supplying pure water to the community.

Turbidity in water is primarily a colloidal suspension of finely divided mineral matter (usually clay) together with a similar suspension or solution of certain organic dyes of the tannic acid variety, which give rise to colour. In addition to these there are usually present certain minute vegetable growths, given the general name of plankton, and almost universally bacteria.

It is the problem of the sanitary engineer to remove this matter and produce a clear, odourless, colourless, tasteless water for the use of the consumer. In addition to the physical requirements the water should be for all practical purposes sterile, at least as far as pathogenic bacteria are concerned. He must also be able to accomplish this result in such a manner as to bring the process within the range of economic possibility. There are many methods of doing this and obtaining satisfactory results which are not applicable when used on a plant scale.

The engineer must also recognize the changing whims of the consuming public. The consumer, although he does not realize it, has each year become more fastidious, and this is particularly pronounced in the case of water. Water that was quite satisfactory ten years ago and which is just the same now as it was then may not suit the consumer now at all. Ten years ago the use of artificial softeners was confined to a few laundries and some commercial steam plants. Now the modern house that makes claim to being up to date has a softener installed. Most laundries have found that it is cheaper to soften water than to buy soap for a hard water. As time goes on, the general public will become aware of the tremendous cost of soap that is wasted and will demand that they too be supplied with soft water. The amount involved can be realized when it is stated that by a conservative estimate, in the city of St. Thomas alone with a population of 18,000 served by the water works, there is now used annually 90,000 pounds of soap more than would be necessary, if three quarters of the present hardness were removed. The term soap in this case includes all substances that are used by the general public and industry for softening water. In the household the more common are washing soda, soap flakes, ammonia powders, etc., while in industry there is soda ash and all the varieties of boiler compounds. St. Thomas water has only 180 parts per million of total hardness. The terms hard and soft as applied to water are of course relative ones and depend on what the consumer is used to and the purpose for which the water is to be used. Ordinarily, however, water with a total hardness of less than 30 p.p.m. is considered very soft while over 300 p.p.m. is very hard.

The treating of water naturally divides itself into several parts each of which requires careful consideration.

The following are the main divisions of the problem:

1. Preliminary sedimentation.
2. Mixing and coagulation.
3. Sedimentation after coagulation.
4. Filtration.
5. Aeration.
6. Sterilization.

Preliminary Sedimentation

This was formerly the first step in the purification of water but with the general improvement in the science that has taken place in the past decade is now usually unnecessary except where incidental to a water supply storage scheme.

However in certain cases it may be of service. In the introduction it was stated that turbidity was a colloidal suspension, but in some cases there may be a granular suspension as well, as when water is taken from a rapidly flowing stream. In a lake, except after a storm, the fine sand, etc., will rarely be carried by the water and will not find its way into the plant. However, if it is being kept in suspension by storm or currents, some provision will need to be made for grit chambers.

This may be accomplished by a slowing down of the velocity of the incoming water to, from 0.5 to 1.0 feet per second, for a suitable detention period.

Impounding reservoirs formed by the construction of a dam on a stream will give the necessary storage and time element for the deposition of granular suspensions.

This treatment has a history of great antiquity and an interesting case of its use is found at Canterbury cathedral. On a Norman plan of the cathedral dated 1165, which is preserved in the Great Psalter of Eadwin in the library of Trinity College, Cambridge, the source of the water supply of the cathedral and monastic buildings is shown. The water was drawn from certain springs which are still used, and was treated by passing it through a series of four sedimentation tanks. The water was admitted to the bottom of the up-stream end and withdrawn from the top of the down-stream end. Provision was also made for drawing off the accumulated sediment through pipes in the bottom.

Mixing Chambers

These are of several types and are usually known as:

(*a*) The over and under.
(*b*) The around the end type.
(*c*) The hydraulic jump.
(*d*) The spiral flow vertical type.
(*e*) Mechanical mixers.
(*f*) Variations and combinations of these.

The term "mixing chamber" is somewhat of a misnomer in the light of modern practice. In some plants, notably in Cleveland, the use of the hydraulic jump is favoured. This is a true case of mixing, as the jump is for the sole purpose of causing an intimate mixing of the applied chemicals with the water being treated. However, as the term is generally used, it refers to the process of not only an intermingling of the chemicals but also the continued gentle agitation of the treated water. This is to promote the formation of the gelatinous "floc" of aluminium hydroxide and basic aluminium carbonate where alum is used as the coagulant, or ferric hydroxide in the case of plants using iron sulphate and lime.

When either of these chemicals is added to the water the chemical reaction immediately forms tiny particles of floc. These are dispersed throughout the water and cannot be distinguished with the naked eye. The water still looks turbid. If this water is subjected to a gentle stirring or mixing for some time the particles of hydroxide will tend to coagulate or adhere to one another with these coagulated particles forming larger ones. The structure of these larger particles may be compared to a sponge. In passing through the water these "sponges" are brought into intimate contact with all parts of the turbid water. The finely divided particles of turbidity are believed to possess an electric charge and the particles of floc to possess a charge of the opposite sign. This intermingling brings the particles of turbidity into the range of influence of the charge on the particles of floc. When this occurs the mutual attraction of the opposite charges causes the turbidity to be collected on the surface of the floc. It is the aim of the designer to cause the floc to be completely coagulated into large particles having in the process collected all of the turbidity so completely that the water has the appearance of a clear water with large particles of floc in suspension giving a "snowstorm" effect.

This *coagulum* is very sensitive and a severe agitation will cause it to disperse again and the water to lose its clarity, or sparkle. The designer is working between two factors. He must keep the floc in suspension through constant motion so that it can perform its work *of sweeping up the turbidity* but on the other hand he must keep velocities low enough to prevent the redispersion of the floc. Some waters will permit of rougher handling than others. At Ottawa the floc is so sensitive that it is difficult to draw a sample of coagulated water without destroying the coagulation. Other waters yield a floc that is "harder" and can be collected for examination without difficulty. The designer must investigate each water and determine for himself the quality of the floc produced. This may be generally found by jar tests but if the project is large enough it is well to arrange for an experimental unit treating quantities of water so large that actual operating conditions may be simulated. A miniature plant using 20,000 gallons per day is about the smallest capacity that will give dependable results.

There is little to choose between the "over and under" and the "around the end" type of mixing channels and the decision will usually lie in the adaptability to local conditions. The velocity in the channels should be from 1.5 to 2.0 feet per second. The floc must be kept in suspension without being broken up or redispersed. It is often desirable that some means be provided to adjust the velocities. This can be accomplished by means of moveable baffles providing for working some of the channels in series or parallel as the occasion demands. The larger the plant the greater the leeway that the designer has at his disposal in this connection. As in the spiral flow type the time element is important.

The hydraulic jump type of mixing does little more than cause an intimate intermingling of the chemical with the water. It gives little emphasis to the time element and should be followed by some of the other methods of conditioning. A few years ago, before the importance of proper conditioning was recognized, this was often used and the water allowed to coagulate as best it could in the settling basins. The production of the hydraulic jump is simply a matter of the correct application of the laws of hydraulics and where the available head is limited the loss of head in this arrangement is a disadvantage.

In the spiral flow type of mixing chamber, the water is led through a series of comparatively small cells usually square with filletted corners. The water is introduced tangentially and is withdrawn the same way, its withdrawal being coincident with its admission to the next cell. In this way the water is given a gentle stirring motion and

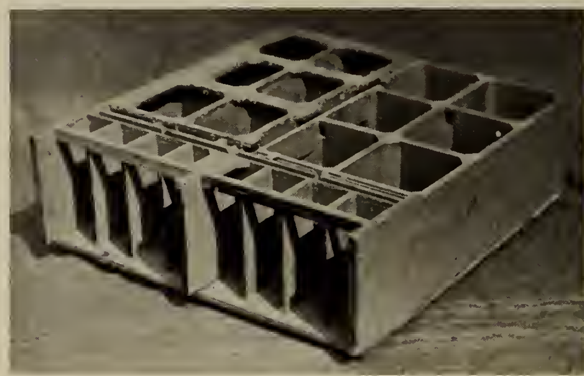

Fig. 1—Model of Spiral Flow Conditioning Chambers.

the velocity can be controlled in the design by the loss of head given the water in its progress through the mixing tanks.

Fig. 1 illustrates a scale model of spiral flow conditioning chambers. The plant of which this is a model consists of two conditioning units operating in parallel. The near unit has the floor system removed. The vertical walls in the foreground are in the upstream end of the settling tank and keep the water, as it leaves the ports of the distributing trough, from being diffused laterally.

The time element is the most important single factor. Some waters will be completely coagulated in about twenty minutes. It has been found that half the time with twice the velocity, even keeping the velocity within the critical point when the floc redisperses, will not give the results that may be obtained with the optimum time. While twenty minutes will suffice for most waters, there are always exceptions to all rules, and occasionally a water is found that may take as long as ninety minutes. This optimum period should be ascertained by experiment before a design is made.

Unless the water calls for a very prolonged slow mix, it is usually considered good practice to make the detention period in each cell from eight to fifteen minutes. The loss of head through the mixing chambers should be adjusted to produce a velocity that will, in ordinary operation, keep the coagulated floc in suspension on the one hand, but will not destroy or redisperse it on the other. This may be adjusted by the size and shape of the orifices between the cells.

In the case of chambers where a long slow mix is indicated, an inverted hopper bottom will keep the floc in suspension at the bottom of the cells where there is liable to be a dead space and thus prevent the deposition of a quantity of floc in the bottom. In the mixing chambers the water is being continually sent to the bottom of the cells and an accumulation of a body of the floc in the bottom, where through lack of air it will become foul smelling in time, is likely to give a taste to the water.

Some of the later plants have been attacking the problem of conditioning the floc by means of mechanical mixers. These mixers are of two types and may be roughly distinguished by the position of the axis of the mixing device. In the older type with the axis vertical and the paddles swung vertically from an arm that is hung from a vertical shaft the paddles are free to swing from the top attachment and the whole mechanism rotates at a predetermined speed. The paddles through being free to swing from the top will permit a lag in the circumferential velocity of the water until the whole is brought to the optimum condition of rotation without undue shock. Generally, however, a consideration of the laws of hydraulics will permit producing this velocity in the spiral flow mixing chambers without such mechanical contrivances.

In the case of plants where the spiral flow system has been installed and due to a change in the character of the water, or a change in the hydraulic conditions, the conditioning of the water has been impaired, one or more units of this type of mixer can be inexpensively installed in the spiral flow tanks.

A later type of mechanical contrivance for this purpose was exhibited last year for the first time. It consists of paddles arranged on a horizontal axis and is located at the inlet end of the sedimentation basin. (See Fig. 2). The water, with the chemicals added, is admitted to the basins and immediately met by batteries of paddle wheels with fairly wide blades rotating in such a manner as to give the water a rolling motion and thus induce a coagulation of the floc particles. As the water passes along the basin it is successively stirred by additional paddles that decrease in width as they progress along the basin. The narrower paddles cause a decrease in the rolling action as the floc is developed and finally, as the water leaves the zone of the paddles, it is admitted to the settling zone without having to pass through ports of any kind. In the case of the rehabilitation of an old plant of sufficient size, this type offers some advantages, in that the mechanism may be installed with a minimum of construction work. The addition of mechanical features with consequent maintenance, constitutes the objection to this type of installation. The design of ports between the mixing units and the sedimentation zone, is of greatest importance, as a poorly designed port will undo a lot of the good that is accomplished in the mixers. The entire absence of such ports is an additional advantage of this latter type.

A recent installation makes use of a similar set of paddles, but with the axis of rotation parallel with the flow of the water, somewhat similar to one of the types of paddle aerators used in German sewage treatment practice.

Fig. 2—Mechanical Conditioning Unit Located at one End of Settling Basin.

Sedimentation Basins

If the water has been properly conditioned the deposition of the coagulated floc will be accomplished quite rapidly. Velocities of from 1.0 to 1.5 feet per minute can usually be maintained. The detention period required depends on a number of factors, the condition of the floc and the temperature of the water being the most important, always assuming that the hydraulics of the basin are correct. Baffling the basins used to be considered good practice, but latter practice inclines to leaving the basins as free of obstructions as possible. Where possible, even columns should be eliminated. From two to three hours detention is usually sufficient, if the water is well prepared. It was formerly considered good practice to leave a quantity of suspended floc in the water as it left the basins, on the assumption that it was needed to cause the filters to work to advantage. Modern practice however, leans to the idea that the filters should have as little work to do as possible

Fig. 3—Mechanical Collecting Unit in a Settling Basin.

and the effort now is to obtain as complete a sedimentation as possible. This leaves to the filters only the straining out of the floc that cannot be settled out economically and thus allows longer filter runs with a consequent economy in the use of wash water. Runs of seventy-two hours are easily possible with good design, when temperature conditions are favourable.

The continuous removal of the sludge mechanically offers attractive possibilities and is practised in some of the newer plants, thus following the lines of sewage disposal practice. Fig. 3 illustrates a mechanical collecting unit in a settling basin where the sludge is continuously ploughed to the centre and removed. Construction costs can often be lowered as well, as the designer does not have to provide for sludge storage space in the basin. The return of some of the settled sludge to the incoming water may often be practised to advantage and is of great assistance in certain waters usually resulting in a saving in chemicals. Where sludge is returned, however, it should be comparatively fresh. Sludge which has been allowed to accumulate for some weeks in one of the older types of settling tanks will usually become foul smelling and unsuitable for re-using.

Filters

With the modern methods of conditioning water the work of the filters has been materially changed. When poorly conditioned water was applied to a filter as was the practice ten years ago, a great deal of the work of collection of the turbidity by the floc was done in the passage of the water through the sand. This is of course done to some extent now, but the greater part of the clay and the colour has already been left in the settling basins.

In its elementary conception the filter unit consists of a bed of sand supported on beds of gravel of gradually increasing size. Each gravel layer will be supported on but will not penetrate the layer next below it. Depending on the type of water and its treatment the sand and gravel layers are of varying thicknesses. Customary practice will usually provide 24 to 30 inches of sand and 20 inches of gravel.

The size of the filter sand has a great influence on operation and is expressed in filtration practice in the metric system with two factors used to rate it. These are "the effective size" and the "uniformity coefficient." The effective size is the geometric mean diameter of the largest particles in the smallest 10 per cent of the sand and the uniformity coefficient is the ratio of the size of the geometric mean diameter of largest particles in the smallest 60 per cent to the effective size. If all of the sand grains are of the same size the uniformity coefficient will be 1.0. This is of course, never attained in practice. A uniformity coefficient of 1.6 is usually specified. The trend in the last few years has been to larger sand sizes. Twenty years ago sizes of .3 mm. were common and until the last few years .4 mm. was considered coarse. However, with improved methods of conditioning the use of coarser sands is now common. In the St. Thomas plant a sand with an effective size of .55 mm. is being used and this is by no means the largest in use as .6 mm. has been used under certain conditions with good results.

It is important that the sand used in filters shall not be disintegrated by the action of water with which it is constantly in contact. For this reason the sand has to be high in silica content and to insure durability it is generally required that not more than 5 per cent shall go into solution in hydrochloric acid after twenty-four hours digestion, or in other words the sand shall contain at least 95 per cent silica. Calcium and magnesium carbonates must not exceed 2 per cent.

Obviously this requirement rules out the use of local sands and gravels for all but the largest sizes of the gravel. The rate of solution of sands is largely a function of the surface that is exposed to the action of water. The finer sizes exposing a great area in proportion to the total mass are very susceptible to the action of the water, hence the rigid requirements. In the lower layers of gravel the area per unit of mass is much smaller and the use of local gravel may be permitted without fear of trouble.

The supplies of sand that can meet these rigid requirements are very limited, and in most places where they are found there is not usually a great enough demand to warrant the installation of machinery to grade it accurately to the required sizes.

Great care must be used in the sizing of the sand. It is a well known fact that when sand or gravel is of a nearly uniform size, the voids are about 45 per cent, while a variety of sizes in the sand will reduce these voids to less than 25 per cent. As the voids in the sand constitute the space that the water must traverse in the filtration process, the smaller the passages in the sand, the greater the head or pressure required. The depth of water necessary to overcome the extra loss of head will require deeper filters if poorly graded sand with a high uniformity coefficient is used. Deeper filters would also mean more concrete, more reinforcement, higher buildings with their increased capital cost, and more wash water would be needed in operation, as the filters would have to be washed oftener. Again higher wash water tanks would be required to provide for the greater head that would be necessary to wash. It is anticipated in the St. Thomas plant, that the percentage of filtered water that will be used for the washing of the filters will run a little less than 2 per cent for an annual average.

It is a source of some wonder to the layman that water having a turbidity many times smaller than the spaces in the sand beds can be filtered by passing it through these beds. When a filter is placed in service it will not filter effectively as it takes about three or four weeks for the sand to "ripen." This ripening process consists of the encouragement of the formation of a slimy or gelatinous layer to completely coat the sand particles. This layer consists mostly of the hydroxides of aluminium that are not settled out in the settling basin and if a bit of sand from a properly ripened bed is taken in the hand it will appear to be slightly sticky. The settled water, or as it is termed, the applied water, is brought into intimate contact with many thousands of these coated sand grains and its velocity is controlled. The remaining aluminium hydroxide floc with its entrained clay and colour is attracted to these sand grains and gradually builds up on them at the same time filling the interstitial spaces in the bed. As the spaces are filled the area of a given cross section is reduced and the velocity of the water. increased. This increase in velocity will require more head to force the water through the sand and will also reduce the tendency for the sand to attract the particles of floc. In time the bed will "break down" and turbid water will be passed, if remedies are not applied. Usually the loss of head in the filter will give the required indication as to when the bed should be washed and this is the main purpose of the loss of head gauges that are found on the operating tables.

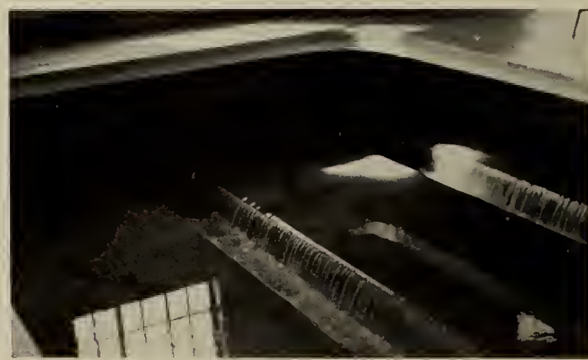

Fig. 5—Rapid Sand Filter During Wash.

When the loss of head is great enough to cause an incipient breaking down, the bed is taken out of service, the effluent and influent valve shut off, and the sewer valve opened. The wash water from the tank is then admitted to the under side of the filter, the water forced upward and the mud washed out of the sand and carried off through the sewer. The valves are then reversed and the filter put back into service again. This process of washing takes six or seven minutes.

While the filter is in service the floc particles are lightly attached to the sand grains and are more or less in equilibrium. A slight increase in velocity, if made suddenly,

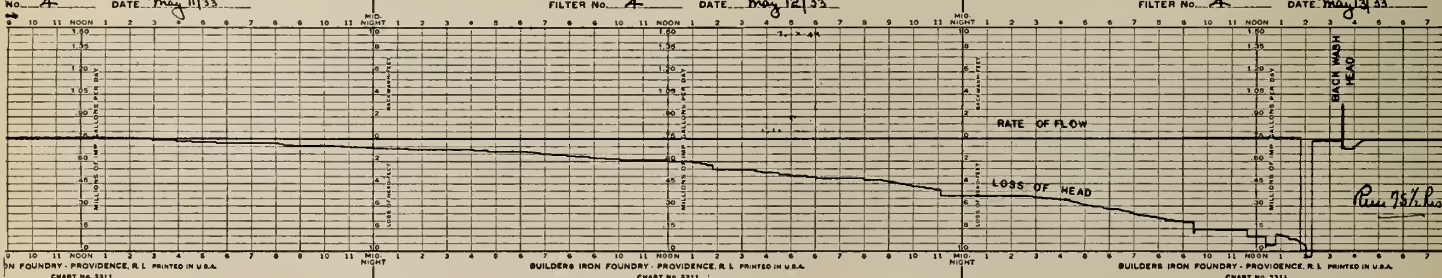

Fig. 4

will dislodge them and those nearest the bottom may be carried through into the effluent. It is therefore, essential that there should not be sudden changes in velocity through the sand beds, however the clogging of the bed would cause a reduced flow if the outlet valve were not adjusted. This involves constant minute movements of the valves and would entail constant attention on the part of the operator, who, at the best, could not do the work with perfect efficiency. The function of the rate controller on the filter effluent is therefore for the purpose of accomplishing this very thing. The difference in head on the throat of a venturi tube with varying rates of flow is used to operate a set valve and the controller set to give a constant flow. This is done very efficiently as shown in the chart in Fig. 4.

Aeration of Water

One of the oldest treatments of water to improve its quality is aeration and the beneficial effects have long been recognized, being perpetuated in the old adage that "running water purifies itself."

Water is an almost universal solvent. The fact that it is renders the art of water purification necessary. Water is not ordinarily thought of as dissolving gases as one is generally more concerned with the solution of solids. However, water will dissolve gases but their solution takes place under conditions somewhat different from that of solids. An increase in temperature will usually increase the solubility of solids, but in the case of gases, the reverse is the case. The higher the temperature the less the gas that may be held in solution.

Water without oxygen in solution will taste flat, for example the taste of boiled water. It is also known that if boiled water is slightly agitated before drinking, the taste will be greatly improved. Oxygen is readily soluble in water and experiments to illustrate its solubility are easily made and give interesting results. Tables are available giving the amount of oxygen that will dissolve in water at different temperatures. In certain instances it is possible to supersaturate water with oxygen, especially under the influence of photosynthesis in slow reaches of sluggish streams with a healthy growth of algae.

Water also contains a great deal of material that will oxidize if exposed to the influence of oxygen. One of the measures of the quality of water used for comparative purposes only and not as an absolute measure, is a figure known as "oxygen consumed." It is determined by introducing a known quantity of oxygen into the water, usually in the form of permanganate of potassium, and after a certain interval with appropriate treatment by heating under standardized conditions, the amount of oxygen remaining is measured, the difference being the amount of oxygen consumed by the materials in solution. These materials will also be consumed by oxygen in its free dissolved form in water and the object of aeration is principally to provide sufficient free dissolved oxygen to do so and to replace any that has combined in the process with additional oxygen and to provide such a surplus in the water as may be necessary to bring it to the standard of purity that has previously been decided on.

One of the most susceptible of the elements to the use of the aeration process is iron. Iron in concentrations greater than 0.3 ppm. will give trouble in the form of "red water," the familiar red stain on enamelled fixtures in bath rooms being visible evidence of its existence. Iron under favourable conditions will promote the growth of "iron bacteria" known as crenothrix. Iron is usually found in its soluble form, the salts of the ferrous series and proper aeration will generally add the extra atom of oxygen to the ferrous salts and change them to the ferric state when they are not soluble. If the aeration is carried out in advance of a suitable period of subsidence the iron will settle out or will be caught in the filters, provided there is an excess of oxygen always present. Should the oxygen become depleted in the process, there will be a tendency for the ferric iron to give up its oxygen to some other more attractive substance the iron then going back into solution and not being retained on the filters.

Other gases such as carbon dioxide and hydrogen sulphide are readily soluble in water, but are easily driven out by agitation in the presence of oxygen. The rendering of the sulphur water in the wells at London, into palatable drinking water, is a splendid example of this fact. The internal mechanics of this process are not well understood, but the fact that it may be done is self evident if one will stand in the vicinity of an aerator when this type of water is being treated. Foul smelling gases resulting from the decomposition of animal and vegetable matter in the bottom of storage reservoirs will also usually be swept out by aeration of the proper type.

Those familiar with the phenomena occurring in the treatment of sewage by the activated sludge process, know of the effect obtained through exposing the liquid to the influence of atmospheric oxygen. It is known that the greater part of the oxygen that is absorbed in the process comes from the contact of the sewage with atmospheric oxygen. The obvious procedure therefore, in the case of water is to break the water into as small particles as can conveniently be done, thereby exposing a larger water surface to the action of the atmospheric oxygen. This is ordinarily done by forcing the water through a set of sprays but a series of cascades may also be used and in the case of St. Thomas, a splasher type has been used for some years. Another recent development is to make use, to a certain extent, of the principle of the hydraulic air compressor, and an installation of this type has recently been installed in the town of Dundas, Ont.

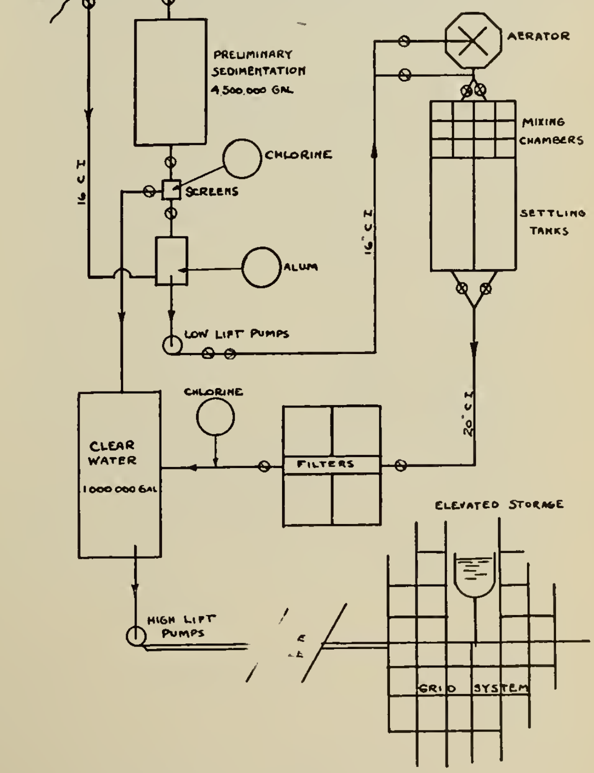

Fig. 6—Flow Sheet—St. Thomas Water Works.

The author believes that enough attention has not been given in the past to the matter of the time element in aeration, and predicts that a further consideration of this phase of the question will be along the lines of a more prolonged aeration.

In the case of highly coloured swamp waters, it has been observed that the addition of aeration into the flow sheet just after the addition of the alum, will produce excellent results, much better than without it and the amount of chemicals used will be greatly reduced in consequence. In the case of other types of waters the chemicals will be found to have better effect if added after the aeration period. Where lime and copperas is used as a coagulant the aeration should always precede the application of the chemical. In this way the carbon dioxide is removed, thus requiring less lime to produce the chemical results required. This is especially the case when the removal of manganese is desirable. Where no coagulant is being used aeration will not produce as great a reduction of carbon dioxide in highly coloured water as it will in clear.

The design of the aeration phase of the treatment will require experimental study before the final arrangement is decided upon. It has been learned from experience that water is a temperamental thing and rarely are two waters found that are exactly alike. With the standards that are demanded by the public, it is no longer safe to think that any standard treatment will be entirely satisfactory.

The process of aeration will, to a great extent, run parallel with that of chlorination. The application of the chlorine is made first for the destruction of substances in the water that are objectionable and until they are destroyed the chlorine will not have an opportunity to effectively sterilize the water. In this way the aeration, if effective, will greatly reduce the chlorine demand of any given water.

Chlorination

Probably the greatest contribution to the water purification problem in the past twenty years, is the application of chlorine. In the early days of filtration it was considered excellent work, and it was, if the B.Coli was reduced in the process by 99 per cent. However, the remaining 1 per cent of B.Coli that was left in the water was still active and as long as a water gave indications of its presence, there was a danger of infection. It is true that the chances of infection were greatly reduced, but they were still there. However one can now be sure that treatment can reduce the B.Coli 100 per cent. A graph of the incidence of typhoid fever in any municipality will almost always reflect the exact date that chlorination was commenced and a marked diminution will invariably be noted.

The mechanics of chlorination are not even yet agreed upon and it was held for many years that the process was one of oxidation, the chlorine combining with the hydrogen in the water yielding hydrochloric acid and free nascent oxygen with the latter considered the active substance. This theory is not now universally held. However the fact still remains that no pathogenic bacterium has yet been discovered that will remain alive for more than ten minutes in the presence of free chlorine. The technique of the process is simply to add chlorine to the water until all the reactive material is destroyed, using enough that there will be a small surplus. If this surplus will persist in the water for a period of fifteen minutes, one can be certain without waiting for the laboratory tests, that the water is sterile as far as disease breeding bacteria are concerned. This gives one greater confidence in the process, as when dependent wholly on the laboratory test to determine the efficiency of the work, reports were not available for a period of forty-eight hours after the sample was taken and if there was a bad run of water it might not be known until long after the chance of trouble had started. The test for free chlorine is so simple that the non-technical operator can apply it and be sure of his results. The laboratory test has been in this way more or less relegated to the position of a sort of chemical or bacteriological auditor. The test in the laboratory merely confirms what the operator is already reasonably sure of.

In the practice of chlorination there are two schools of thought. The older uses the filtration process as the chief means of purification and considers the chlorination as a sort of factor of safety. The other relies on the chlorine as the factor in the process that makes the water safe and considers the filtration as the means of making the water free of objectionable materials from an aesthetic standpoint. However the author has always held that both are an essential feature in the hygienic treatment of water.

Back in 1915, Joseph Race, who was then bacteriologist for the city of Ottawa, introduced the use of ammonia in conjunction with chlorine. The combination produces substances that are known as chloramines. He found that this combination was very effective in his practice at Ottawa, but the application of chloramines has not been general until the last few years. It has been found that with these substances there is a lag in the reaction with the substances in the water, and this is of some advantage in the case of waters where there is a taste. Several of the western Ontario waterworks have recently adopted a modified chloramine treatment by the addition of a relatively inexpensive chemical, ammonium sulphate, in conjunction with the chlorine. The effect has been in nearly, but not all cases, a great improvement in the palatability of the water, especially where there are phenols present. One municipality with difficulties due to the proximity of oil fields, has made this treatment a regular part of its programme. Another with weedy tastes in a river water, is now using this method to overcome it. Another large plant using water from one of the Great Lakes is successfully eliminating iodoformic taste by the application of ammonium sulphate. In the latter place, on several occasions during the past year, deliberate interruptions in the ammonia treatment were made as a check and in each case the reappearance of taste showed conclusively that the ammonia was a sure means of controlling it.

The last two years have seen the development of the use of activated carbon in the treatment of tastes and odours in water. Charcoal has long been known to possess certain qualities of adsorption, but it was not until certain research was undertaken during the war that a carbon was developed that possessed these qualities to the extent that made it useful for the adsorption of gases. What had been used as a protection against gas attacks has later been put to a more peaceful use, but its application to the removal of gases that produce tastes and odours in drinking water has been somewhat delayed. This material is fed as a suspension in the water along with the coagulant and is either settled out with the other floc in the sedimentation units or filtered out in the filters. It is a somewhat happy fact that water that will not respond to the use of ammonia may usually be freed of taste by the use of carbon.

It is to be hoped that the rudiments of these processes have been explained in such a way that the average engineer will be able to obtain an appreciation of the science involved in this, the most important of the public utilities. The development of the art of water supply to the point that the consumer can have a supply of clear wholesome water, sufficient for all purposes, at a cost so low that 50 per cent of the consumers pay less than one-half a cent a person per day, is one in which those engaged in this work can take a pardonable pride.

Acknowledgment is due to the Dorr Company for Figs. 2 and 3.

Recent Progress in Oxy-Acetylene Welding and Cutting Processes

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Paper presented before the Montreal Branch of The Engineering Institute of Canada, January 12th, 1933.

SUMMARY.—Some recent improvements in oxy-acetylene welding are noted in this paper; namely, the use of a carbonizing flame and new type of welding rod to effect an increase in the speed of welding; the use of automatic oxy-acetylene cutting machines with machine-controlled blow pipes to increase the speed and produce smooth cuts, and, further, the use of flame machining, in which the blow pipe is held almost tangential to the surface of the metal.

Without enumerating the advances made in all the fields of application of oxy-acetylene welding and cutting, it is intended in this paper to present some of the salient features of a new method of welding steel, the progress made in the use of automatic machines, and a newer type of blowpipe construction in cutting steel. The possibilities of these particular fields make them of general interest at the present time.

A New Welding Process

Until recently in welding steel with the oxy-acetylene process it has been the practice to adjust the gas pressures on the blowpipe so that a strictly "neutral" flame is obtained.

A recently introduced process however uses a carbonizing flame in a special way to effect remarkable increases in the speed of welding. This is done with a properly adjusted flame which produces a reducing atmosphere surrounding the puddle and carburizes the walls of the vee, just preceding the advancing puddle. When the carbon content of steel is raised, the melting point is lowered, so the carburized surface film melts uniformly before the steel immediately beneath. This makes it possible to fuse weld metal and walls of the vee with very slight melting of the base metal, thus increasing the speed of fusion.

A new welding rod, possessing suitable metallurgical characteristics for use with the carbonizing flame, has been developed especially for this method of welding. Generally, a rod 1/16 inch larger in diameter is used for a given thickness of metal than would be the case with former methods of oxy-acetylene welding.

The welding technique employed is one in which the flame is pointed backwards against the puddle and completed weld. The flame is held close down in the centre of the vee, both walls of which are prepared for fusion at the same time. There is no necessity for moving the flame sideways because the flame is produced by a tip larger than is used ordinarily. Since the rod is also larger, the only motion necessary for flame and rod is in the line of the weld. The manipulation of rod and blowpipe is thus simplified.

The combined result of these changes is that a smaller amount of welding rod is needed to produce a high quality weld and it is deposited at greatly increased speed.

Less rod is used because contraction in the joint ahead of the puddle during welding is reduced to a negligible amount making possible a narrow spacing at the time the joint is set up. A slight reinforcement on the weld gives a 100 per cent joint efficiency, allowing further saving. Welding is facilitated if a 70-degree vee is used in place of the usual 90-degree and this further reduces the consumption of welding rod.

Increased speed of welding rod deposition is due to the lessened amount of rod and blowpipe manipulation and the efficient manner of producing fusion with the walls of the walls of the vee by means of the carbonizing flame, which in turn makes practical the use of a larger welding tip. Besides reducing the consumption of welding rod about one-third, a similar saving in gases is effected by these changes.

Because of the simplified nature of the welding technique, this new process lends itself much more readily to the use of semi-automatic blowpipes. With the new blowpipe developed especially for this process, it is possible to make rotation welds in pipe in one quarter to one third less time than with the regular hand blowpipe—almost four times as fast as the former method of oxy-acetylene welding. The operation of this new blowpipe is extremely simple and the position of the operator using it is such that he can work with a maximum of comfort. (See Fig. 1.)

Much could be written about the applications of this new method of welding steel. Of major importance are the great economies in welding joints in long gas and oil pipe lines. It was on this type of construction that this process was first used extensively. Many thousands of miles of pipe lines have now been welded and the economies effected are now well known in the oil fields. It was first used in Canada in the summer of 1931 when short lines of gas pipe were laid by a large utility in the Toronto district. One job was divided into two representative sections, one of which was welded by the original method, the other with

Fig. 1—Welding 12-inch steel pipe.

the new process. All the welding on both jobs was done by the one crew under the same foreman, the pipe in both cases being 6-inch diameter and practically all field conditions identical. The economies possible by using the new process with the usual hand blowpipe are clearly indicated by the fact that using the new process thirty to forty joints per ten-hour day were averaged per welder, whereas on the other section the average was twenty. The maximum per man per day was fifty-three in the first case and only twenty-five with the ordinary method.

On a recent 125-mile line of 20-inch natural gas pipe, the average time for rotation welds on pipe 9/32 inch in wall thickness was seventeen minutes with the special blowpipe, as compared to twenty-four minutes per joint averaged on previous work with the new process by hand, and seventy minutes per joint by the method used before this process was introduced. On these large diameter joints a special steel liner is used to back up the weld and secure the greatest efficiency in conserving heat as well as providing a means for readily obtaining a uniform 100 per cent penetration to the bottom of the vee. Dollies are used to facilitate turning the pipe for welding on lines of this type and to provide the means for quickly and accurately lining up the pipe preparatory to welding.

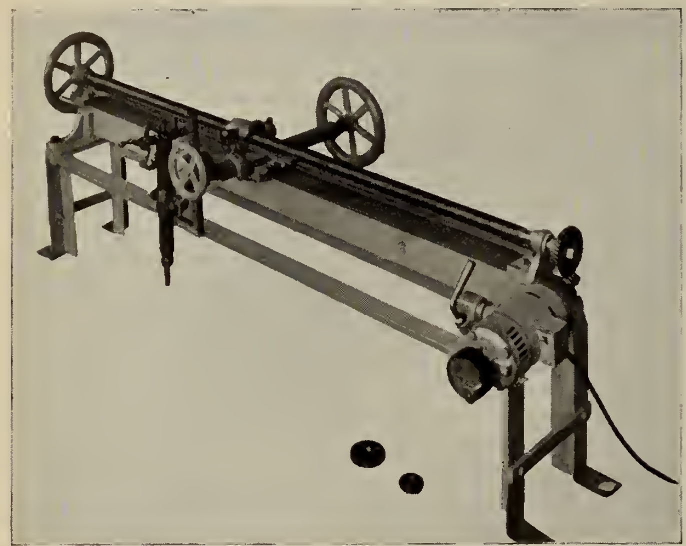

Fig. 2—Straight Line Automatic Oxy-Acetylene Cutting Machine with Electric Drive.

This new or "Lindeweld" process is being used as a regular means of producing 40-foot lengths of steel pipe in one well-known Canadian mill. On this work the special semi-automatic blowpipe is used and it is interesting to note that whereas only two welds per hour were averaged in 12-inch pipe using the ordinary method, this speed has been doubled since the introduction of the new process.

On steel tank and plate work the new process is gradually supplanting the older method and is particularly well adapted for production jobs where fatigue of the operator has always been an important factor. It has now been applied to the welding of tubular joints in aircraft. Joints in unusually thin tubing which previously had not been satisfactorily welded by any other means, have been successfully made in this manner.

With this new process, the quality of the weld metal is increased in spite of the unusual speeds obtained. The deposited metal in pipe welds, for instance has an elongation of 25 to 35 per cent in ½ inch, and with 0.20 to 0.35 per cent carbon steel having tensile strengths of 60,000 to 80,000 pounds per square inch, test welds cut from completed work consistently failed in the base metal.

Automatic Oxy-Acetylene Cutting Machines

In the field of oxy-acetylene cutting one of the most notable features has been the increasing use of automatic machines for guiding blowpipes. There are four main reasons for the use of machine-controlled blowpipes.

(1) To reduce the cost of cutting by increasing the speed and thereby reducing the oxygen, acetylene, and labour required.
(2) To produces moother cuts than are possible by hand, in order to reduce or eliminate machining of cut surfaces.
(3) To facilitate production by enabling the production department to make up parts immediately out of stock, and by reducing the effect of the human element and simplifying the control of cutting practices in the plant, as well as facilitating the design of both standard and special parts.
(4) To enable economical cutting and shaping of stock formerly too heavy to cut or shape by machine tools.

Many simple forms of manually controlled guides and holders for hand blowpipes have been in use for years. These take the form of guide wheels for straight line cutting and circle cutting devices of all kinds. They are, however really only aids to hand cutting. The simplest device for producing smooth machine cuts is the straight line cutting machine, the blowpipe of which is held in a carriage which is fed along the bed of the machine by an accurate feed mechanism. This screw-fed type of machine may be operated by an electric motor but in most cases is operated by hand as the cuts so produced have machine-like precision when done by a good operator. (Fig. 2.)

The economy in gases and labour resulting from the use of this type of machine, particularly on heavy plate or billet cutting, is the result of the steady movement of the blowpipe which allows lower cutting pressures to be used and causes less waste of material due to narrower kerfs.

The advantages attending the use of electric motors for driving the blowpipe at constant speed are obvious. Small portable electric-driven machines have now been developed and are being used in all large steel plate warehouses and fabrication shops. The machines may be allowed to drive themselves on the surface of the plate to be cut or simple tracks may be fabricated from angle iron and placed on or above the work. Such machines have accurate speed control and for the usual cutting up to 6 inches in thickness have a speed range up to 24 inches per minute. (Fig. 3.)

These small portable automatic machines are used for all kinds of straight line and circle cutting. This latter is readily accomplished by the use of a radius arm permitting the machine to pull itself around a centre point. Circles having a minimum radius of 3 inches and practically unlimited maximum are possible with some machines. These machines also lend themselves to a variety of special uses. Slitting I-beams, cutting round-cornered billets and making irregular cuts on a steel plate can all be accomplished by proper set up and manipulation. Some machines may be hand guided along irregular curves and complicated patterns while producing a smooth, clean cut much beyond the ability of even the most skilled operator with a hand blowpipe.

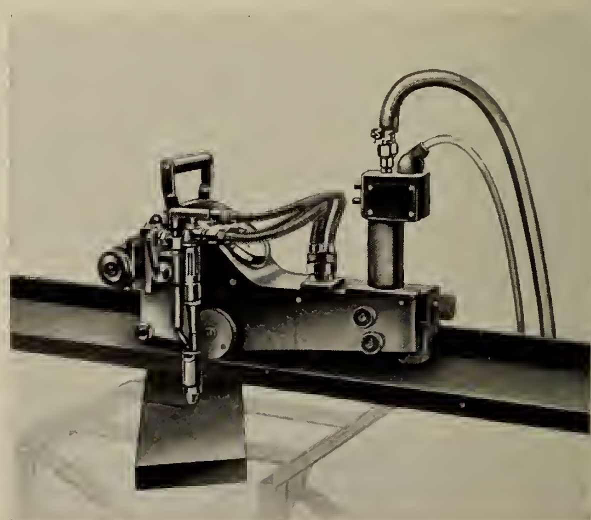

Fig. 3—Portable Automatic Cutting Machine.

The highest development in automatic cutting machines represents a combination of the best machine tool design plus the most improved cutting equipment available. The first automatic machine was developed in Germany in 1906. Many complex types have been developed since then. Some of these run on two sets of rails at right angles, combinations of movements of the blowpipe carriage along

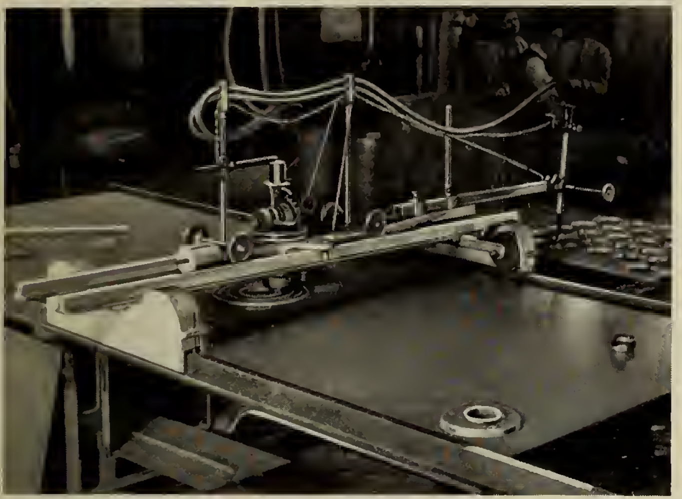

Fig. 4—Stationary Automatic Cutting Machine.

one set and the first set on the second set, giving any desired motion of the blowpipe. The pantograph principle, of course, is used and the driving mechanisms vary from the use of cams to feed wheels which creep along wood or metal strip formed into a templet. Some of the more complex machines have incorporated a combination compound traversing head and templet mechanism and these allow a wide variety of cuts to be made without the use of templets. Combination of right-angle straight cutting or circular or arc-shaped cuts in combination with straight cuts are possible without interrupting the cut. Some of these machines have hand tracing devices which allow irregular shaped cuts to be made following a drawing. This is a great advantage when a single intricate pattern must be made, as the expense of templets is saved.

Machines have been installed in Canada capable of making shaped cuts up to 8 feet in width and 18 feet long. This type of machine is generally equipped with blowpipes for cutting up to 12-inch thickness but, of course, can be made to cut much thicker material if desired.

The immediate effect of the use of oxy-acetylene shape-cutting has been to speed up production to a phenomenal extent in every plant where this process is used. As the use of welded rolled steel plate construction continues to increase in the manufacture of machinery bases and of frames for presses, shears, lathes, motors and engines, etc., automatic shape-cutting will be used more and more and the development of these machines will undoubtedly continue. Fig. 4 illustrates a stationary automatic cutting machine set up for production work making circular cuts from templet.

Flame Machining

Until the past few years, the oxy-acetylene cutting process has been used primarily as a severing tool. No paper referring to developments in the process would be complete today without reference to the decided interest and activity in the applications of "flame machining." Ordinary cutting is done with the blowpipe usually in a plane 90 degrees to the surface of the part cut, thus causing the oxygen stream to sever the parts with a narrow kerf. If the blowpipe is held almost tangential to the surface of the metal, an entirely new range of oxy-acetylene cutting operations is opened up. This type of cutting is now generally referred to as "flame machining," due to the similarity of applications to many operations of customary tool machining.

When the blowpipe is inclined at an angle of, say, only 30 degrees to the surface of the metal and special nozzles used which cause the cutting oxygen stream to issue at low velocity from a comparatively large orifice, grooves up to 2 inches in width and ⅜ inch or more in depth can be cut at speeds from 15 feet to 30 feet per minute. This principle has been in use for deseaming steel billets and cleaning up cracks and sand holes in castings and is now being used for veeing thick plates preparatory to welding.

It is probable that this method of oxy-acetylene cutting blowpipe manipulation will find a wide usefulness in flame turning as it lends itself readily to many lathe turning operations of roughing.

The rate of tangential cutting in terms of pounds of metal removed per hour varies with different types of cuts. For simple cuts the rate will vary from 500 to as high as 1,800 pounds per hour with single jets. Using compound

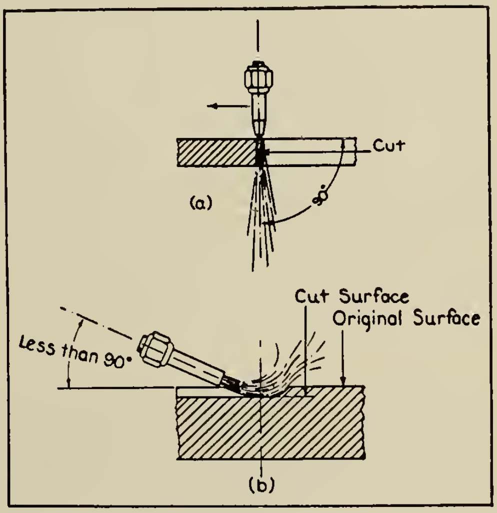

Fig. 5—Relative Position of Blowpipe Nozzles: (a) for Severing; (b) for Flame Machining.

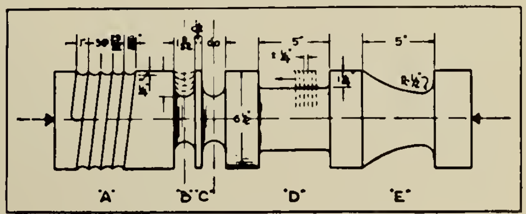

Fig. 6—Types of Milling Cuts Possible to Make by Multi-Passes of the Planing Nozzle.

jets there seem to be no limits. It would appear from data recorded to date that on most work of this kind, about 2 to 2¾ cubic feet of oxygen is used per pound of metal removed.

The possibilities of flame machining for the preparation and shaping of carbon steels seem to be limited only by the degree of precision obtainable commercially by the flame machining nozzle.

Mapping from Aerial Photographs

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SUMMARY.—After a brief discussion of the precautions which must be taken by the pilot in flying for photographic mapping purposes, the paper describes the technique of map making from aerial photographs including the developing, printing, building up of the original mosaic, the correction of prints for scale and elevation of points, and contouring with the precision stereoscope. The author points out the remarkable saving in cost as compared with maps produced from ground surveys.

This subject is voluminous and therefore a great amount of detailed explanation has been omitted. It was originally the intention that the paper should deal only with the laboratory end of the work, but since the taking of the photographs and the making of the map are so intimately connected, a short description of field operations and equipment has also been added.

Several books have been written on the subject, and various methods of mapping described, however, in most cases the systems evolved have had application only over territories already well mapped where abundant control is available, as in European countries. In Canada it has been necessary to devise methods somewhat different, with application mainly to large, rugged areas, where little, if any, ground survey has been done. A great deal of credit is due to the Topographical Survey of Canada in this respect, who with the assistance of the Air Force and the Geodetic Survey, have made an enviable reputation for Canada, particularly in the field of small scale mapping for the standard topographical sheets.

This type of mapping is called "oblique" to distinguish it from the more generally known "vertical" system. It is accurate and economical and its mode of application, practical, simple and very rapid. It is limited, however, to areas where changes in elevation do not exceed 1,500 feet. So far its use has been confined to the making of topographic small scale line maps by the government, and commercial concerns have had no call for the work. It is not proposed to discuss this system in detail, but since it has a very useful and practical commercial field it will come into more general use and should not be omitted from this paper. It is based on the fact that a perspective grid may be drawn to scale on any aerial photograph which shows the apparent horizon, providing the focal length of the camera is known and its altitude at the moment of exposure. This is only absolutely true in flat country, but up to 1,500 feet, the errors are within scale limits on four- or eight-mile sheets or even less.

In practice an aerial camera is mounted on a semi-circular track in the nose of a flying boat, clear of obstruction in such a manner that photographs may be taken from three angles, one right; one centre; and one left, each containing the horizon in the upper inch of the print and each side picture overlapping slightly the area covered by the centre one. The airplane is flown a straight course at 5,000 feet and at every two miles three exposures are made as above, along the line of flight. Each series overlaps the next group of three so that the background of one series becomes the foreground of the next. In this manner, an area six miles in width is covered in one strip. Additional flights parallel to the first and six miles apart overlap each other at the sides sufficiently to carry out the mapping system over an extended area.

A series of grids is drawn to cover all cases within the practical limits of maintaining altitude and constancy of camera angle. These are photographed on clear glass and when superimposed on the corresponding prints mark off the area in ten chain blocks. By detailed plotting on squared paper these photographs may be rectified to constant scale and the separate plots of each retraced to form a continuous map.

Maps from "vertical" photographs, as the name implies, are those made from photographs taken when the camera axis is vertical, as opposed to those just described at an oblique angle.

The camera used for such work takes photographs 7 inches by 9 inches. The film is panchromatic, which is very rapid and highly sensitive to various shades of colour. It is used in rolls 75 feet long, containing about one hundred and ten exposures. Cameras may be driven and tripped automatically by an electric motor, wind motor or cranked by hand. The latter is considered by most operators as preferable, since a man is required at the camera in any case, and if winding by hand, can usually detect immediately any trouble which may develop, thus saving the loss of film and valuable time. Extra rolls are placed ready in separate magazines so that when one is finished another can be put in place in the matter of a few seconds, that is, between exposures, so that flying along the line need not be disturbed. These cameras are equipped with an optically ground glass plate immediately in front of the film, against which the film is pressed flat at the moment of exposure, in order to avoid distortion due to buckling in the film. The perspective centre of the lens system is usually marked by a small cross etched on this glass, or by markings at the sides which reproduce on the prints. The intersections of lines joining these points locates the centre of the photo, which must be known and the importance of which will be seen later. Fig. 2 illustrates a Fairchild automatic aerial camera showing view finder (for interval) camera, automatic electric interval ometer for timing picture interval and battery.

Fig. 1—Grid Superimposed on Oblique Photograph.

Flying for vertical photography is an art in itself. Very few pilots have the qualifications necessary for this extremely tedious and exacting type of flying. It is essential to maintain constancy of speed, lateral fore and aft level, altitude as far as possible within plus or minus 100 feet, and remain within a few hundred feet of an imaginary straight line on the ground. Over comparatively unmapped country, from a height of 10,000 feet this is a herculean feat, as in such work, parallel lines about one mile apart and fifty miles in length are usually flown, and existing maps seldom record more than 5 per cent to 10 per cent of the lakes, and many of these are taken from inaccurate sources and often misplaced.

Normal expectancy of suitable weather, which must be almost entirely cloudless, is one day in seven, with an average of two and a half working hours. Suitable aircraft and camera equipment for one crew involves a yearly

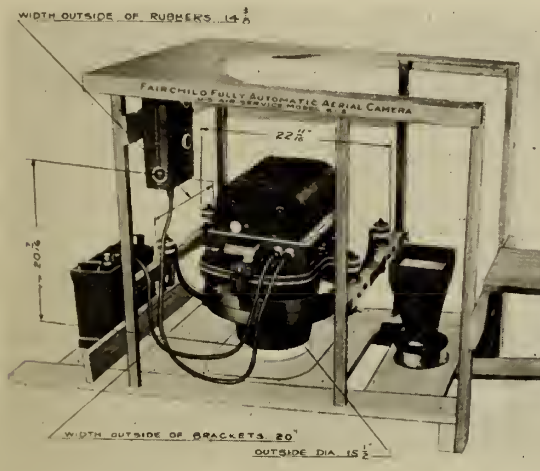

Fig. 2—Aerial Camera for Vertical Photography.

expenditure of some $25,000 and the cost per hour of running the engines is extremely high so that great care must be taken to conserve flying time. It is essential therefore, that not one hour of good weather must be lost on the job, which means that the crew must literally sit on the machine for a week (seven days) to do two and a half hours work, and a constant vigil must be kept for the signs of clearing weather. In mid-summer, this vigil starts at 4.30 a.m., but varies with the season, as suitable pictures can only be obtained three hours after sunrise or before sunset.

Assuming that a clear day has arrived, the machine takes off for the area to be mapped. Some forty minutes are required to make altitude, the altimeter reading being corrected for temperature at this time. The starting line is located from the flight map, and approached from a distance of three or four miles. While flying this distance, which takes about two and a half minutes, the pilot crabs his machine to offset any tendency to drift off the line due to cross wind, and the camera operator calculates his ground speed and picture interval and also sets his camera parallel to the line of flight, which may be crosswise to the fore and aft line of the machine. This ensures the pictures overlapping squarely, which is an important consideration in the mapping process.

To assist the already overtaxed pilot, we have found it advisable to use a navigator to help keep the machine on line. He is seated in a compartment so placed to give him good visibility, and is provided with a flight line guide, which is actually a grid designed for that altitude and which shows him the parallel lines that they must pass over. As the machine progresses along the line, he sketches in the points flown over and additional ones which must be passed over on the return flight. He can quickly pick up any tendency to drift and telephone his correction to the pilot. At two miles a minute a few hundred feet can soon be lost and a very costly gap result.

Meanwhile the camera operator has one eye on the stop watch and the other on the camera level bubble, which must indicate level when the camera is tripped. The average interval is fifteen to twenty-five seconds, and his allowable error not over two seconds. It is quite possible to keep tilts within ½ of 1 degree, although this will be exceeded in rare cases, after a too sudden correction by the pilot, which momentarily makes the level bubble useless. Normally at high altitudes the machine flies with exceptional smoothness. A 50-mile line will take some twenty-five to thirty minutes and the turns are negotiated in two to three minutes.

It will be readily seen that on a long flight of five to six hours, which is not uncommon, one has hardly time to shift a cramped leg—and the powers of concentration are sorely taxed. Fatigue from this grind at high altitudes is keenly experienced once the flight has been completed.

On one flight of seven hours fifteen minutes, which is quite exceptional, 563 square miles were photographed at 800 feet per inch. The machine arrived back at its base with not enough gas to taxi ashore. Nine lines 55 miles long were flown and nine hundred and fifty exposures made.

Exposed film is at once forwarded to the laboratory for developing and examination. It is essential to have an immediate check-up to see if the photography is acceptable, overlap correct and area completely covered. Ordinarily the machine must remain on the job until this has been done, and if, as often happens, two or three photographic days are missed, a further wait of two or three weeks may be necessary before the re-flight can be made. It has been necessary to wait five weeks on a job to make one short flight. If it is found essential to make a re-flight, a rough photographic map is sent to the field, showing the gap or gaps which must be re-flown.

The developing process is probably well understood as it is similar to the developing of ordinary hand camera film except that it must be done in complete darkness and on a large scale. The tank process is used instead of trays for ease of handling. Particular care is taken in washing after each step of the process, to preserve the negative and detail. About two hours is required to develop, fix and wash the film. Complete information is given in the field report to assist the photographer in determining how to treat the film for best results.

After developing and washing, the film, still in rolls, is carefully wound on to a large open-faced drum, which is

Fig. 3—Navigator's Compartment Replacing Standard Door.

rotated rapidly on its longitudinal axis, by a suitable electric drive. This dries the film, the time required depending largely on temperature and humidity, but averaging roughly two hours under normal conditions.

After drying, the film is put through a numbering machine which perforates the border with a system of numbers used for recording prints, map index, filing and all future reference.

A set of contact prints is then made, so called because they are made in direct contact with the negatives, and neglecting slight changes for contraction or expansion of the paper, are the same scale as the negatives. The contact printer is essentially a box having a glass covered opening 7 inches by 9 inches in the top. It contains a series of electric lamps controlled individually and collectively by switches and a rheostat, all or part of which may be regulated to suit the negative, so that an even tone may be obtained in the successive prints made. An arrangement is made to provide perfect contact between the film and

Fig. 4—Navigator's Guide for Use in Flight.

paper at the time of exposure, thus preventing displacement of detail or fuzziness. An exposure of some five seconds is required. One man handles the printing, and another the developing, fixing and washing, which is done in trays. Here again washing is of paramount importance to prevent prints from discoloration at some future date. Two large washing tanks are provided with continuous running water, which syphon out every few minutes and then fill again. Prints are given one hour in the tanks before removing and are then allowed to drain, or excess water is removed by blotting paper.

Prints not required in a glossy finish are next put through a Pako dryer, which consists mainly of a large electrically heated drum, which is rotated slowly. The prints are placed three abreast on a canvas apron which travels in contact with the face of the revolving drum throughout one circuit, carrying the prints with it. After one circuit, taking five minutes, the prints drop into a tray, dry. About four hundred and fifty contact prints can be made in a day by two men.

As soon as the prints are dry they are taken to the mapping room, where they are laid out on beaver board, and pinned down in the form of a rough map. The flight report gives the direction of flight and flight lines covered by each roll, which makes this layout quite simple. As this is being done, overlaps are checked and should any gaps appear, the board is at once copied to some small scale and a print from this is sent to the field to be used as a flight map to re-fly the gap.

Assuming no re-flight is necessary, this first layout is prepared for copying to be used as an index to prints and for reference during the mapping process. The reference numbers of the prints at the end of each line and a few intermediate ones are marked in large white figures on the faces of the photographs. The area covered by each individual print can be clearly seen on this index and sufficient numbers show to enable one to estimate the reference number of any particular print.

Ordinarily the area is photographed at approximately the scale of the delivered map. Sometimes, however, it is more economical to photograph at a smaller scale than the delivery. This saves in flying, film, developing, printing, ratioing and all mapping labour. Maps are usually laid at approximately the scale photographed, but not necessarily so. This decision rests with the map-maker, however, as the final scale may be obtained in the laying of the mosaic, in copying the mosaic board, or both.

Assuming that some ground control has been supplied for the job or obtained if necessary, this will be plotted to the laying scale on the mounting board. Needless to say, surveys used for control must include a tie-in to certain definite objects recognizable on the photographs. Mounting tables consist of a light wooden frame, covered by a sheet of ⅜-inch thick Vehisote wood composition board, which is durable, non-warping and suitable for gluing.

Due to change in barometric pressure, ground elevation, or change in flying height, the scales of individual photographs will vary and it is essential to rectify these prints to a common scale in order to make an accurate mosaic. The next step, then, is to find the factor of enlargement or reduction required for each print to bring them all to a common scale. This may be done by comparison of scale distances between well selected points at the same elevation appearing in the overlap of consecutive photographs, by calculation or graphical methods, the choice of which depends on the requirements of the particular job and the preference of the operator.

In addition to print ratios just described, the common ratio of the strip to control is required. By an ingenious graphical method called radial control, this factor may be obtained as well as a true traverse of print centres and true locations of such side points as desired. Such a traverse is invaluable as it may be plotted on the mounting board and used as secondary control in laying the mosaic. Although there are other methods also for obtaining this information this system is undoubtedly the most popular.

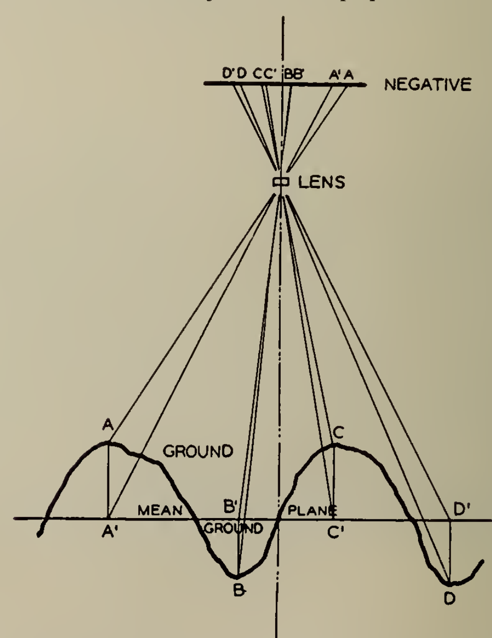

Fig. 5—Displacements Due to Change in Ground Elevation.

Assuming this method is to be used, a strip of contact prints is chosen, containing some known ground points at each end, on which to commence work. With 60 per cent forward overlap, each print contains its own marked centre, and the centres of the photographs ahead and behind; these are located by inspection and clearly marked; three on each print. Since a photograph is a conic projection of the ground, high or low spots will be displaced from their true plan position on the negative due to being observed at an oblique angle from the lens; except the one vertical point at the centre. These displacements, however, will only be towards or away from the centre of the print, therefore the angle between any two points on the picture subtended at centre will agree with angle on the ground. Admitting this fact, then, it may be said that the angles between centres on each photograph are true, but their scaled distances will vary according to their respective elevations. Every ground point appears in three different photographs. Selecting any common well-defined point near the edge of a print, true angles corresponding to three shots with a transit on the point from three centres on a traverse are known, one true angle from each print. The true location of such a point may be located graphically, if the centres are known, or a centre located if the position of the point is known. Two intersections locate a point, the third intersection will locate the third centre. In practice four side points are chosen instead of one. The scale of the first photograph is accepted. The second fixes the four points to the scale of the first; the third, fourth and following centres are fixed by the third intersection on these points. Four fresh points are selected for each print so that the system carries on throughout the strip, each print being changed to the scale of the first. The final result of such a traverse is a tracing showing the true traverse of centres and four points opposite each centre also located to scale. From these centre distances the ratios of each print may be checked and an additional common factor applied to each, to ratio the whole strip to agreement with the controlled over-all distance.

The law of displacement of points is not true in the case of tilted photographs. When a bad tilt is observed, that print must be dealt with by a rather lengthy mathematical process, but as shown previously, the simplest remedy is to prevent bad tilts by care in the field. Small tilts up to two degrees do not affect the accuracy of the method, also the same side-points selected for one strip may be selected for the adjoining two strips. It is most unlikely that the same tilts will occur in three consecutive lines, so that in building up the secondary control such errors are certain to be noted and adjustments applied in the same manner as closing any ground traverse. It may be of interest to note that a photographic traverse such as described can be made around an area and with accurate draughting will close and should close in every respect similar to a ground traverse plotted from field notes. Occasionally small triangles of error occur at intersections of points indicating trouble which almost invariably is found to be inaccuracy of plotting.

Fig. 7—Copying a Mosaic on 22-inch by 24-inch Negatives.

Enlarging factors having been determined for each print and an allowance made for paper shrinkage, a set of ratio prints is ordered at the scale desired for laying. This work is handled in a projection camera. The roll of film is placed ahead of light source and back of a lens and the negative projected through the lens to a frame which holds the paper. Corresponding ratio settings having been made at the lens and projection frame, the paper is exposed,

Fig. 6—Vertical Photograph of Section of Grand'Mere, Que. Scale: 1 inch = 150 feet.

developed, fixed and dried similar to contact prints. In this case the toning of prints is given special attention. The type of photography done in surveying is a distinct specialty and requires a man who is not only a high class photographer, but technical and artistic as well.

Ratio prints are returned to the mapping room where they are re-checked for scale and if satisfactory, mounting is commenced. The first print is laid down and oriented over plotted control points after the board has been treated with a gum arabic paste. The second print is torn so that the edges are feathered and placed over the first. The glue is so mixed that it will not set for several minutes, thus allowing time to make minor adjustments. In many cases, highways, fence, property or railway lines are used as match lines to avoid any confusion in detail, but ordinarily prints are so well toned that the match lines cannot be found even by close inspection of the mosaic. The second strip is ratioed in a similar manner to the first, which however serves as an excellent guide and simplifies this step. It is then laid so that prints overlap each other as well as the first strip. Other strips follow in succession.

It is freely admitted that ratioing prints in this manner does not give perfect scale all over, but it must be remembered that points near the centre of the prints suffer only very slight displacements, and that with 60 per cent forward overlap and 40 to 50 per cent side overlap, an average area of only 2½ inches by 4 inches of a 7-inch by 9-inch print is used in the mosaic. In addition, there is the secondary control of twelve points per print to refer to, so that any errors resulting from scale variations beyond control are localized and not cumulative. The making of mosaics is a specialty, like any other business and if done by a man who understands the sources of error and the means of correction, an excellent map will result. If the slight displacement of mountain tops is of vital importance, a line map should be made from radial control with the required detail traced in the corrected position from the prints, the essential detail being located by the control method—a line map would be the final delivery. Ordinarily, however, in rough country, accuracy is required only along the rivers, around the lakes or in the valleys, be it power, railway or highway location, and prints can easily be ratioed for the datum in which the client is interested. In special cases, continuity of ground cover is of more importance than the high degree of accuracy in line maps, and here again the mosaic has an undisputed field. With prints properly ratioed, a mosaic will go together quite easily when handled by an experienced man. If not, however, it will take comparatively few photographs to get into a hopeless tangle, which indicates to the experienced map-maker some source of error which requires investigation. Placing the prints under a stereoscope will indicate the probable troubles which must be corrected. In the majority of maps where the country is rolling or relatively flat, one ratio may often be applied to a whole strip or several prints where it can be seen in the initial layout that the scales are consistent. Depending on the size of the job, one or more mosaic boards may be required. In this case great care must be exercised in duplicating the last line of each board for the commencement of the next.

Once mapping is completed, the board must be copied for final delivery, the master mosaic not being in delivery form. The most desirable size of copying film, determined by several factors, is 22 inches by 24 inches. The mosaic board is then marked off in areas this size, if the copying is one to one, otherwise in blocks which at the copying scale,

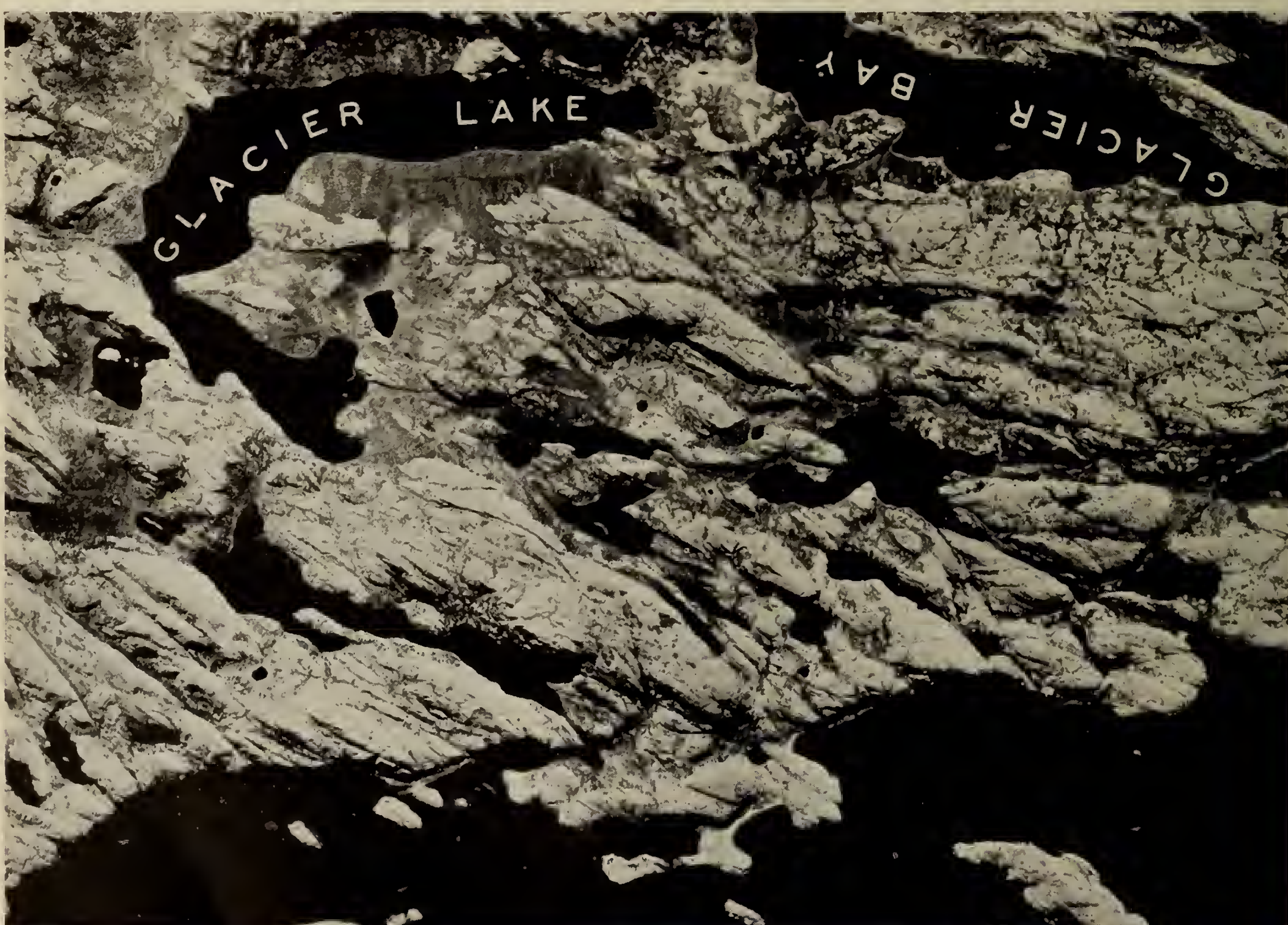

Fig. 8—Vertical Photograph of Section of Great Bear Lake. Scale: 1 inch = 3,000 feet.

will fill a 22-inch by 24-inch negative. The board is then mounted vertically in front of the copying camera in a movable frame which readily allows any desired area to be centred on the lens. Before making the final negative, the scale is checked on a ground glass, and if correct, the negative is placed in position, exposed, developed and fixed, and hung up to dry. A separate dark room is provided for this work. Trays are used for developing and fixing. About ten negatives are required to cover each board at a one to one scale. One inch of overlap is allowed on all sides, so that one or more copyprints may be laid out to form a continuous map. The mosaic board moves only in one plane so that one camera setting is all that is required for each board. Five 1,000-watt lamps with strong adjustable side lights are required to give proper lighting for copying. Exposures average about thirty seconds.

Each whole board is copied on one 8-inch by 10-inch negative before removing it from the frame. Prints from these are used to make a small scale mosaic which is used as an index map for copy prints.

After the negatives are dry, they are laid out on a large glass top tracing table illuminated from below, and are checked closely for scale and quality. Accepted negatives are masked off with red paper, which gives a clean white uniform finish line when printed.

At this stage, titles are set up and copied in whatever form is required for their incorporation in the final delivery.

Contact prints from copy negatives are called copy prints. Printing is done in a similar manner to that described in the making of contact prints, except that perfect contact is obtained by placing a rubber mat over the film and paper on the large glass top of the printer and exhausting the air to form partial vacuum. Nine banks of seven 60-watt lamps provide the light and twenty-one switches control them so that perfect tone may be obtained and different ground cover made to blend smoothly. The method of developing, fixing and washing is similar to contact printing but is done in large trays.

Prints may be finished matte, semi-matte or glossy. The first two types are advisable where any drawing work is to be done on the map, but glossy finish, which gives slightly sharper detail, is otherwise used.

Depending on the wishes of the client, these copyprints may be delivered unmounted, mounted on linen separately or mounted on linen to form a continuous map. This is usually decided according to the size of the final map. Standard mounting tables are 4 by 12 feet. Any number of these might be combined within ordinary practical limits to make one large wall map. The usual practice in large areas is to mount the separate prints on linen with a tab at one end and number them consecutively, for delivery in album form. An index to copyprints is prepared, areas being outlined and numbered to agree with the coverage of each album sheet and numbered to correspond. This index is also prepared on a 22-inch by 24-inch sheet. The indexes, title and a complete set of copyprints are then placed in an album ready for delivery. A set of contact prints is delivered with the album for field use or study by stereoscope.

Wall maps are often made to some convenient scale for general study, copy sections are provided for more localized study and individual prints for detail study under stereoscope and use in the field.

The final record of any job is a set of copy negatives which are carefully handled in a special film vault and from which enlargements or reductions, at any future date, are readily and cheaply obtainable. Once copied the master mosaic has no value.

Another phase of the work which is of major importance, but apart from a laboratory discussion on mapping, is the making of contour maps. The field is comparatively new but unquestionably of vital importance. Contour machines have been developed in Europe which have proved to be of uncanny accuracy. The development of these machines has been very costly and their sale and use so restricted that the cost of such work is admittedly high at present, though still as cheap, if not cheaper, than a similar ground survey, and giving an abundance of ground detail not possible by any other method. Their application, it is true,

Fig. 9—Stereoscope with Grids for Accurate Contour Work.

has so far been confined mainly to fairly well mapped areas, but not entirely so, and will unquestionably have some application in this country.

The author is of the opinion, however, that in the bulk of the work, the small scale precision stereoscope has the most economical and practical application. This machine is not entirely suitable for spotting elevations of individual points unless a great deal of control is available, nor is it possible to carry elevations accurately through several prints without some intermediate control. It is essentially an interpolation machine between known heights, and an excellent one. For contour intervals of 50 feet for initial study of large rugged areas, elevations of one or two points per square mile for scales of 800 feet to 1 inch are satisfactory in addition to the horizontal control traverses. Five foot intervals naturally require considerable additional ground work, but such maps can be made accurately at scales of 100 to 200 feet per inch with a saving of time and money.

It is preferable in all types of contour work to have photography done when leaves are off the trees, however ground cover is not as serious as generally supposed. Timber must be unusually dense to affect the use of the stereoscope and it is indeed rarely found impossible to get through to ground in numerous places. Timber also, as a rule, is quite constant in height over the area covered in a stereoscopic overlap and for general purposes indicates topography with sufficient accuracy. The stereoscope used in this work is such that a horizontal grid appears to lie over the whole area viewed. This grid may be raised or lowered at will until it rests on a desired ground point. When any part of the horizontal grid passes into a side hill or encounters a solid object in its plane, the grid lines break into confusion. The trace of this line of confusion is a contour on the slope at some elevation which may be determined from calibrated scales on the machine. Timber is rarely sufficiently dense to give this effect of breakup of the lines and the ground is usually encountered through the trees before this happens. Determination of this critical point can only be done by a man experienced in stereoscopic interpretation, nevertheless, it is quite safe to say that it can be done, and is done.

Rather than make dogmatic statements about speed and economy of this type of work, the following example may be cited.

A rapid decision had to be made for an option on a possible power site. Two seasons of ground work still left some doubt as to its value. Ground survey was extremely costly due to density of timber and ruggedness, and the work consequently very slow. The author's firm was called upon to prepare a contoured mosaic at 800 feet to the inch, with 50-foot contours over the whole area, and 25-foot contours along a river. A traverse of the river, part of a railway line and a section of highway location profile was provided for horizontal control, and some additional fifty elevations were obtained by corrected Paulin altimeter readings on high points along the river. Elevations ranged from 600 feet to 1,600 feet. A model in plasticene was made from a layout of contact prints and only two known elevations and completed five days after delivery of the film and before horizontal and vertical control was obtained by us. The model was only roughly to scale but proved remarkably accurate on later check-up. It was studied closely by the consulting engineer who obtained some excellent and essential information from it, much to his satisfaction. The control later supplied to us had already been completed on the ground before photographs were taken. Much less horizontal and vertical control selected by us would have been sufficient to produce an equally good map and improve the accuracy of the contours.

The contoured mosaic of 60 square miles was completed three months after delivery of control, at a cost of $100 per square mile to the client.

The value of such a map applied to location problems of all types, logging operations, such as dams, storage, flumes, hauling roads, etc., need not be stressed here. The uses of such a topographic map are multitudinous.

One point that has probably not been sufficiently stressed in the past is, that with proper care in maintenance of altitude during any one or successive flights, the contact print scales are remarkably consistent. The prints may be examined in the stereoscope and using this information combined with that obtained from a rough mosaic, a wealth of information is readily obtainable for any initial study. Where the initial study appears to justify more detailed information, accurate mosaics, line maps or contour maps may be completed of all or any part of the area at any desired accuracy, at any future date, and this cost need not be incurred unless it appears justifiable.

The cost to the client of delivery of a set of contact prints, except for areas of a few square miles varies from $15 to $25 per square mile. Mosaics completed from these prints cost an additional $15 to $20 per square mile. A good general figure for most reasonably sized areas at 800 feet to 1 inch would be $35.00 per square mile for a controlled mosaic. Contouring will vary from $70 per mile, as in the case cited, to possibly $200 to $500 per mile for 5-foot contours on small areas.

The cost for 400 feet to 1 inch contacts or mosaics will normally run 20 to 25 per cent higher than those at the 800-foot scale. Naturally it is impossible to give detailed cost figures since scale, size, shape and location of all areas directly affect the cost, and in practice each job is figured independently.

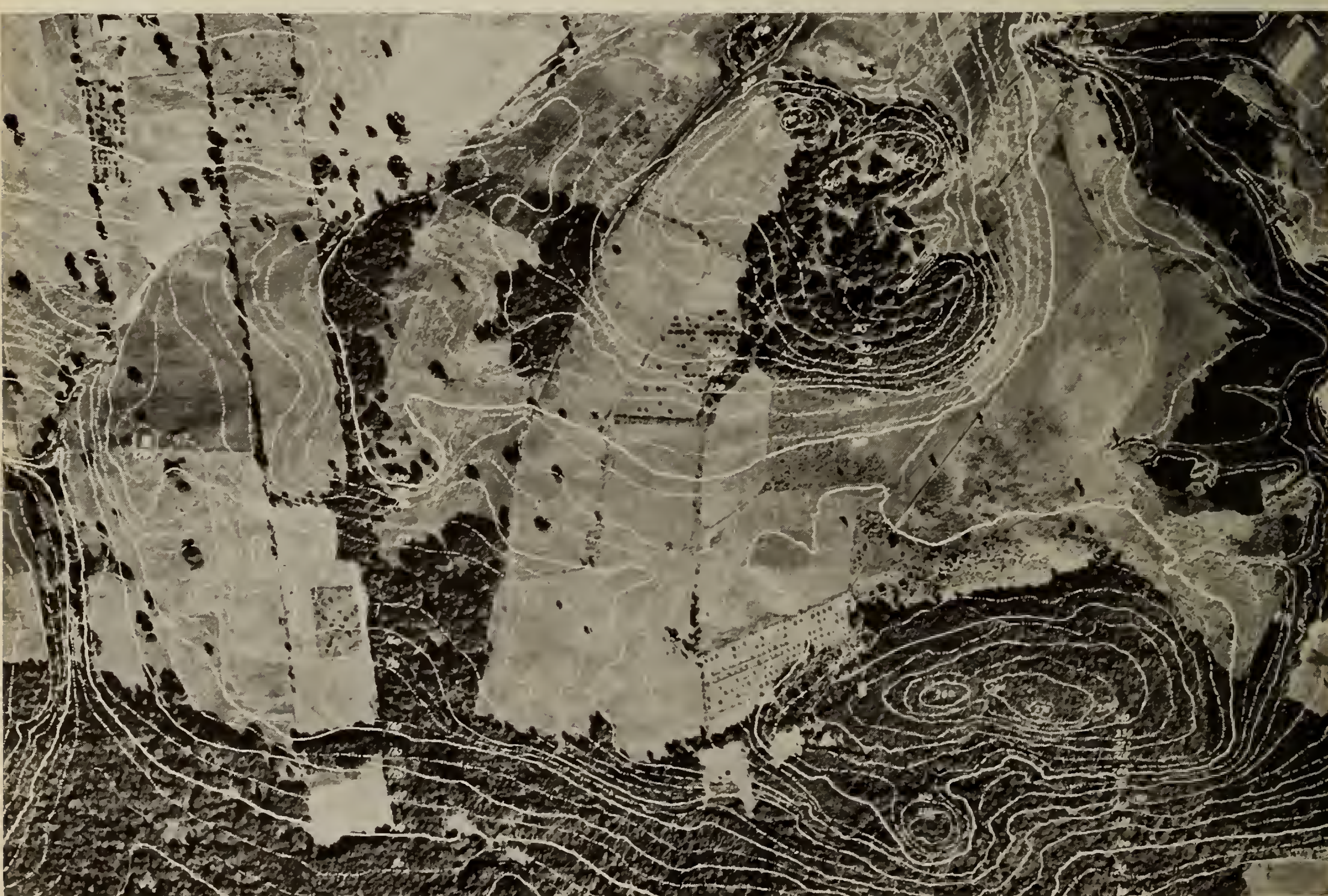

Fig. 10—Contour Map. Scale: 1 inch = 600 feet; Contour Interval: 5 feet.

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Unemployment Problems in Canada

Among the difficult problems connected with the subject of unemployment relief none has given rise to more argument than the vexed question whether direct relief is not really better for the community than relief works. Three years ago it seemed obvious to everybody that work should be provided, if possible, before direct relief. Experience gained since that time, however, has shown the existence of certain unforeseen difficulties, largely financial, that have somewhat changed the picture. A number of relief work schemes have been tried in Canada, some of them on a generous scale, and they have undoubtedly afforded employment for a very large number of workers. The results, however, have not always fulfilled expectation. In some cases operations were hampered by various restrictions and there were indications of undue external influences. In others the works to be done were unwisely selected and uneconomical methods of construction and supervision were adopted. Organized labour showed some uneasiness and the ultimate economic value of the works was questioned. Generally speaking the final result was a substantial increase in the burden on the taxpayer without a compensating addition to the assets of the community. These happenings have led some to believe that perhaps after all the provision of direct relief is the lesser evil, in spite of the many difficulties surrounding its satisfactory administration and the troublesome problem of apportioning the responsibility and the financial burden between Dominion, provincial and municipal authorities.

The admirable report* recently published by the Unemployment Research Committee of Ontario explains many of the reasons for these partial failures, but indicates clearly that while the policy of dropping relief works may appear to be justified in terms of short run financial considerations, it is open to serious question in terms of the long run and in terms of social results. Dr. Cassidy admits that it will be necessary to continue direct relief for the immediate future but believes that if properly selected works were undertaken and there were adequate safeguards to guarantee reasonable efficiency in their prosecution, it would seem that money which would otherwise go towards direct relief might be used with advantage in the creation of assets valuable to the community.

This view appears to be gaining ground, and is shared by such bodies as the National Construction Council of Canada, whose proposals look far ahead and are based on the use of tried and efficient methods and organization. The policy is also in line with the action of the Dominion government in providing funds for the very extensive scheme for relief work for single men which is now being administered by the Department of National Defence, and which is described on another page of this issue. The results of that scheme, so far as it has yet progressed, have confirmed the experience gained with the road programme of the Ontario government on the Ontario portion of the Trans-Canada highway, and have shown that relief works, if properly selected and administered, form an effective and not too expensive weapon in the fight against unemployment.

Such schemes have one feature of vital importance which alone would justify their adoption in many cases, namely, their effect in restoring and maintaining the morale of the worker. The great majority of the unemployed have no wish to loaf, and are grateful for any opportunity to perform useful work irrespective of the amount and kind of remuneration available. A few days after arrival at a work camp listlessness disappears and the hopeless outlook of the man who has been spending his days in enforced idleness is replaced by alertness, activity and a renewed interest in life. The value of such rehabilitation cannot be measured in money.

In connection with the work camps of the Department of National Defence The Institute has been privileged to render substantial assistance by submitting names for employment on the supervisory staffs of the various camps. It has been impossible for the permanent staff of the Department to supply sufficient officers for this work, and many of our members who are unemployed are qualified by their training in engineering and construction for such appointments. Actually upwards of fifty unemployed engineers are already at work in positions of this character, and the reports received from them all agree as to the smooth development of the organization and the satisfactory conditions under which the staffs and their men are living and working.

Critics who so frequently comment on the ineffectiveness of government departments would do well to follow the working of this scheme. No one can doubt the necessity of an organized national effort to put an end to the present state of drift. Here is a plan already in operation which can be extended to take care of from fifty to seventy thousand men during the trying times which are still ahead. The projects under contemplation provide for this extension, as they involve types of work which under normal conditions would not be undertaken for some years to come. Thus they cause no interference with private enterprise. Such a development cannot solve the whole problem of unemployment, but is an example of a working plan which, with the modifications indicated by experience, may well be studied by other public bodies in their efforts to meet the existing situation.

**Unemployment and relief in Ontario 1929-1932.* A survey and report by H. M. Cassidy, under the auspices of the Unemployment Research Committee of Ontario. Toronto, J. M. Dent & Sons, 1932.

Annual Meeting 1934

At the meeting of Council held on May 26th, 1933, the invitation of the Montreal Branch to hold the Forty-Eighth Annual General and General Professional Meeting of The Institute at Montreal was accepted with appreciation.

The Past-Presidents' Prize 1933-1934

Council has selected as the subject of the essays to be submitted for the competition for the prize year July 1st, 1933 to June 30th, 1934:—

"The Engineering Features of City Management"

The rules governing the award of this 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 no 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 the Council at the beginning of the prize year, which shall be July first 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 during the prize year by the General Secretary of The Institute, either direct from the author or through a local branch.

Results of May Examinations of The Institute

The report of the Board of Examiners, presented at the meeting of Council held on May 26th, 1933, 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 C—For admission to Associate Membership:

W. Shuttleworth, Jr.E.I.C. Montreal, Que.
P. Varley, Jr.E.I.C. Montreal, Que.

The Past-Presidents' Prize 1932-33

The Council has approved one month's extension of time for sending in essays on "The Relation of Economics to Engineering" in competition for this prize. *Such essays will be received by the Secretary's office up to July 31st, 1933.*

June 23rd, 1933. R. J. Durley, Secretary.

ELECTIONS AND TRANSFERS

At the meeting of Council held on June 23rd, 1933, the following elections and transfers were effected:

Member

ROSS, Allan Crawford, B.Sc., (McGill Univ.), president, Ross, Meagher Ltd., gen. contractors and engrs., Ottawa, Ont.

Associate Members

MILLER, John Leonard, Major, M.C., (A.M.Inst. M.E.), mgr., Herbert Morris Crane & Hoist Co. Ltd., Niagara Falls, Ont.

SIMPSON, Albert Edward, B.Sc., (McGill Univ.), supt., aerial surveys laboratory, Canadian Airways Ltd., Montreal, Que.

Junior

MUIR, William Gordon, B.Sc., (N.S. Tech. Coll.), field engr., Alexandre Murray & Co. Ltd., Halifax, N.S.

Students Admitted

BUELL, Milton Alan, (Queen's Univ.), 54 Wellington St., Kinston, Ont.

GARVOCK, Alex. Graham, B.Eng. (McGill Univ.), 136 Lewis St., Ottawa, Ont.

YATES, John Munro, (Central Technical Institute, Toronto), 18 Grafton Ave., Toronto, Ont.

Recent Graduates in Engineering

Congratulations are in order to the following Students and Juniors of The Institute who have recently completed their course at the various universities.

McGill University

Honours Medals and Prizes

Chalk, Henry Edwin, Westmount, Que.—B.Eng., (Chem.); Society of Chemical Industry's Bursary for Summer Essay.
Craig, Carleton, Ottawa, Ont.—B.Eng., (Ci.); British Association Medal; Honours in Civil Engineering; Departmental Prize for Summer Essay.
Jolley, Malcolm Porter, Montreal, Que.—B.Eng., (Mech.); British Association Medal; Honours in Mechanical Engineering; The Jenkins Brothers, Ltd., Scholarship.
Mason, Orley Batcheller, Grand'Mere, Que.—B.Eng., (Mech.); The Babcock-Wilcox & Goldie-McCulloch Ltd., Scholarship.
Mendelsohn, Lewis, Montreal, Que.—B.Eng., (El.); Honours in Electrical Engineering; The Montreal Light, Heat and Power Consolidated First Prize.
Rolbin, Max, Montreal, Que.—B.Eng., (El.); The Montreal Light, Heat and Power Consolidated Second Prize.

Degree of Bachelor of Engineering

Archer, Maurice George, B.Eng., (Ci.), Quebec, Que.
Bourque, Philipps, B.Eng., (El.), Calgary, Alta.
Chennell, Alwyn Charles Stansfield, B.Eng., (El.), Outremont, Que.
Connelly, Alan Burton, B.Eng., (Ci.), Calgary, Alta.
Evans, Philip Norton, B.Eng., (Mech.), Westmount, Que.
Gamble, Samuel Gill, B.Eng., (Ci.), Ottawa, Ont.
Garvock, Alex Graham, B.Eng., (Ci.), Ottawa, Ont.
Gordon, Hugh John, B.Eng., (Ci.), Florenceville, N.B.
Heavysege, Bruce Reid, B.Eng., (Ci.), Lachine, Que.
Henniger, Charles Freeman, B.Eng., (Ci.), Smith's Falls, Ont.
Hough, Ayton Lloyd, B.Eng., (El.), Montreal, Que.
Hutchison, William Harper, B.Eng., (Mech.), Westmount, Que.
Laurie, Ernest Stuart, B.Eng., (Mech.), Westmount, Que.
McGee, Leonard Davidson, B.Eng., (El.), Westmount, Que.
McIntosh, Douglas Elliott, B.Eng., (El.), Victoria, B.C.
Maclaren, James Isbester, B.Eng., (Ci.), Westmount, Que.
Martin, Reginald Lee, B.Eng., (Mech.), Granby, Que.
Mayerovitch, Robert, B.Eng., (El.), Rockland, Ont.
Miller, Lindsay, B.Eng., (Mech.), Montreal, Que.
Mitchell, Robert Walter, B.Eng., (Chem.), Town of Mount Royal, Que.
Moore, George Albert, B.Eng., (El.), Westboro, Ont.
Nesbitt, Arthur Deane, B.Eng., (El.), Westmount, Que.
Painter, Gilbert Walter, B.Eng., (El.), Montreal, Que.
Potts, James Edward, B.Eng., (El.), Stirling, Ont.
Price, Robert William, B.Eng., (El.), Hamilton, Ont.
Quigley, Robert Webster, B.Eng., (Chem.), Regina, Sask.
Ramsdale, Donald Osland Dallas, B.Eng., (El.), Westmount, Que.
Rivenovich, Israel Reuben, B.Eng., (El.), Montreal, Que.
Sangster, Andrew Gordon, B.Eng., (El.), Sherbrooke, Que.
Schofield, William, B.Eng., (Mech.), Montreal, Que.
Seybold, Hugh Gordon, B.Eng., (El.), Westmount, Que.
Tinkler, Howard Hyman, B.Eng., (El.), Montreal, Que.
Vogin, Maurice A., B.Eng., (Ci.), Montreal, Que.
Walsh, Geoffrey, B.Eng., (El.), St. Catharines, Ont.

Master of Science

Bennett, Robert Douglas, B.Eng., (McGill); M.Sc., (Chem.), Montreal, Que.

Master of Engineering

Chipman, Robert Avery, B.Sc., (Univ. of Manitoba); M.Eng., (El.), Winnipeg, Man.
Evans, Delano Ernest, B.Sc., (McGill); M.Eng., (Ci.), Montreal, Que.
Stanley, Thomas Douglas, B.Sc., (Arts), B.Sc., (El.), (Univ. of Alberta), M.Eng., (El.), High River, Alta.

Queen's University

Degree of M.Sc.

Campbell, James Stouffer, B.Sc., (Queen's Univ.), (Me.); M.Sc., (Me.), Toronto, Ont.
Franklin, Gordon Alexander, B.Sc., (Queen's Univ.), (Chem); M.Sc., (Chem.), Vankleek Hill, Ont.

Degree of B.Sc. (with honours)

LaFontaine, Daniel Joseph, B.Sc., (Me.), Walkerville, Ont.
Pilkey, Gordon Everett, B.Sc., (Me.), Myrtle Station, Ont.

Degree of B.Sc.

Baker, Clifford Malcolm, B.Sc., (Ci.), Hastings, Ont.
Benjafield, John Fordyce, B.Sc., (Ci.), St. Thomas, Ont.

Brown, Ralph Cuthbert Chisholm, B.Sc., (Me.), Kingston, Ont.
Flexman, James Kenneth McAthy, B.Sc., (Ci.), Kingston, Ont.
Hartley, Eric Llewellyn, B.Sc., (Ci.), Kingston, Ont.
Lackey, Wesley James, B.Sc., (Ci.), Toronto, Ont.
McKnight, Charles Ernest Voyle, B.Sc., (Me.), Ottawa, Ont.
Stewart, Duncan Edward, B.Sc., (El.), Waba, Ont.
Stewart, Stanley Bean, B.Sc., (Me.), Orillia, Ont.
Stewart, Walter Duncan, B.Sc., (Me.), Lennoxville, Que.
Walter, John, B.Sc., (Ci.), Kingston, Ont.

University of Saskatchewan

Degree of B.Sc.

Schneller, Armin Geoffrey Ewald, B.Sc., (Ci.), Saskatoon, Sask.
Trischuk, William, B.Sc., (Ci.), Rosthern, Sask.

Nova Scotia Technical College

Honours and Medal

Ripley, Howard Andrew, Fairview, N.S.—B.Sc., (Me.), Honours in Mechanical Engineering; Governor-General's Medal; and Association of Professional Engineers of N.S. Prize.

Degree of B.Sc. (with honours)

McKay, Robert Donald, B.Sc., (Ci.), Yarmouth, N.S.

Degree of B.Sc.

Archibald, Manning Clifford, B.Sc., (El.), Charlottetown, P.E.I.
Corkum, Perry Daniel, B.Sc., (Me.), Feltzen South, N.S.
Duff, Duncan Clemens Verr, B.Sc., (Ci.), Stellarton, N.S.
Egan, Edward Joseph, B.Sc., (El.), Halifax, N.S.
Ford, Wilson Harlow, B.Sc., (El.), Caledonia, N.S.
Fullerton, Roland McNutt, B.Sc., (El.), Truro, N.S.
Hamilton, Parker Cleveland, B.Sc., (El.), Halifax, N.S.
Harrigan, Mayo Arthur Perrin, B.Sc., (Me.), Halifax, N.S.
Hayes, Gerald Joseph, B.Sc., (El.), Chatham, N.B.
Keating, Harold Johnston, B.Sc., (El.), Halifax, N.S.
Lipton, Samuel, B.Sc., (El.), Halifax, N.S.
MacDonald, Arden Morris, B.Sc., (Me.), Sydney, N.S.
Outhouse, Holland Wilbur, B.Sc., (Ci.), Halifax, N.S.
Parsons, Ezra Churchill, B.Sc., (El.), Walton, N.S.
Saltman, Frederick Everett, A.M.E.I.C., B.Sc., (Me.), Halifax, N.S.
Stanfield, John Yorston, B.Sc., (Me.), Truro, N.S.
Sutherland, William Collie, B.Sc., (El.), Westville, N.S.
Wickwire, Lawrence David, B.Sc., (El.), Halifax, N.S.
Wood, Albert Lewis, B.Sc., (Me.), Halifax, N.S.

University of Manitoba

Degree of B.Sc.

Aitkens, John Curry, B.Sc., (Ci.), Boissevain, Man.
Howe, Lawrence McLean, B.Sc., (El.), Flaxcombe, Sask.
Moore, Robert Hugh, B.Sc., (Ci.), Winnipeg, Man.
Rensaa, Egil Mikkelson, A.M.E.I.C., B.Sc., (Ci.), Winnipeg, Man.

Ecole Polytechnique

Honours and Medals

Benoit, Jacques, Montreal, Que.—B.A.Sc., (Ci.), Bronze Medallist.
Boucher, Raymond, Montreal, Que.—B.A.Sc., (Ci.), Bronze Medallist.

Degree of B.A.Sc.

Nantel, Maurice, B.A.Sc., (Ci.), Montreal, Que.

University of Alberta

Degree of B.Sc.

Alexander, Alwin Paul, B.Sc., (El.), Monarch, Alta.
Craig, William Royce, B.Sc., (El.), Lethbridge, Alta.
Eckenfelder, George, B.Sc., (Ci.), Edmonton, Alta.
Elliott, Lisgar Webster, B.Sc., (El.), Edmonton, Alta.
Hole, William George, B.Sc., (Ci.), Edmonton, Alta.
Fleming, Donald Corbett, B.Sc., (El.), Calgary, Alta.
Gold, William John, B.Sc., (El.), Edmonton, Alta.
Hurdle, Harold Lancelot, B.Sc., (El.), Edmonton, Alta.
Newman, William Cyril, B.Sc., (El.), Hillmond, Alta.
Robson, William John, B.Sc., (El.), Edmonton, Alta.
Sharp, William Gray, B.Sc., (El.), Didsbury, Alta.
Sinclair, George, B.Sc., (El.), Edmonton, Alta.
Smith, Walter Alexander, B.Sc., (Ci.), Calgary, Alta.
Williams, David Gabb, B.Sc., (El.), Edmonton, Alta.

University of Toronto

Degree of B.A.Sc. (with honours)

Bridgland, Charles James, B.A.Sc., (El.), Toronto, Ont.
Hammond, Rowland Ernest, B.A.Sc., (El.), Angus, Ont.
McColl, William Ross, B.A.Sc., (Ci.), Sandwich, Ont.

Degree of B.A.Sc.

Addison, John Hillock, B.A.Sc., (Ci.), Toronto, Ont.
Donaldson, John Logie, B.A.Sc., (Ci.), Hamilton, Ont.
Lemon, Marvin Reginald, B.A.Sc., (Ci.), Stouffville, Ont.
Lichty, Lyall John, B.A.Sc., (Chem.), Kitchener, Ont.
Wilson, Thomas Whiteside, B.A.Sc., (Ci.), Toronto, Ont.

Degree of M.A.Sc.

Jones, Llewellyn Edward, M.A.Sc., (Hydraulics), Transcona, Man.

University of New Brunswick

Degree of B.Sc.

Lynch, John Franklin, B.Sc., (Ci.), Fredericton, N.B.
McCormack, Donald Neill, B.Sc., (Ci.), Fredericton, N.B.

The Dominion's Relief Work Camps

A glance at the accompanying map of Canada will show the extent of the system of work camps now being developed by the Dominion government for the employment of single, homeless men. Some eight thousand are already at work under conditions which promote the workers' morale and efficiency, and this number will be very substantially increased as further projects now being organized come into full operation.

In planning this comprehensive scheme, the officers of the Department of National Defence, working with those of the Department of Labour, have had in mind an elastic organization, capable of extension to deal with requirements as they arise, and based on definite guiding principles. First, the works to be carried out must be such as under ordinary conditions would not be undertaken for some years to come. Second, the scheme must be nation-wide; should provide primarily for single, homeless men, and should permit them, as far as possible, to work at the trades or occupations to which they have been accustomed. Third, the cost to the country must be a minimum. Shelter, food, clothing, and medical care must be furnished, and the living conditions must be adequate. With these ends in view, the following directions have been given by the Department of National Defence:

> "Accommodation, clothing, food and medical care will be provided in kind, and an allowance not exceeding 20 cents per diem for each day worked will be issued in cash.
>
> Eight hours per day will be worked; Sundays and statutory holidays will be observed; Saturday afternoons may be used for recreation, etc.
>
> Personnel will be free to leave the work to accept other employment offered; they may be discharged "for cause" and if so discharged will subsequently be ineligible for re-employment under the scheme.
>
> Free transportation will be given from place of engagement and return thereto on discharge—except for misconduct.
>
> The standard of rations shall be that prescribed for the Army.
>
> No military discipline or training will be instituted; the status of the personnel will remain civilian in all respects.
>
> Where personnel of the Department of National Defence are not available for supervisory and administrative staffs these will be organized in accordance with prescribed conditions from persons having the required professional qualifications who are in need of relief."

The instructions continue—

"Officers in charge of projects are responsible for the care of the men placed under their supervision and it will be their object to ensure that their efficiency—mentally, physically and at their trades—is improved so that when conditions permit they may be returned to the economic life of the country well able to again take up their usual work. To assist in this, educational and instructional classes will be organized; recreation, amusements and games will be arranged; every possible opportunity will be given to men to work at and to become proficient in their own selected trades.

All concerned are reminded that the funds are limited and that it is desired to care for the maximum possible number of men in need; that the possibility of obtaining additional funds depends to some extent on the value of the work done, and, in consequence, that efficient direction and strict economy in all matters are, therefore, of great importance."

A start was made in October 1932 with the clearing of certain intermediate landing fields on the Trans-Canada airway and with the execution of certain repair work to the Citadels at Quebec and Halifax which was badly needed. Over seventy projects are now in hand. One of the main features of the programme is the establishment of a series of emergency landing fields along the proposed Trans-Canada airway. Hitherto, the absence of such fields has made it necessary for airmen flying with Canadian mail to use United States airways between Windsor and Winnipeg. There are no landing fields in the north, although they have been projected for some time. Now the land is being cleared for them and they are being built. Many communities would have built airports before this but lack the finances. The Federal government has now provided means whereby the airports can be built at a minimum cost to the municipalities, giving work to men who would otherwise be drawing relief with nothing to do. Reforestation is receiving attention, and forests are being planted on areas connected with military training centres as at Camp Borden, Petewawa and Valcartier.

As regards cost, the experience already gained indicates that it will be possible to operate at a cost of slightly under $1.00 per day per man, including the daily allowance and the cost of providing quarters when a camp is first established. This low figure is made possible through the utilization of the experience of the Department of National Defence in the organization and handling of large bodies of men and compares very favourably with results obtained in other labour camp schemes.

There are, of course, small camps and large camps. On the reforestation jobs as many as fifteen hundred men

Location of Dept. of National Defence Unemployment Relief Camps.

Project No.	Location	Establishment	*Strength	Project No.	Location	Establishment	*Strength
1	Halifax Fortifications	320	290	40	Petawawa training camp	1000	856
2	Cambridge Airways	....	....	41	Havelock airways	5	....
3	Blissville Airways	7	7	42	Barriefield barracks	316	278
4	Upper Brockville Airways	5	5	43	Cooking Lake airport	....	....
5	Megantic Airways	90	79	44	Dundurn training camp	800	602
6	Bishopton Airways	86	60	47	H.Q. North Bay airways	14	12
7	Quebec	423	412	48	H.Q. District No. 11	17	16
8	Diver Airways	109	62	49	H.Q. District No. 13	8	7
9	Gillies Airways	56	54	50	Kapuskasing airways	13	....
10	Ameson Airways	109	....	53	St. Johns barracks	55	50
11	Pagwa Airways	109	....	55	Hope-Princeton	428	201
12	Nakina Airways	109	96	56	Princeton-Hope	207	113
13	Kowkash Airways	109	13	57	West coast road	277	98
14	Lamaune Airways	109	....	58	Coleman airways	109	....
15	Wagaming Airways	109	102	59	N.D.H.Q. Ottawa	10	5
16	Sioux Lookout Airways	109	....	60	Kingsgate	134	89
17	Amesdale Airways	109	97	61	Crow's Nest	268	81
18	Vermilion Bay Airways	109	....	62	Kimberley	268	63
19	Rennie Airways	....	....	63	Long Beach	268	115
20	Lac du Bonnet Air station	109	106	64	Goatfell	134	21
21	Winnipeg Air station	....	....	65	Nelway	134	1
22	Yahk Airways	109	107	66	China Creek	134	52
23	Kitchener Airways	109	103	67	Shoreacres	134	28
24	Salmo Airways	109	82	68	Rock Creek	134	61
25	Princeton Airways	129	112	69	Sheep Creek	66	38
26	Flood Airways	87	77	70	Group H.Q. Yahk	9	4
27	Ottawa Air station	419	406	71	Group H.Q. Long Beach	9	4
28	Trenton Air station	514	492	73	Hope-Rosedale	261	....
29	St. John airport	149	149	74	Agassiz	512	....
30	Camp Borden air station	238	233	75	Esquimalt barracks	135	....
33	Long Branch barrack site	733	497	76	Hope-Bostonbar	521	....
34	Cranbrook Rifle Range	40	34	77	Group H.Q. Hope	10	5
35	H. Q. Nakina airways	12	10	78	Group H.Q. Princeton	10	5
37	R.M.C. mess building	263	253	79	Group H.Q. Sooke	5	2
39	Valcartier training camp	1500	1389	A	Airways Landing Fields	1090	....

*Strength as at June 15th, 1933.

are employed on one project, while on some of the air fields only a small number will be needed to clear the area of trees and underbrush and level it. Where there are no quarters on the camp site the men are building their own bunk houses, cook shacks, mess and recreation rooms and administration buildings; these are not planned on any elaborate or costly scale. As an example of the moderate costs involved: one bunk house for forty men was built by the men and equipped with electric lighting and stove for $450.00. The food consists of army rations, and has been found satisfactory. Clothing is furnished for those men needing it. Recreation is not lost sight of; games, magazines and camp sports are provided.

There is no attempt at military discipline, and there is nothing of militarism about the plan. Organized labour will be able to support it no less heartily than other sections of the population. The discipline maintained is similar to that which would have to be enforced in a commercial construction camp. There are no penalties other than exclusion from future benefit if a man causes trouble and is dismissed from camp. No one is required to stay any definite time, for it is not the intention of the government to keep men at the camps, but to help them back to their normal livelihood as soon as possible, and they are encouraged and expected to accept permanent employment should such be available in any case.

It may be necessary to maintain these employment camps for some time, until readjustment will allow Canadian workers to provide for themselves. A vital feature of the whole scheme is the fact that it is saving thousands of young men from the demoralising effect of compulsory idleness. Communications received from men who have already had experience of life in the camps indicate that they realize this; that they are well provided for and that the living conditions are appreciated. Men for the various camps are nominated by the Federal, provincial and municipal employment agencies. Up to the present there have always been more men desirous of being placed than it has been possible to admit.

In appointing the supervisory staff the Department of National Defence has realised that experience in similar work is desirable, if not essential, and has consulted with the officers of the Headquarters and branches of The Engineering Institute of Canada. From the records of our Employment Service Bureau it has been possible to furnish the names of a large number of unemployed engineers, and valuable assistance has also been rendered by the officials of the various Associations of Professional Engineers.

Estimates indicate that there are now between fifty and seventy thousand single men on relief in Canada, and if all, or nearly all, of the men in this category can be effectively absorbed by the Dominion government scheme a great step in advance will have been made towards the solution of our present unemployment problem. The extension of the scheme will, of course, depend upon the amount of money which can be made available, the real necessity for the projects, and the continuance of efficient administration.

The whole programme, from which such encouraging results have already been obtained, was prepared under the direction of the Hon. Donald M. Sutherland, Minister of National Defence, and the Hon. Wesley A. Gordon, Minister of Labour, and all concerned are to be congratulated on the progress which has been made in this attempt to meet a very pressing social need. Members of The Institute will share the gratification of the President and Council that The Institute has been called upon for assistance in this matter and has been able to make so effective a response.

OBITUARIES

Matthew Joseph Butler, C.M.G., LL.D., M.E.I.C.

The membership of The Institute will learn with deep regret of the death of Past-President Matthew Joseph Butler, C.M.G., LL.D., M.E.I.C., which occurred at Sydney, N.S. on June 22nd, 1933.

Born in 1856, Mr. Butler began the study of engineering at the University of Toronto in 1874, and afterwards served three years' apprenticeship.

M. J. BUTLER, C.M.G., LL.D., M.E.I.C.

He was successively assistant engineer for the Kingston and Pembroke Railway, chief engineer of the same railway, chief engineer of the Napanee, Tamworth and Quebec Railway, superintendent of the Temiscouata Wood Pulp Enterprise, and assistant engineer of the National Transcontinental Railway. In 1885 Mr. Butler conducted a number of surveys for the Ontario government. In 1905 he became deputy Minister of Railways and Canals, a position which he relinquished in 1909 to become chairman of the Board of Management of the Canadian Government Railways. Mr. Butler assumed the general managership of the Dominion Iron and Steel Corporation in 1910, holding the position until 1913. Later, he took charge of the Longueuil plant of the Armstrong-Whitworth Corporation, and in 1919 was located at Oakville, Ontario, where he was in private practice as a consulting engineer.

A member of the Institution of Civil Engineers, and the American Society of Civil Engineers, Mr. Butler was also a Dominion and Provincial Land Surveyor. In 1900 Mr. Butler was a member of the Royal Commission on Municipal Assessment and Taxation and in 1907 a member of the Royal Commission of Forestry.

Mr. Butler became a Member of The Institute (then the Canadian Society of Civil Engineers) on January 20th, 1887, and always took an active part in its affairs, being a member of Council in 1896, 1897, 1904 and 1905, a Vice-President in 1906 and 1907, and President in 1914. He became a life member on June 21st, 1932.

John Murray Mackay, A.M.E.I.C.

John Murray Mackay, A.M.E.I.C., died suddenly at Regina on June 12th, 1933.

Mr. Mackay was born at Glasgow, Scotland on September 2nd, 1885, and received his early education at the Glasgow High School and the Glasgow and West of Scotland Technical College. In 1902-1907 he was a pupil in the office of the city engineer, Glasgow.

In 1907-1910 Mr. Mackay was assistant on the construction of the Glasgow main drainage scheme. Coming to Canada in 1910, he was engineer in charge of the construction of the Regina sewerage scheme, and in 1913 was appointed superintendent and engineer of water works for the city of Regina. In 1927 Mr. Mackay became assistant engineer to the division of sanitation of the Department of Public Health in the government of Saskatchewan, which position he held until the time of his death.

Mr. Mackay was well known to the municipal engineers of Saskatchewan and his death came as a shock to the members of the profession in the west.

Mr. Mackay joined The Institute as an Associate Member on January 16th, 1917.

John A. MacMurray, S.E.I.C.

Regret is expressed in recording the untimely death at Campbellton, N.B. on September 12th, 1932, of John A. MacMurray, S.E.I.C.

JOHN A. MacMURRAY, S.E.I.C.

Born at Saint John, N.B. on July 10th, 1904, Mr. MacMurray received his early education at the Saint John High School, and following graduation from that institution was on the staff of T. H. Estabrooks Company Limited for two years. He resigned from this position to take the civil engineering course at the University of New Brunswick, and received the degree of B.Sc. in 1929.

Following this, Mr. MacMurray joined the engineering staff of the Restigouche Company Ltd., in connection with the construction of the company's mill at Atholville, N.B., and on completion of the mill was retained as resident engineer. He remained on the staff of the Restigouche Company until the time of his death.

PERSONALS

C. S. Gzowski, M.E.I.C., chief engineer of construction of the Canadian National Railways, Montreal, has been appointed acting manager of the industrial and natural resources departments, and will fulfill the duties of this appointment in addition to those of the office which he already holds. Mr. Gzowski, who was educated at Bishop Ridley College, and the University of Toronto, has devoted almost his entire career to railway work in this country, having been connected for a number of years with the Canadian Pacific Railway Company, and later with the Grand Trunk Pacific. Subsequently he was a member of the firm of Macdonell, Gzowski & Company, contractors and engineers, carrying out a number of important engineering works including the tunnels at Field for the Canadian Pacific. In 1919 Mr. Gzowski joined the Canadian National Railways to undertake special work for the vice-president in charge of construction. In the following year he was appointed assistant to the vice-president, and in 1923 was appointed chief engineer of construction.

Group Captain J. Lindsay Gordon, D.F.C., A.M.E.I.C., succeeds Brigadier-General J. M. Ross as Officer Commanding Military District No. 12 at Regina, Sask. Group Captain Gordon, who was born at Montreal, Que., joined the Royal Naval Air Service in 1916 as Flight Sub-Lieutenant. In 1918 he was promoted to the rank of Captain in the Royal Air Force and in October of the same year obtained the rank of Major, and was appointed to command No. 232 Squadron. In March 1920, Group Captain Gordon was appointed to the Air Board as Superintendent of Flying, and in September 1921 was placed in command of the R.C.A.F. Training Station at Camp Borden with the rank of Wing Commander. In May 1922, he was made acting director of the Royal Canadian Air Force. Group Captain Gordon graduated from the Royal Air Force Staff College in 1924 and from the Imperial Defence College in 1932. In 1928 Group Captain Gordon became director Civil Government Air Operations, R.C.A.F., Department of National Defence, Ottawa, and on the amalgamation of the Air Services in 1932 he was appointed Senior Air Officer, which office he now relinquishes to go to Regina.

Major General Armstrong Retires

Major General C. J. Armstrong, C.B., C.M.G., M.E.I.C., has recently retired and will make his home at Carillon, Que.

Major General Armstrong was born at Montreal, Que., on August 27th, 1872, and graduated from the Royal Military College, Kingston, in 1893.

Following graduation, he was until 1899 assistant engineer and later resident engineer on the construction and maintenance of the Atlantic and Lake Superior Railway, and in 1899-1900 served in South Africa with the Royal Canadian Regiment. In 1900-1901 Major General Armstrong was on the staff of the director of Imperial Military Railways in South Africa. In 1902-1907 he was divisional engineer in charge of construction of the Central South African Railways at Harrismith and Krugersdorp, and in 1908-1910 was district engineer in charge of maintenance and new works of the Orange River Colony railways.

Returning to Canada in 1911, he became assistant representative for Sir John Jackson (Canada) Limited, engineers and contractors. During the Great War Major General Armstrong held many important posts; he proceeded to England with the 1st Divisional Engineers, C.E.F. and in 1914-1915 commanded the Royal Canadian Engineers, 1st Canadian Division in England and France. In 1915-1916 he commanded the Royal Canadian Engineers, Canadian Corps, in France and was engineer-in-chief for Canadian engineer defences in France from February to November 1918. From that time until March, 1919, he was chief engineer, VII Army Corps, France.

Following his return to Canada, Major General Armstrong was appointed District Officer Commanding Military District No. 4, Montreal, in October, 1919. He commanded that district until 1926 when he was appointed to command Military District No. 1, at London, Ont.

Major General Armstrong was promoted to his present rank in January, 1933.

He joined The Institute as a Student in 1894 and was transferred to Associate Membership in 1902, becoming a Member in 1912.

Major General Armstrong has always taken an active part in the affairs of The Institute, and has been for a number of years chairman of the Honour Roll and War Trophies Committee.

RECENT ADDITIONS TO THE LIBRARY

Proceedings, Transactions, Etc.

American Society of Civil Engineers: Proceedings, May, 1933.
The Mining Institute of Scotland: Transactions, 1933.
Institution of Civil Engineers: Minutes of Proceedings 1931-1932, Vol. 233.
The British Engineers' Association: Classified Handbook of Members and their Manufactures, 1933.
International City Managers' Association, Chicago: City Manager Year Book, 1933.

Reports, Etc.

Canada Bureau of Statistics, Census of Industry 1931—Central Electric Stations in Canada.
City of Winnipeg Hydro-Electric System, Annual Report, December 1931.
Department of Mines, Canada:
Canadian Limestones for Building Purposes.
Canadian Mineral Industry in 1932.
Investigations of Fuels and Fuel Testing 1930 and 1931.
Ohio State University: Studies Circular No. 29—A Method of Determining Values of Different Fuels for Power Plant Use, H. M. Faust.
University of Toronto: Bulletin No. 140, Further Tests on the Heat Output of Concealed Radiators, E. A. Allcut, M.E.I.C.
Kenya and Uganda Railways and Harbours—Report of the General Manager on the Administration of the Railways and Harbours, 1932.

Technical Books, etc., Received

The Engineering Index, 1932, (*American Society of Mechanical Engineers*).
American Men of Science, by J. M. and J. Cattell, (*The Science Press, New York*).
Prominent Men of Canada by R. Hamilton, (*National Publishing Company of Canada Ltd., Montreal.*)

BOOK REVIEWS

City Manager's Year Book 1933

The International City Managers' Association, Chicago, Ill., 1933, Cloth 6 by 9¼ in. 350 pages, $2.00.

The title of this volume, which is issued by the International City Managers' Association, Chicago, gives little idea of the varied nature of its contents. The greater portion of the book is devoted to the proceedings of the 1932 conference of the Association, at which many of the topics dealt with were of marked interest, not only to the engineer concerned with municipal affairs, but also to the average citizen who desires to know something of the problems involved in city administration.

Among the subjects considered at the conference may be mentioned methods of financial retrenchment; police problems of to-day, with special reference to "rackets"; experience in various cities in administering unemployment relief; recent developments in fire protection and water supply, and methods of promoting citizens' interest in municipal government. A taxpayer in any city, whether he is an engineer or not, will find much to interest him in these discussions, particularly as in many cases they embody the results of actual experience in the working of the methods described.

It is noteworthy that more than one-fifth of all the cities in the United States with ten thousand or more population now operate under the council-manager plan. Additional information on the city manager profession includes statistics as to the length of service of the four hundred and twenty-four city managers holding office at the end of 1932; qualifications for managerial positions; average salaries by population groups, etc.

A valuable feature of this Year Book is a series of twenty articles covering the more significant events and developments in 1932 in the various fields of municipal administration, such as municipal budgeting and accounting; city planning and zoning; playgrounds and recreation; police administration and public works and utilities. The volume can be recommended to anyone desiring information on the working of city manager administration as now carried on in North America.

Industrial Piping

Engineering Publications, Inc., Chicago, 1933, cloth, 5½ by 8½ in., 279 pp., figs., tables, $3.50.

The twenty-three chapters of this book cover, in a general way, an introduction to the subject of industrial piping, a new series of tables for economical steam pipe sizes for heating, process and power steam, pipe bends, design of piping for process plants, for high temperature lines, for a mile-long underground line; steam coil installation, the economical thickness of insulation, the handling of viscous liquids, trap installations, air piping, and refrigeration piping.

There are a number of drawings, charts and tables, and an index aimed at making reference easy and convenient.

Prices

By George F. Warren and Frank A. Pearson, John Wiley and Sons Inc., New York, N.Y., 1933, cloth, 6 by 9¼ in., 386 pp., figs., tables, $3.90.

Reviewed by J. Colin Kemp, A.M.E.I.C.*

This book by two members of the staff of the Department of Economics at Cornell University should prove a valuable addition to any library. It is stated in the preface that since "the progress of civilization is now being held up by the lack of economic knowledge" the object of the book is to add to that knowledge by submitting a detailed analysis of various factors, which enter into the economic life of nations, such as the history of silver as a medium of exchange, the variation in price of farm land and the recurrence of periods of inflation and deflation.

The various cycles of prosperity and depression in the United States during the last hundred years are examined in great detail and prove very interesting reading in the light of present day conditions. For those who are attempting to understand the various remedies which are being suggested for the present world condition the book should prove a great help for it contains chapters on the use of gold and the effect of prices on gold production, on silver and on the various theories of bi-metallism and it contains an admirable index.

There are 168 figures and 69 tables in the book and many of the former are very illuminating and are carried back to days in history which are not usually considered in discussions on modern financial conditions. In spite of the mass of statistics the book is not all heavy reading and there are many passages such as the following which will be found on page 297:

> "The financial success of an individual is due in part to his own ability and in part to the time when he was born. The young man who started farming after the Civil War and who showed the most energy and courage usually suffered the most. Prices declined so rapidly that it was difficult to maintain the capital, to say nothing of making a profit. From 1897 to 1913, prices of farm products rose rapidly. The young man who started farming early in this period and who went heavily into debt was successful. The uninformed point with pride to the initiative and success of this individual as compared with his father, when in reality the only extra credit that is due to him is in the choice of the time to be born."

The book is recommended, not only as a volume of reference for the student of economics, but also as a source of information for the ordinary man in the street.

*Examining Engineer, National City Company Ltd., Montreal.

BULLETINS

Metal Coatings—A 20-page bulletin has been received from the International Metallizing Association, Jersey City, N.J., which describes the metallizing process, its application, advantages, and accessory equipment. The booklet contains a number of photographs showing the different types of work done, listing the objects coated, type of metal used and the process of coating.

Oxygen Welding—The May-June, 1933 issue of Dominion Oxwelding Tips, published by the Dominion Oxygen Company Limited, of Toronto and Montreal contains a number of interesting applications of the oxwelding process and the general maintenance of plant and construction equipment. A number of photographs effectively illustrate some of the many uses.

Metalclad switchgear—The June number of The Delta Star published by the Delta Star Electric Company, Chicago, Ill., describes the various types of switchgear with details of a number of installations.

Chain Drives—A 36-page booklet on the modern chain drive practice for automobiles deals with the application of chains for cam shaft and auxiliary drives in automobile engines and power transmission drives on motor cycles. Sections are included dealing with wheel manufacture and automatic adjustment. A number of tables are included. The booklet is distributed by Renold-Coventry Limited, Montreal and Toronto.

Gear Generators—Farrel-Birmingham Company Inc., Buffalo, N.Y. have issued an 8-page pamphlet describing the Farrel-Sykes 22-foot Gear Generator. This weighs 120 tons and handles gears up to 50 tons, and has a wide range of capacities and cutting speeds.

Road Surfacing—A four-page leaflet received from The Barrett Co. Ltd., describes points of interest in the treating of gravel roads with Tarvia.

Regenerative Turbine Pumps—A 4-page leaflet has been issued by Roots-Connersville-Wilbraham, Connersville, Ind. describing regenerative turbine pumps. These pumps are suitable for handling small quantities of liquids efficiently at high heads. Capacities range from 5 to 300 gallons per minute at heads up to 350 feet.

Concrete—A circular has been received from the Consolidated Pipe Company Ltd., Montreal, giving a detailed description of precast concrete joists, including tables of safe loads.

WATER POWERS OF THE WORLD

H. E. M. Kensit, M.E.I.C.,
Ottawa, Ont.

Presented before the Ottawa Branch of The Engineering Institute of Canada, April 20th, 1933.

With the exception of the uncertain wind, water is the only inexhaustible and non-depletable source of power. All sources of fuel power are depletable and will ultimately be exhausted—their duration is measurable and in some cases uncomfortably short, but water power is endlessly renewed by the cycle of evaporation and rain. It is possible that some new source of power may be made available, but to surpass water power this must be produced in enormous quantities at a very low price and unless this is achieved water power will become more and more valuable as time goes on.

Water Power Resources

In discussing the water power of the world one should first review the total resources so far as at present ascertained. These may be stated in terms of the horsepower continuously available at ordinary low water and including that already developed, and may be tabulated as follows:

North America:			
Canada	20,300,000		
United States	35,000,000		
Mexico	6,000,000		
Other	5,700,000		
		67,000,000	14.7 per cent
South America		54,000,000	11.9 "
Europe		58,000,000	12.7 "
Asia		69,000,000	15.2 "
Africa		190,000,000	41.8 "
Oceanica		17,000,000	3.7 "
		455,000,000	100 per cent

These figures bring out a number of striking points. It will be noted that Africa contains over 40 per cent of the total water power of the world, or nearly three times as much as the whole of North America—Europe, popularly supposed to have little, contains more than Canada and the United States put together, and Canada itself contains only 4½ per cent of the grand total.

The figures given for Canada are our own official figures, and the others are a summary of those compiled by the United States Geological Survey. That body has for many years made exhaustive inquiries into the water power of the world, utilizing every known source of information available to the government at home and abroad, and its figures may be considered the best data available on the actual position.

This seems a suitable point at which to ask, which is the greatest water power river of the world? Without doubt it is the Congo in Central Africa—on two stretches of the main river over 100,000,000 h.p. could be developed and there are other great powers on the tributary streams.

This location may seem impracticably remote, but in the present stage of the world's development in the use of power and in means of communication, and the overcrowded condition of most of the manufacturing countries, this is not a safe assumption. Less than five hundred miles from the site, in equally inaccessible Nigeria, two considerable hydroelectric plants have been installed for tin-mining, and coming closer home we may instance the aluminium industry on the Saguenay—this was established in what was then a remote spot for the sake of the water power, not to utilize local labour or raw material-local labour was practically non-existent and nearly the whole of the raw material is brought by ship from British Guiana.

Developed Water Power

The United States leads the world in the amount of water power developed, with over 16,000,000 turbine horsepower installed, and Canada comes next with over 7,000,000. Yet curiously enough the United States is not properly termed a "water-power" country and Canada is, because the power supply in the United States is mainly from fuel and in Canada mainly from water—the figures for the respective power installations in the two countries show that in the United States some 67 per cent of the total is fuel power and in Canada some 80 per cent of the total is water power, so that the position as to the main source of power is reversed in the two countries.

Next to Canada comes Italy with nearly 6,000,000-h.p. installed and then Japan with 3,650,000; many European countries follow with somewhat smaller totals. The total developed water power of the world is estimated at some 50,000,000 installed turbine horsepower, so that Canada has some 14 per cent of the total.

The Standing of Canada

Thus Canada, with only 4½ per cent of the total water power resources of the world, possesses 14 per cent of the total amount developed, and this indicates a great degree of utilization. But Canada also stands in the front rank of the science and practice of water power development. She holds or has held the records for size of developments, size of generating units, size of distribution systems, length of great transmission spans, and in other respects. Her rate of progress has been continuous—over the past fifteen years it has averaged 318,000 additional horsepower installed per year, or nearly 8 per cent per annum. The capital invested in the Canadian water power industry, including development, transmission and distribution, now amounts to $1,620,000,000, considerably more than in any other single industry in Canada with the exception of agriculture and steam railroads. This remarkable progress has without doubt been largely due to the work of the Dominion Water Power Bureau of the Department of the Interior—by an enterprising development policy, by exhaustive studies of the principal power rivers, by tactful collaboration with the provinces in the obtaining of hydrometric measurements over a long series of years and by the compiling of these together with all related data for power streams throughout Canada in one central office for the information of the public and of investors, that bureau has greatly assisted in attracting capital for water power development.

As an example of the value of water power Ontario and Quebec may be taken. These provinces, the centre of the population and industry of Canada, are practically coal-less, and it is obvious that without their abundant water power they could never have attained their present degree of industrial development.

Another interesting example is Winnipeg—considering its geographical position it is apparent that that city could never have achieved the position of being the fourth manufacturing city in the Dominion if it had not had available its water power resources.

The Utilization of Water Power

The degree of utilization of energy, that is the amount used per year per head of population, has long been a matter of competition and claims. Norway, by means of her great electro-chemical industries and small population, has for many years held the record and if each country is considered as a whole is likely to continue to do so. But Norway has only one-twentieth the area of Canada and over five times the population density, and therefore legitimate comparison is not possible with so great an area containing such widely different local conditions as Canada. For example the electric consumption per capita varies from under 50-kw.-hrs. in Prince Edward Island and about 200 in Saskatchewan to 3,790 in Quebec and consequently the average for Canada is a comparatively small figure. A comparison might however be made between Norway and a self contained portion of Canada of similar area, climate, population and nature of industries. Such an area is the populated portion of the province of Quebec; this, while still somewhat the larger is closely comparable to Norway in all other respects mentioned, and on a per capita basis the installed horsepower considerably exceeds that in Norway. It seems fair therefore to state that in the degree of utilization of hydroelectric energy Canada is not surpassed, if equalled, by any country in the world.

Some Large Developments

It may be of interest to give brief particulars of a few of the great water power developments in various parts of the world, in operation, under construction, and projected.

It seems natural to speak first of the St. Lawrence, though it has not yet the largest completed plants. The Beauharnois Company has 200,000-h.p. now installed, and aims to increase this at the rate of 100,000-h.p. per year up to 500,000-h.p.—and to ultimately extend to 2,000,000-h.p., the entire capacity of the river, if the necessary diversion rights can be obtained from the Dominion government, the works having been constructed with this in view. The international section of the St. Lawrence would also give about 2,000,000 h.p. in a single plant, but this would be equally divided between Canada and the United States, and as is well known the proposed treaty is not yet ratified. While the St. Lawrence is by no means the largest river in the world it is unique in regard to the immense natural storage given by the Great Lakes and has therefore unequalled regularity of flow.

The Queenston plant of the Hydro-Electric Power Commission of Ontario on the Niagara river, with 560,000 h.p. installed, still holds the record for the largest completed hydroelectric plant in the world, but it will soon be surpassed by the Dnieper river development in Russia which will contain nine units rated at 84,000 h.p. each, a total of 760,000 h.p., but capable of delivering 900,000 h.p.—five of these units, the largest ever built, are now in operation. Even this Russian plant however will not long hold the record—the next and a still larger to come into operation will probably be that at the Hoover dam on the Colorado river, which will develop about 1,800,000 h.p. in a single plant in units of 115,000 h.p. each, the largest units yet planned. Its construction commenced in the spring of 1931 and is now expected to be completed in 1936, but the units are to be installed gradually. The immensity of this undertaking may be judged from the facts that the flood discharge has been as much as 250,000 cubic feet per second and is believed to have been considerably more, equal to the whole flow of the St. Lawrence river. The river has a velocity of thirty miles per hour when in flood, and is confined in a gorge 1,200 feet deep and only 400 feet wide at the bottom. The floods have been widely destructive and the primary object of the undertaking is flood prevention, not power. The whole river has had to be diverted through four 50-foot tunnels 4,000 feet long before a yard of concrete could be poured for the dam—this work is now completed and the dam commenced. The dam will rise 727 feet above bed-rock, higher than any yet built, will be 650 feet thick at the base and will create a lake 115 miles long. The control of the floods will enable 7,000,000 acres to be irrigated and 1,000 million gallons of water per day will be conveyed to southern California where the local resources of water are now fully utilized. This water will be taken over a mountain range and be pumped against a head of 1,500 feet, requiring 70,000 h.p.

In Russia a further undertaking is projected constituting the largest single hydroelectric power station yet planned. A decree has been issued for the construction of a plant on the Volga river near Moscow of 2,000,000-kw. capacity, giving at 95 per cent efficiency about 2,820,000 h.p., with a dam two miles long and 98 feet high. It is scheduled to be completed in 1937 and aluminium, copper, chemical and other industries will be established at a cost of three billion dollars to assist in absorbing the output of ten billion kilowatt hours per annum. These figures are enough to give one mental indigestion, but Russia has a population to justify them—about 150,000,000 people.

The Present Position in Canada

In relation to the present position of water power in Canada, it should be noted that the optimism induced by years of rapid progress has led to the continuation of programmes of development even after the business depression became apparent, and this has resulted in a temporary condition of over development. The power demand during the past two years has as a whole actually diminished, but this reduction has been due to decrease in manufacturing activity; the demand for electricity for domestic purposes, illumination and other such uses has continued to increase, and a number of power companies in Canada have shown moderate increases in both output and revenue right through the slump. To get back to a normal over-all rate of progress in the use of power some improvement in business conditions is required, but not necessarily any marked increase of wealth or population. Owing to the steady growth of new uses for electricity, to the growing mechanization of industry and to the multiplying demand for comforts and luxuries, all ever-increasing factors, the demand for power grows at a much greater rate than wealth or population—for example, in Canada over the ten year period from 1920 to 1930 the average annual rate of increase in population was 1½ per cent, in national wealth 3½ per cent, but in the use of power it was 12 per cent. It is believed therefore that even a small improvement in general business conditions will cause a marked increase in the demand for power, and that there is no ground for anxiety as to the future prosperity of the water power industry in Canada.

Steel Wire Drawing

The drawing mill is that department in wire manufacture in which the wire rod is converted into wire. The distinction between wire and wire rod is, perhaps, not as widely known as it might be: wire rod is the product of a hot rolling process, while wire is that of a cold working, or pressure, operation. The material, when undergoing the drawing process, is passed through a hole in a tapered steel die. The pressure imparted as it is pulled or drawn through the die reduces it to the smallest diameter of the tapered section. The pulling or drawing power is supplied by revolving drums, termed blocks, on which the wire winds after being drawn.

For lubricating the material in its passage through the die a solid lubricant is used, composed of a small percentage of olive or palm oil, mixed with a soap compound. Tallow and various liquid mixtures are used for the drawing of small sizes of mild steel, but for high strain wire, such as is required for pit winding ropes, these are unsatisfactory, the heat generated by the pressure exerted thinning them and making them inefficient as lubricants.

Machines that will only draw the wire one hole or pass at one operation, known as single-hole blocks, are used for the drawing of high strain and winding-rope wire, but for other classes of work machines in which the wire can be reduced in from two to as many as six passes at one operation, have been used for a number of years. These multiple machines were first introduced in this country in 1900, the R. P. Slinger three-decker being the first successful experiment in this method. While answering the purpose to a certain extent, the machines allowed little latitude in the drafting of the dies, and in 1911 the inventor patented an improved type. The new machine, consisting of four single-hole blocks mounted in one frame, proved a big advance on previous models. Tested with high-strain wire, it drew this correctly, but it was found that the torsion requirements were destroyed, due to the fatigue stresses set up by the rapid reduction. These fatigue stresses are encountered in the single-hole system of drawing, and the higher the carbon content of the material, the greater the susceptibility to this form of defect. With the single-hole system, in order to maintain output and yet not destroy the uniformity of temper by too rapid reduction, it is the practice to draw four to six coils at one time, each taking its turn in being passed through the die, and being allowed to rest while the remaining coils receive the same treatment. No better method of eliminating fatigue stresses produced in wire by drawing has, as yet, been discovered, and until this trouble is overcome in the single-hole process, it is useless to attempt to do so in machine drawing, the quicker passage through the dies by the latter method only intensifying the disadvantage.—*Engineering.*

Canada, with one motor vehicle to every 9.4 persons, ranks fourth in density among world countries, according to recently compiled government statistics. The United States leads with one car to every 5.1 persons. In Canada, Ontario leads all the provinces with 6.5 persons per car.

BRANCH NEWS

Calgary Branch

J. Dow, M.E.I.C., Secretary-Treasurer.
H. W. Tooker, A.M.E.I.C., Branch News Editor.

"Protection of Inductive Windings against Lightning" was the subject of an address given by Mr. A. B. Cooper, M.E.I.C., General Manager of Ferranti Electric Limited, Toronto, to the members of the Calgary Branch and their friends on Friday, April 28th, 1933.

Protection of Inductive Windings Against Lightning

Lightning, Mr. Cooper said, has been a menace to mankind since the beginning of time. The use of electrical energy in the home and industry, with the consequent use of conductors to carry and distribute the electricity, widened the scope of lightning damage by providing a path for the propagation of surges and induced strokes to all parts of the connected circuit.

When a lightning discharge occurs from a cloud to a transmission line, a travelling wave of current and voltage is formed on the line. This wave or peak of voltage starts immediately to spread in both directions at a speed of 186,000 miles per second. The shape of the initial wave will depend on the atmospheric conditions affecting the time and law of the cloud discharge.

The shape of the wave as it travels along the line from the charged area under the cloud to the uncharged area will be further affected by the physical properties of the line insulation, conductor spacing, distance from the ground or ground wire et cetera, and as it starts forward it will have, in almost every case, an extremely steep wave front, there being various factors in its path which tend to absorb its energy, reduce its amplitude and slope off its wave front, these factors varying tremendously with different installations, but there is under the worst conditions an inherent protective factor in distance.

Since the protection of inductive windings is the principal concern, all surges except those originating at or in the vicinity of the station can be dismissed. It will be interesting to comment here that the first 220,000-volt transformers supplied in Canada were guaranteed to be safe against lightning, except in the case of a stroke in the vicinity of the station.

Electrical engineers for over thirty years have been trying to guard against the steep wave front high amplitude surge originating at or near the transformer. The maximum voltage of the surge where it is impressed on the line depends primarily upon the flash-over value of the line insulators. It may vary between 1.2 and 2.5 times the 60-cycle dry flash-over of the insulators and it is safe to assume that twice this dry flash-over will be the maximum voltage encountered under lightning conditions, and unless the line is over insulated the modern transformer will stand this stress to ground.

Referring to transformer insulation, the speaker said that in the low voltage class the 2,200-volt units were tested at 10,000 volts 60 cycles for one minute without oil, and as the voltage increased this insulation safety factor was materially reduced, but in a well designed transformer the insulation to ground would stand any instantaneous stresses which reached it without the line insulator having flashed over.

Summing up the situation, in simple words, if lightning doesn't go to ground on the line, it won't go to ground in a properly designed transformer.

Stating that transformers do fail from lightning, Mr. Cooper went on to explain how and why. Following the steep wave front surge into the transformer, he showed by the aid of diagrams how the surge, going round and round the high tension turns travelling to the end of the layer and then back round the turns of the next layer, placed the full stress of the surge between the first turn of the first layer and the last turn of the second layer, adjacent to each other and separated only by a thin thickness of layer insulation. This stress being many hundred times the normal working voltage, puncture occurs instantaneously.

There is no doubt that these stresses do occur inside the windings and that they cause the vast majority of failures due to lightning and switching surges. All internal stress would be reduced if the wave front could be bend back so that instead of reaching its maximum in one microsecond it would take five or six microseconds to reach its peak. To do this the surge absorber has been devised—a combination of inductance and capacitance intended to be inserted in series in the line ahead of the transformer to be protected. It may be considered as a filter circuit performing essentially the same functions as a filter circuit or so called "B" battery eliminator does in smoothing out the 60-cycle pulsations to give d.c. for radio tubes.

Mr. Cooper's address was illustrated by a number of slides showing surge absorber construction, and by moving pictures showing a water analogy in which the constants of surge impedance under different conditions are correctly apportioned to represent a normal distribution line with a transformer at the end.

At the conclusion of the address, the meeting was opened for discussion, many interesting questions being put forward, following which R. Mackay, A.M.E.I.C., tendered the speaker a hearty vote of thanks.

London Branch

W. R. Smith, 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 the 17th of May in the City Hall Auditorium, V. A. McKillop, A.M.E.I.C., chairman of the Branch presiding. The speaker was Gordon Culham, M.L.A., B.S.A., and the subject of his address "Building Livable Canadian Cities."

Introducing the speaker, S. W. Archibald, A.M.E.I.C., gave an outline of Mr. Culham's training and wide experience in the matter of Town Planning in America, the Continent, and the British Isles.

BUILDING LIVABLE CANADIAN CITIES

Mr. Culham opened by stating that a stranger coming into London would be at once conscious of a feeling of tree shaded spaciousness and broad beautiful graded avenues. Driving out of the city west and north he would find broad views of a lovely country-side over and along a winding river, with fine public buildings occupying commanding situations. In all this there had been deliberate planning of a kind to make a city a pleasant place to live in. He emphasized the advisability of the city securing possession of all unoccupied lands along river banks before they were built upon, so that driveways, parks, playgrounds, etc., might be established, and furthermore the erosion of the river banks taken care of. London should have a plan prepared for the future so that parts of it might be continuously executed as funds became available.

The lecture was illustrated by many slides and the first views shown were of Paris and its environs. Parisians were city lovers and had taken care of the beautification of the city, but outside the reverse was the case. Beyond the city limits blocks of dwellings, apartments, etc., were to be met with both ugly and crowded.

It appears that the Continent is not so fortunate in the raising of areas of greensward such as are plentiful in England and this country. Consequently the parks and open spaces are not as restful to the eyes.

In England on the other hand the people were lovers of the country and knew how to beautify the landscape without affecting its natural beauty and contour. Some views were shown of lovely beauty spots in England where the artificial efforts including mansions and cottages harmonized with the surroundings.

Regarding this country and America instances were shown where this principle was being adopted with more or less success from a beauty standpoint.

Examples were shown of advantageous layouts for both city and suburban areas.

E. V. Buchanan, M.E.I.C., in the course of discussion remarked that town planning and zoning had been given a tryout in London but owing to objections being raised by persons who were actuated by selfish interests it had not been a success.

A hearty vote of thanks was proposed by W. C. Miller, M.E.I.C., and unanimously carried.

Moncton Branch

V. C. Blackett, A.M.E.I.C., Secretary-Treasurer.

The annual meeting of the Branch was held on May 31st. H. J. Crudge, A.M.E.I.C., Councillor of the Branch, presided. The annual report and financial statement was presented and, on motion, adopted. Scrutineers F. O. Condon, M.E.I.C., and G. C. Torrens, A.M.E.I.C., reported that as a result of the balloting for election of Branch officers, there was a tie for the office of committeeman. A ballot was then taken in the meeting, after which, it was announced that the following will form the Branch executive for the year 1933-34.

Chairman	H. W. McKiel, M.E.I.C.
Vice-Chairman	J. G. Mackinnon, A.M.E.I.C.
Secretary-Treasurer	V. C. Blackett, A.M.E.I.C.
Executive Committee	R. K. DeLong, A.M.E.I.C.
	E. V. Moore, M.E.I.C.
	C. S. G. Rogers, A.M.E.I.C.
	G. E. Smith, A.M.E.I.C.
	H. B. Titus, A.M.E.I.C.
	F. L. West, M.E.I.C.
(*Ex-Officio*)	H. J. Crudge, A.M.E.I.C.
	T. H. Dickson, A.M.E.I.C.

Niagara Peninsula Branch

P. A. Dewey, Secretary-Treasurer.
C. G. Moon, A.M.E.I.C., Branch News Editor.

The Annual Meeting took place on May 18th, at the Welland House, St. Catharines, with President O. O. Lefebvre, M.E.I.C., as the principal speaker and E. P. Murphy, A.M.E.I.C., as chairman.

Dinner was served at 7.15 p.m., and was followed by musical numbers given by S. R. Frost, A.M.E.I.C., who sang several songs, and Victor Shearer, a young local violinist. Major A. W. O. L. Butler also contributed to the enjoyment of the evening with a sketch wherein he attempted to define the meaning of a horse-power and thereby prove that he was a fit candidate for admission to The Institute.

A. J. Grant, M.E.I.C., introduced Dr. Lefebvre, who outlined the affairs of The Institute, its aims and objects, and stressed the point that young engineers could not do better than to train themselves in the art of public speaking at every opportunity. The advantage of being able to express themselves clearly before an audience could not be over-estimated.

Referring to the financial status of The Institute, Dr. Lefebvre stated that revenues had decreased in common with other institutions, that the Headquarters staff had made sacrifices and that publications were being curtailed. However one of the first principles of good government was to have a balanced budget and the Council this year believed that a balanced budget would be achieved.

The meeting of a plenary council was necessary, under mandate from the Annual Meeting, to discuss the report of the development committee and to decide upon some definite course of action. This meeting would cost at least $2,000, but the Branches had been asked to subscribe on the basis of 20 cents a member and the response so far had been gratifying.

Some misunderstanding appears to exist with regard to the Provincial Associations, continued Dr. Lefebvre. Many engineers labour under the impression that they are more or less competitive with The Engineering Institute. This, however, is not the case. The Associations had been brought into existence through the direct instrumentality of The Institute. Their one and only object was to secure a legal standing for the engineer in the various provinces which could not be obtained by a Dominion corporation, such as The Institute, owing to the provisions of the British North America Act. All social and educational functions should be quite properly vested in The Engineering Institute of Canada, which has the advantages of a Dominion wide organization and, if this distinction is kept in mind, there can be no thought of anything but cooperation between the two bodies.

Mr. E. G. Cameron, A.M.E.I.C., in moving a vote of thanks, humourously remarked that he was glad that Dr. Lefebvre had among other things dealt with the matter of publications. This Branch had always insisted that they comprised the life blood of The Institute and, as such, should receive primary consideration. Now the question was finally settled and summarily determined by the state of the financial market and they had nothing left to raise Cain about. Alex. Milne, A.M.E.I.C., seconded the vote which was heartily endorsed by the meeting.

Chairman E. P. Murphy, in his retiring address, reviewed the work of the Branch for the last year and pointed with some pride to the attendance records. He thanked the Executive and Members of the Branch for the spirit and hard work which had made this possible. Before adjournment he presented the incoming executive to the gathering. Sixty-two members and guests participated in the meeting.

After the general meeting, the new Executive discussed plans for the coming year. Dr. Lefebvre attended and gave valuable information as to the methods employed in Montreal. The resulting discussion brought out points in Branch management which were of interest to the committee and which should prove helpful for future guidance.

Ottawa Branch

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

"Trends in gasoline engine design and fuel design for optimum performance" was the subject of a luncheon address before the local Branch at the Chateau on May 25th. Frederic R. Speed of the Ethyl Gasoline Corporation, Detroit, Michigan, was the speaker.

Group-Captain E. W. Stedman, M.E.I.C., chairman of the local Branch, presided, and in addition to the chairman and speaker, head table guests included: Gordon McIntyre; G. M. Connor; Lieut.-Col. N. O. Carr; L. L. Bolton, M.E.I.C., Dr. G. S. Whitby; Dr. R. W. Boyle, M.E.I.C.; D. W. Piper; C. McL. Pitts, A.M.E.I.C.; J. H. Parkin, M.E.I.C.; B. F. Haanel, M.E.I.C., and O. S. Finnie, M.E.I.C.

GASOLINE ENGINE AND FUEL DESIGN FOR OPTIMUM PERFORMANCE

Real progress is still being made in the manufacture of automobile engines, stated Mr. Speed, and there is still room for further improvements both in performance characteristics and fuel design.

In the first engines built, only a very small per cent of the fuel's energy was converted to work because the engine design lacked many refinements which contribute to its present-day efficiency. Today, internal combustion engines will convert from 5 to 25 per cent of the fuel's energy to work. The engine used in the Schneider cup races represents an exceptional case in which a thermal efficiency of 40 per cent was attained.

During the past seven years automotive engineers have accomplished much in the way of increasing the total horsepower output of gasoline engines, the increase during that time being approximately 72 per cent. The improvement has taken place through increased volumetric efficiency, increased compression ratio, and, to a lesser degree, improved cooling. For 1933 there are fifty-six cars designed with standard or low compression whose average compression ratio is 5.30, and forty cars designed for high compression with average compression ratio of 5.97.

Compression ratio is designated as the ratio of the volume of the cylinder with the piston at bottom dead centre to the volume of the cylinder with the piston at top dead centre. This term is frequently used to indicate changes n compression pressure. Changes in compression pressures can be effected without change of volumetric compression ratio. Such changes can be accomplished by design changes which affect the quantity of air consumed by the engine. Thus two cars with the same cylinder dimensions in which one car may have a higher compression ratio than the other may not develop horsepower in exact proportion to their compression ratios on account of the quantity of air consumed. Such quantities of air consumed would be affected by carburetor manifold and valve design.

In bringing about improvements to engine design, these could not have been worked out so successfully without improvement in the fuel available for the engine. There are certain requirements of a fuel for the gasoline engine whether it is of the high efficiency, high compression or of the low compression type if we expect the best performance of it. In the earlier days of the automotive industry not a great deal of thought was given to this problem. However, since 1925 much thought has been paid to it. The important properties of a fuel for gasoline engines are heat of combustion, volatility, freedom from objectionable impurities, and a tendency to detonate. With regard to the fourth property mentioned, in 1927 definite standards of antiknock were established and standard antiknock gasolines were distributed throughout the country and sold at a premium price. Since that time steady improvement has been made, until in 1933 a very high standard has been established for such premium fuels. Standard testing equipment and procedure has been devised whereby the antiknock characteristics can be definitely established. The speaker then went on to elaborate upon various methods of testing these characteristics.

The necessity for improvement in the performance characteristics of road vehicles is recognized not only by the manufacturers of such vehicles but also by the manufacturers of fuel. Active co-operation between these industries has prevailed for a number of years. The continuation of the present trend in high compression engine design and high antiknock fuel design, is, therefore, to be expected.

Seal Fishing in the White Sea, Northern Russia

In a very graphic manner, J. H. Martin, a former member of the British-Australian-New Zealand-Antarctic expedition of 1929-31, described his experiences while seal fishing in the White Sea, northern Russia, at the noon luncheon on May 30th. Mr. Martin underwent these experiences while with a Norwegian sealing ship, the "Quest," during March, 1932, which he accompanied solely for the experience.

While *en route* to lead the Oxford University expedition to Spitzbergen this summer, from the vicinity of Great Bear Lake where he spent the past winter, he stopped over for the day at Ottawa and thus the local Branch was afforded the opportunity of hearing him.

The ship, stated Mr. Martin, set sail from the harbour of Tromso on February 25th, and arrived amid the ice outside the White Sea on the last day of that month. Since the territory was in Russian waters a fee was charged all vessels in accordance with their size. Mr. Martin characterized the hunting of seals as anything but a delicate operation and stated so far as hunting was concerned, the animals themselves did not have a sporting chance for their lives.

The seals are skinned immediately after they are killed, a good man taking less than one minute for the operation. The skins are then piled on the ice in small mounds, each mound being marked by a flag stuck on the end of a long pole to facilitate its being picked up by the ship later. The entire work is rather hazardous and subjects the men to unpleasant conditions, Mr. Martin himself undergoing the experience of falling into the open water several times during the first day.

During sealing operations work is carried on continuously with very little rest for the men. Thus, after a day's capture of the seals on the ice the ship immediately works its way in amongst the mounds of skins and takes them aboard. This is done by means of a long extra-flexible steel cable operated by windlass from the ship itself.

One of the chief principles in carrying on the entire operation is to prevent the ship from becoming frozen in. This is effected by expert navigation and when such an occasion happens it may prove rather disastrous to the success of the entire expedition. On the ship which Mr. Martin accompanied this actually did happen and several days were used up by the crew in their efforts towards getting themselves free. Mr. Martin spoke about the difficulties which certain sealing vessels had with Russian authorities and also, in the most interesting manner, upon the methods used by Norwegian "Witch Doctors" for combating injuries, sickness, etc.

On this occasion there were six ships advancing steadily towards the pack with men from each ship on the ice ahead stalking and shooting the seals, skinning them, and preparing the skins to be taken aboard. During the operations described by Mr. Martin, two men met their death, one by drowning and the other through being accidentally shot.

As an example of the amount of seal destruction which takes place on an occasion like this, the speaker stated that in eighteen hours the crew of his ship took on board eighteen hundred seal skins.

Group-Captain E. W. Stedman, M.E.I.C., chairman of the local Branch, presided, and in addition to the chairman and speaker, head table guests included: Colonel L. R. LaFleche; Doctor Charles Camsell, M.E.I.C.; Charles A. Bowman, A.M.E.I.C.; O. S. Finnie, M.E.I.C.; Colonel Eric MacKenzie, D.S.O.; Andrew W. MacLean; Major D. L. McKeand; Major D. H. Nelles, M.E.I.C.; F. C. C. Lynch, A.M.E.I.C.; R. M. Stewart, M.E.I.C.; J. P. Henderson, A.M.E.I.C., and C. McL. Pitts, A.M.E.I.C.

Peterborough Branch

H. R. Sills, Jr.E.I.C., Secretary.
W. T. Fanjoy, Jr.E.I.C., Branch News Editor.

At the meeting of the Peterborough Branch of The Institute held on April 27th, Mr. A. G. Scott of the Imperial Oil Company, Toronto, spoke, his subject being "The Story of Lubrication." Mr. George Cunningham, manager of the local branch of the Imperial Oil Company introduced the speaker.

The Story of Lubrication

Mr. Scott outlined the part played by lubrication in the machine age and its application to modern mechanics. With the advent of the wheel, man began to experience the disagreeable effects of what we know as friction. There is a record of a chariot being found in a tomb dating about 1,400 B.C. which had some of the original lubricant on its bearings, so it would appear that even at that early date some effort was being made to combat friction. Until the close of the nineteenth century the scientific application of lubricants consisted of smearing or rubbing surfaces with a substance such as tallow, suet, animal oils and fish oils.

The underlying reason for applying lubricants to any mechanism is to reduce the friction between moving surfaces as this friction induces heat, and waste power and causes wear. If a thin layer or film of oil is placed between two moving surfaces it is known that the solid friction between the surfaces has been replaced by the lesser fluid friction between molecules of oil. The extent of this fluid friction depends on the type of lubricant, the method of application and the form and character of the surfaces lubricated.

Annual Meeting

Marking the close of another successful year of activity, members of the Branch held their annual meeting and election, Thursday evening, May 11th. The meeting, well attended and enthusiastic was held at the Kawartha Golf and Country Club and was preceded by dinner.

B. Ottewell, A.M.E.I.C., retiring chairman of the Branch, presided, and announced election by ballot of the executive for the ensuing year.

In relinquishing chairmanship of the Branch Mr. Ottewell expressed his appreciation of the loyal support and co-operation he had received from the executive and committees during his term of office. Despite a decrease in membership of the Branch, he noted with satisfaction that interest in the various meetings had been maintained at a high pitch. It reflected, he believed, the high quality of the numerous technical papers that had been presented.

In calling upon H. R. Sills, Jr.E.I.C., to present the secretary's report, Mr. Ottewell regretted that the Branch had been deprived of the services of W. F. Auld, Jr.E.I.C., who, he remarked, had faithfully and efficiently discharged the secretarial duties for the past two years.

The financial report was tendered by V. S. Foster, A.M.E.I.C., treasurer, and showed a credit balance of $64.70 on the year's operations.

R. L. Dobbin, M.E.I.C., who has represented the Branch on the Council of The Institute gave an informative outline of the various activities in which the Council is engaged. Mr. Dobbin is upon the outset of his thirteenth consecutive term as representative to the Council.

Among the various committee reports received by Mr. Ottewell, during the course of the meeting, was one from W. M. Cruthers, A.M.E.I.C., chairman of the Unemployment Committee. Reflecting a new phase of The Institute's activity necessitated by present conditions, the report revealed that there were from eight to ten unemployed engineer members of the local Branch. None of them were in need of relief.

Other reports covered the year's activities. That of the Junior Branch revealed a membership of thirty made up of thirteen juniors and seventeen students, who gave freely of their assistance in the activities of the Branch as a whole.

At a subsequent meeting of the newly elected executive the following officers were appointed for the ensuing year:

Chairman	V. S. Foster, A.M.E.I.C.
Secretary	H. R. Sills, Jr.E.I.C.
Treasurer	A. H. Munro, A.M.E.I.C.
Meetings and Papers Committee	A. B. Gates, A.M.E.I.C.
	B. Ottewell, A.M.E.I.C.
	E. J. Davies, Jr.E.I.C.
Membership Committee	B. L. Barns, A.M.E.I.C.
	A. E. Caddy, M.E.I.C.
	A. A. Richardson, A.M.E.I.C.
Unemployment Committee	W. M. Cruthers, A.M.E.I.C.
	A. H. Munro, A.M.E.I.C.
	E. J. Davies, Jr.E.I.C.
Attendance Committee	D. J. Emery, S.E.I.C.
Social Committee	R. L. Dobbin, M.E.I.C.
	A. L. Killaly, A.M.E.I.C.
	E. J. Davies, Jr.E.I.C.
By-Laws Development Committee	R. L. Dobbin, M.E.I.C.
	B. Ottewell, A.M.E.I.C.
	A. B. Gates, A.M.E.I.C.
Auditor	E. R. Shirley, M.E.I.C.
Branch News Editor	W. T. Fanjoy, Jr.E.I.C.

Quebec Branch

Jules Joyal, A.M.E.I.C., Secrétaire-Trésorier.

VISITE AU RÉSERVOIR

Samedi, le 13 mai dernier, les membres de l'Engineering Institute of Canada, Section de Québec et quelques-uns de leurs amis ont visité le réservoir du Parc des Champs de Bataille.

Ce réservoir, qui fut le sujet de nombreuses discussions au Conseil de Ville et qui fit couler beaucoup d'encre dans les colonnes des journaux locaux, fut construit dans le but de créer une réserve d'eau qui pourrait être utilisée au cas de bris des conduites qui amènent l'eau à la distribution de la Cité et qui de temps en temps faisaient des leurs et se rupturaient laissant ainsi les citadins en proie à tous les inconvénients que peut comporter un manque d'eau.

Avec ce réservoir dont la capacité est de 30,000,000 de gallons d'eau, les citadins ne seront plus, comme autrefois, exposés aux inconvénients précités et le réservoir pourra suppléer aux conduites durant la période des réparations au cas de bris de ces dernières.

Tous ceux qui ont pris part à cette réunion furent vivement impressionnés par la grandeur de l'entreprise et furent à même d'en reconnaître toute l'utilité.

La construction est entièrement en béton armé et le réservoir est divisé en deux bassins qui peuvent être opérés conjointement ou indépendamment l'un de l'autre.

Cette visite se fit sous la direction conjointe de MM. Edouard Hamel et J.-A. Tremblay, respectivement ingénieur en chef et ingénieur de l'aqueduc de la Cité de Québec; ces messieurs se sont dévoués pour fournir aux visiteurs tous les renseignements d'ordre technique et autres sur le fonctionnement du réservoir, l'opération des portes d'arrêt, etc., etc., et tous les remercièrent bien sincèrement avant de retourner chacun chez soi.

Parmi les personnes présentes l'on remarquait: MM. Hector Cimon, M.E.I.C., président de la Section; C.-G. Piché, A.M.E.I.C., H. Kieffer, J.-U. Archambault, A.M.E.I.C., I.-E. Vallée, A.M.E.I.C., R. E. Cumming, A.M.E.I.C., J.-A. Tremblay, A.M.E.I.C., J.-S.-H. Waller, A.M.E.I.C., H.-E. Huestis, A.M.E.I.C., T.-M. Déchène, A.M.E.I.C., L. Gagnon, J.-E. Drolet, A.M.E.I.C., A.-B. Normandin, A.M.E.I.C., G. Dussault, Ed. Hamel, A.-O. Barrette, J.-E. Roy, A.M.E.I.C., O. Desjardins, A.M.E.I.C., L. Lavoie, P.-N. McDunnough, S.E.I.C., T.-M. Melrose, D.-S. Scott, A.M.E.I.C., L.-O. Morency, R. Wood, S.E.I.C., T.-J.-F. King, A.M.E.I.C., E. Gauvreau, E. Chevalier, H. Gagnon, P.-A. Villeneuve, C.-H. Boisvert, A.M.E.I.C., G.-C. Dawson, W.-R. Ray, A.M.E.I.C., W.-S. Buchanan, A.M.E.I.C., Ed. Gaudette, C.-E. Lamarche, J. Joyal, A.M.E.I.C., et quelques autres.

Sault Ste. Marie Branch

G. H. E. Dennison, A.M.E.I.C., Secretary-Treasurer.

A regular monthly meeting of the Sault Ste. Marie Branch was held at the Windsor hotel on May 26th following the regular dinner. K. G. Ross, M.E.I.C., chairman of the Branch occupied the chair and Mr. B. M. Winegar, vice president of the Canada Creosoting Company was guest speaker of the evening.

H. F. Bennett, A.M.E.I.C., chairman of the Papers Committee announced that he had been in touch with the President, Dr. O. Lefebvre, M.E.I.C., who would be in the Sault to visit the Branch during June. Correspondence with district members was read, relative to the holding of a meeting of the Branch in North Bay this summer, and it was regretfully concluded that the proposed meeting would have to be postponed until a later date.

THE PRESERVATION AND USE OF CANADIAN TIMBER

The address presented by Mr. Winegar dealt with "The Preservation and Use of Canadian Timber" and described the pressure treatment used to obtain penetration into the wood of creosote, zinc chloride or other preservatives and their action in combating decay. Mr. Winegar placed the life of an untreated railway tie at seven to eight years and that of a treated tie at an average of twenty-four years. Instances of treated ties lasting twenty-seven years and more in service were quoted, outwearing two sets of rails and several sets of tie plates. Creosote as a preservative for poles was discussed and some samples cut from poles fifty years in service were shown. Finally the use of creosote in combating the destructive work of the teredo was touched on. To be effective against this enemy the timber must present a completely impregnated surface, since a nail hole or any opening extending inside the treated portion of the timber will allow the worm to enter and attack the untreated heart wood with disastrous results.

THE PRESIDENT'S VISIT

The Sault Ste. Marie Branch had the honour of a visit from the President of The Institute on June 14th and 15th. Dr. Lefebvre arrived at noon on Wednesday June 14th and was entertained at luncheon with the Branch Executive, at the home of K. G. Ross, M.E.I.C., chairman of the Branch, where the afternoon was spent in a discussion of many matters relative to The Institute and to the Sault Ste. Marie Branch in particular.

On Wednesday evening Dr. Lefebvre was guest of honour at a dinner at the Sault Ste. Marie Country Club. K. G. Ross acted as toastmaster and after The King, called on Mr. J. A. McPhail, president of The Great Lakes Power Company and associated companies, and an Affiliate of the Sault Ste. Marie Branch, who proposed a toast to The Engineering Institute. In doing so Mr. McPhail told of his many contacts and associations with engineers and paid high tribute to the ability and integrity of those members of the profession with whom he had come in contact. In replying to the toast Dr. Lefebvre told of his visits to the western branches, where he said confidence was returning, as indeed it seemed to be throughout the east as well. He touched on the work of the Committee on Development and the progress of The Institute toward the ultimate goal it sought, uniformity of provincial regulations governing the practice of engineering and inter-relation between the provincial bodies through the E-I-C. The frame work has developed to a varying extent in the different parts of the country and of its ultimate success there is little doubt.

Judge Frederick Stone, Senior judge of the district, was called on by Mr. Ross and spoke inspiringly of the progress of engineering and the important place of the profession in the everyday life of the community and of the world today. He touched on the local developments in power and industry, impossible without the technical and scientific research afforded by engineering. Mr. Ross concluded the evening with a word of thanks to the speakers, and expressed the pleasure of the local Branch at the visit of Dr. Lefebvre. He expressed the hope of all present that the visit might be repeated in the near future.

Vancouver Branch

A. I. E. Gordon, Jr.E.I.C., Secretary-Treasurer.

VISIT OF PRESIDENT LEFEBVRE

Dr. O. O. Lefebvre, M.E.I.C., President of The Engineering Institute of Canada, reached Vancouver on April 10th. He was met by the chairman and secretary of the Vancouver Branch, and E. A. Wheatley, A.M.E.I.C., Registrar of the Association of Professional Engineers of B.C., and driven around the waterfront, before leaving on the morning boat for Victoria.

Returning April 12th, Dr. Lefebvre was a guest at the usual noon luncheon meeting of the Professional Engineers Club of Vancouver, and in the evening attended a regular meeting of the Council of the Association of Professional Engineers.

On April 13th, the President attended a dinner of the Vancouver Branch Executive at the Hotel Georgia, several prominent members of the Branch being present in addition to the Executive. At 8.30 p.m., a general meeting of the Branch was held when thirty-four members attended. P. H. Buchan, A.M.E.I.C., chairman, introduced Dr. Lefebvre who spoke on Institute affairs. He dealt with economies necessary to meet reduced revenues—cuts in staff and salaries and the elimination of certain services. A member of the Committee on Development, he defended the Busfield Report as he felt The Institute should set its own standards of admission, and not adopt those of the Professional Associations. He stated relations with these associations must be on a most friendly basis, the conception being that The Institute looks after the technical welfare of the engineer, while the Associations attend to the legal side, but both are working toward the common objective of recognition of the Profession. In the discussion which followed C. Brakenridge, M.E.I.C., complimented Dr. Lefebvre on his very able speech and mentioned the difficulty at present of paying dues to two bodies. Professor E. G. Cullwick, Jr.E.I.C., stressed the value of The Institute on account of its broad outlook, but regretted the difficulty of interesting students, and felt that anything which could be done to this end would be of great value. A. S. Gentles, M.E.I.C., endorsed this stand and felt that more interest should be taken in the Branches by senior engineers. Dr. Lefebvre replied explaining efforts made with students in the East and pointing out that it is in a young man's interest to contact older men and advertise himself by delivering a good paper. E. E. Carpenter, M.E.I.C., stressed the value of short papers dealing with certain problems and aspects of work. Major H. B. Muckleston, M.E.I.C., spoke on the report of the "Committee of Eight" recommending the formation of a Dominion Council.

Major W. G. Swan, M.E.I.C., moved a vote of thanks. After the meeting adjourned, refreshments were served, and individual members had an opportunity of meeting Dr. Lefebvre.

On April 14th, Dr. Lefebvre and a small party of Branch members inspected the Stave Falls and Ruskin plants of the B.C. Electric Power Corporation as guests of the Company.

On Monday, May 15th, 1933, fifty-six members and friends attended the final spring meeting of the Branch in the auditorium of the Medical Dental building to hear an address by Professor A. H. Finlay of the Department of Civil Engineering of the University of British Columbia, entitled "The Erection of Sydney Harbour Bridge."

THE ERECTION OF SYDNEY HARBOUR BRIDGE

The address was descriptive rather than technical, and the speaker began by giving the history of the project. At the time of the battle of Waterloo the original proposal was made to bridge Sydney harbour but it was not until shortly before the Great War that an act of the Australian Parliament was passed authorizing construction. Very complete specifications as to location, span, length, clearance, working stresses, etc., were laid down by Dr. Bradfield at the government's request, but the war prevented construction being proceeded with. Interest revived about 1920, however, and four years later, on the basis of the Bradfield specifications, competitive designs and prices were asked from firms in all parts of the world. This resulted in many excellent designs being submitted, and included such types as arch, suspension and cantilever spans. Dorman, Long and Co. of England were the successful bidders, and their tender for a two-hinged arch at a cost of £4,500,000 exclusive of approaches and property damage was accepted and the contract awarded in 1925.

The successful contractors at once erected a plant at the site of the bridge and began construction.

Professor Finlay ran through slides showing progressive stages of the construction paying special attention to the novel method of cantilevering used. One hundred and twenty cables attached to a special anchor plate rivetted to the top chord of the arch near the abutments were passed through a six-foot diameter tunnel in the bedrock of the shore and connected to a similar plate on the other arch ring. These tunnels extended 150 feet back of the abutments, and were concrete lined. Cranes travelling on top of the arch ring erected the steelwork and the cables gradually took up the strain until in 1930 the half-arches from each side met 450 feet above Sydney harbour, with a gap of 40 inches as designed. The cables were then slacked off during a period of three weeks and the arch was gradually lowered into position and rivetted at the crown. The travelling cranes then retreated to each shore laying the deck as they went.

In 1931 the bridge was formally opened for traffic.

In the discussion which followed Major J. R. Grant, M.E.I.C., Major H. B. Muckleston, M.E.I.C., and others took part, and it was stated that labour troubles added greatly to the final cost, which including approaches and property costs is estimated at £10,000,000.

A very hearty vote of thanks to Professor Finlay was moved by C. Hamilton, A.M.E.I.C., and the meeting adjourned.

Victoria Branch

I. C. Barltrop, A.M.E.I.C., Secretary-Treasurer.
Kenneth Reid, Jr.E.I.C., Branch News Editor.

A most interesting address on "The Forest Resources of British Columbia" was given before the Victoria Branch of The Institute by Mr. P. Z. Caverhill, Chief Forester for the Province of British Columbia, on April 11th. Some fifty members and friends of the Branch attended.

President's Visit

The address was preceded by a dinner given in honour of Dr. O. O. Lefebvre, M.E.I.C., President of The Institute. H. L. Swan, M.E.I.C., chairman of the Branch presided at the dinner, which was attended by thirty members who were introduced to Dr. Lefebvre.

Following the dinner, Dr. Lefebvre addressed the members on Institute matters, briefly outlining present conditions affecting its membership, and the relationship between Headquarters and the various Branches.

Besides the President, guests at the dinner included Mr. P. Z. Caverhill, guest speaker for the evening, Mr. J. D. Galloway, Chief Mineralogist for British Columbia and Mr. H. D. Parizeau, Chief Hydrographer of the Dominion Dept. of Hydrographic Survey, Victoria, an old friend and classmate of Dr. Lefebvre.

Forest Resources of British Columbia

Mr. Caverhill pointed out that a forest was more than a mere growth of trees. "It is a community of living organisms, controlled by definite biological laws and consisting of a number of plant species ranging from trees down through shrubs, grasses, mosses, to the micro-organisms of the soil. All are linked together for the common welfare, and each is more or less dependent on the other."

He outlined the difficulty of giving a concrete estimate of British Columbia's forest resources as some based its value on commercial worth only, while others considered its value as an asset for hunting and fishing, and still others believed forests should be looked upon as natural parks, to be preserved for posterity. Besides all these there was the value of the young growth to be considered for the future.

The speaker then proceeded to explain the development of a forest from seedlings to saplings, then to poles, trees, and lastly to veteran timber. This ultimate goal was reached, provided that in the meantime the forest had not fallen victim to any one of nature's hazards, namely snow-break, fungi, insects, smothering, wind-fall, fire, or the axe.

The address was illustrated with slides depicting the various stages of development and growth of forests from the seedlings to the mature tree. A section was devoted to the various methods of logging in use in the province, and the resultant waste.

Others showed modern attempts at reforestation, particularly in certain parts of Europe.

In the sixty odd years since timber operations commenced some fifty billion feet have been commercialized and the value has been in excess of one and one-half billion dollars, giving work to a large portion of the population and returning some $80,000,000.00 to the provincial treasury in direct revenue.

The market for wood, the speaker pointed out, was expanding year by year. In the year 1662 it had been estimated that there were only three hundred and sixty different uses for wood. Today there are forty-five hundred commodities in which wood enters as a primary raw product.

In conclusion Mr. Caverhill observed that economists have pointed out the much faster rate of increase in the use of natural resources than in population. In the forest areas there was a renewable resource and one which, if maintained, would prove invaluable for the future.

Bridge Party

On the invitation of Mr. and Mrs. F. C. Green, the Victoria Branch held its annual bridge party on St. Patrick's Day, March 17th, at Mr. Green's home. Nine tables of bridge were made up by members and their families and a thoroughly enjoyable social evening ensued. The thanks of the Branch was extended to Mr. and Mrs. Green for their kind hospitality.

New Survey Ship

Items of engineering interest in and around Victoria include the departure of the new survey ship, the "Wm. J. Stewart," Mr. H. D. Parizeau, chief hydrographer in charge, for annual field work on the west coast of Vancouver Island. The "Wm. J. Stewart" was built at Collingwood, Ontario, last year for the Dominion Department of Hydrographic Survey and arrived in Victoria last fall after her trip from the east through the Panama canal. After a winter's tie-up in Victoria harbour, she now goes into commission for the first time. The "Wm. J. Stewart" replaces the old survey ship "Lillooet" which will now be used for auxiliary survey work. Members of The Institute on the staff of the survey ship include J. O. Johnson, S.E.I.C., and V. Wiebe, S.E.I.C., both graduates of the University of Saskatoon, and members of the Victoria Branch.

The Erren Hydrogen Engine

The Erren hydrogen engine was described by Mr. E. P. Heinze of Berlin, in *Engineering* of November 18th, 1932. This article aroused the interest of many engineers as there was a widely held impression that the use of pure hydrogen in internal combustion engines was impracticable owing to knock arising from the great rapidity of the combustion. The tests described show conclusively that this fear was unfounded, and that very smooth running was secured even with high compression ratios. One of these engines is now at work in London, where a Diesel engine converted to run on hydrogen has, for demonstration purposes, been installed at the Albion Works, Grayling-road. This engine is of the two-stroke type, being of single-cylinder form, with a cylinder 232 mm. in diameter by 280 mm. stroke. With normal oil fuel it developed 20 brake horse power when making 350 r.p.m. As converted to run with hydrogen it is stated that at the same speed the output is about 30 brake horse power. The hydrogen is supplied from a standard hydrogen bottle, being, on its way to the engine passed through a reducing valve. It is fed to the engine at a pressure of about two atmospheres, the injection being made early in the compression stroke. The compression ratio is 11 to 1, but in spite of this high figure the engine is stated to run quietly at all loads. The ignition is by spark. It is claimed that for motor car work about 4½ cubic metres of hydrogen at N.T.P. are equivalent to a gallon of petrol. The hydrogen it is suggested, can be cheaply provided by generating it electrolytically under a pressure of 3,000 pounds to 4,000 pounds per square inch, taking the energy required from electric power stations during periods of light load.

—*Engineering.*

A booklet has been prepared by the British Electrical and Allied Manufacturers' Association giving a record of the Association's activities during the twenty-one years of its existence. The organization was formed to promote voluntary co-operative action in meeting the economic difficulties affecting the industry, and its members manufacture ninety per cent of the total value of electrical machinery and apparatus produced in Great Britain.

An interesting feature of the Association's work has been the development of a form for Standard Conditions of Contract for use in the purchase of electrical equipment, the form adopted having been worked out in co-operation with the Institution of Electrical Engineers. This was followed by the preparation of Standard Forms for Conditions of Sale, which have received wide acceptance. The BEAMA has also acted in conjunction with the British Standards Institution and with other public and semi-public bodies. The study of post-war electrification problems in Britain, the development of export markets, and other like problems, have received its attention, with undoubted benefit to the electrical industry and the public.

Darling Brothers Limited, Montreal, announce that they have completed arrangements with the American Air Filter Company Inc., of Louisville, Ky., which gives them exclusive manufacturing and selling rights for their entire product for the Dominion of Canada and Newfoundland. The American Air Filter Company is a corporation which resulted from the consolidation of the Reed Air Filter Company, Midwest Air Filters, Inc., the National Air Filter Company and five smaller companies. They have had over twelve years experience in designing, building and testing air filters for all types of services. Previous to Darling Brothers' arrangement with this company, they had been operating in Canada under the name of Midwest Canada Limited.

The Canadian SKF Company Ltd. have taken over the business of Lammers and Maase Ltd. The company have formed a Diesel engine division and Mr. J. Ander, who has been with Lammers and Maase Ltd. since their inception in Canada, will be in charge of this division.

The Diesel engine business will be conducted by the Canadian SKF Company Ltd., in the same manner as their ball and roller bearing business, the head office being in Toronto. The SKF Montreal office has moved to 1075 Beaver Hall hill, where all business for eastern Canada will be conducted, Mr. Drummond Giles being district manager.

The "Royal Scot" Express in Canada and the States

Potential Canadian and American travellers who may have doubts about the convenience, comfort, and speed of the British railway train, will have an excellent opportunity of seeing for themselves how baseless such doubts are by an inspection of the "Royal Scot" express, which the London Midland and Scottish Railway is exhibiting at the Chicago World's Fair this summer. The train, on its way to Chicago and back, will make a tour of 4,400 miles in certain parts of the United States and Canada. The train consists of a locomotive and eight vehicles, these being chosen as representative of different types of rolling-stock. The vehicles are, reading from the locomotive to the rear, a third-class corridor brake coach, a third-class vestibule coach, an electric kitchen car, a first-class corridor vestibule coach, a first-class lounge brake coach, a third-class sleeping coach, a first-class sleeping coach, and a first-class brake coach. The total length of the train is 510 ft. 4 in., not including the locomotive, which measures 63 ft. 2¼ in. over the buffers.

The locomotive is the well-known 4-6-0 type express passenger engine No. 6100, the "Royal Scot," and the first of its class which bears this name, and which now numbers 70 locomotives in all. Constructed in the autumn of the year 1927, the "Royal Scot" has run a total distance of 335,658 miles prior to withdrawal for overhaul in preparation for the Fair.

In 1928, the locomotive "Cameronian," No. 6113, hauled a non-stop passenger train from Euston to Glasgow, a distance of 400¼ miles, the total time taken being 8 hours 7 minutes. The run was, at that date, the longest non-stop journey on record. The engine is of the simple three-cylinder superheated type, with cylinders 18 in. in diameter by 26-in. stroke. The driving wheels are coupled, and the total wheel-base, including the tender, is 52 ft. 9¼ in. The working pressure is 250 lb. per square inch, and the tractive effort, at 85 per cent. of this pressure, is 33,150 lb.

As regards the vehicles, space does not permit more than a few comments on one or two, but it may be said that all of them are splendid examples of modern construction and finish. The third-class sleeping coach is the first coach of a new type to be put into service by the London Midland and Scottish Railway Company, and marks a distinct advance in this form of travel, which is rapidly increasing in popularity. The third-class corridor brake coach is one of the latest put into service, and also embodies many new features, both in regard to exterior and interior finish. From the technical point of view, however, the electric kitchen is of most interest. The use of gas for cooking has been abandoned, the whole of the operations being now performed electrically. As the equipment includes 3 ovens, 2 grills, 2 boilers, 2 urns, 2 tanks, and 10 hot plates and closets, the total load amounts to 67 kw. when all the appliances are in use. The current demand is met by two independent generating sets, each of 27-kw. capacity, and driven by heavy-oil compression-ignition solid-injection two-stroke cycle engines, direct coupled and running at 1,150 r.p.m. Governor gear is provided. The engines have four cylinders without exhaust valves, scavenging being effected by individual air pumps. They are water-cooled, the hot circulating water being passed through a radiator through which air is forced by two motor-driven fans. The air supply enters through vents in the roof of the engine room, and is discharged through the floor of the coach.

The body framing of the coach is of teak, the sides, ends and roof being covered with steel panelling in line with the railway company's latest practice. It is interesting to note that the walls of the kitchen are lined with Messrs. Thomas Firth and John Brown's "Staybrite" steel. Staff compartments and lavatories occupy the ends of the coach.

The train was transported on the Canadian Pacific Railway's S.S. Beaverdale, from Tilbury. The total weight of the consignment was 395 tons. The loading was handled, as regards the heaviest lifts, by the Port of London Authority's 150-ton floating crane and some special tackle. The locomotive was stowed in the hold in a dismantled condition, its main section, weighing 77 tons, the boiler, 24 tons, and the tender, 28 tons, being shipped as separate units. The vehicles were carried on deck, special rails being laid down to receive them. They were protected externally from sea and weather by a coating of wax. On arrival at Montreal on April 21, the train was re-assembled in the Canadian Pacific Railway Company's shops in that city, whence the tour commenced.—*Engineering.*

Photoelectric Control

Photoelectric control was installed sometime ago at the plant of the Jaite (Ohio) Paper Company by the General Electric Company to maintain the register of a cutter on a cement-bag-making machine. The equipment is designed to eliminate the necessity of the operator's continuing observing the cut and making suitable manual corrections.

To accomplish this automatically, a small register mark is printed on each bag at the point where it is desired to make the cut. As the paper passes through the machine, this spot passes underneath an opening in the photoelectric-tube housing, causing a variation in the light passing into the tube, thus making it possible to indicate the exact time that the spot passes underneath the tube. The paper passing underneath the photoelectric tube is illuminated by an intense concentrated light beam.

In order properly to time the movement of the spot underneath the photoelectric tube a selector switch is driven from the roll carrying the cutter knife. This selector switch makes an integral number of revolutions with each cut of the knive, and accordingly when the cut is being correctly made the switch will always be in the same angular position when the spot passes underneath the photoelectric tube. If the spot passes underneath the tube before or after the selector switch reaches its proper position, it is necessary to initiate a correction in the position in which the cut is being made. This is accomplished by amplifying the impulse received from the photoelectric tube and applying it to the control grid of one or the other of two thyratron tubes.

The remarkable feature of this type of arrangement is its great sensitivity. For example, it is stated that the thyratron selected will pass current within a period of less than 1/10,000 of a second, and in so doing will energize a relay which will initiate the proper correction in the relation between the cutter knives and the sheet of paper. It is possible to judge the length of cuts or to obtain a correction in the cut because the cut is being made early or late, though in normal operations a correction will be made very infrequently as the equipment operates before the errors are allowed to accumulate to a large extent.

The operating speed of the foregoing machine is a maximum of 600 feet per minute, or a maximum of 300 cuts per minute. It should be noted that when operating at 600 feet per minute the time required for 1/16 inch of paper to pass a given spot is approximately 1/2,000 of a second.—*Mechanical Engineering.*

Handling Personnel at McIntyre Porcupine Mines

The management of the McIntyre Porcupine Mines, in planning its new administration buildings, has undertaken an interesting experiment in the form of new change houses for the miners, designed to promote their health and comfort, to prevent "high grading" of ore, and to increase the general efficiency of the labour. The new method of handling personnel which has been adopted is described in a paper by A. D. Campbell, M.E.I.C., presented at the Annual Meeting of the Canadian Institute of Mining and Metallurgy in Toronto in April, 1933.

After a full year's operation it has been found that the novel arrangements adopted are sound, that the original difficulties have been overcome, and that the men and the company are satisfied with the innovation.

The underground-miners' change-rooms introduce radical departures from old style change-houses, and set new standards of efficiency and of health and morale building. The facilities provided enable the miners to make, in comfort, complete changes of clothing from mining clothes in one room, to street clothes in another, and to take daily shower-baths and sun-lamp treatment. This had not been possible before in this climate, with a temperature range from ninety degrees in summer to forty degrees below zero in winter, with a mean average yearly temperature of thirty-three degrees.

Another operating problem which depends on supervision and discipline is "high-grading" or the stealing of pieces of raw gold at mines. High-grading has a very insidious appeal. The mines lose in gold and efficiency and the miners in suspicions and in just and unjust losses of jobs therefrom.

From underground, all miners come up on the double-deck cage. From the enclosed steel construction shaft-house, without exposure to outside cold or draughts or an opportunity for outside contacts, they go through a concrete tunnel under the yard and then by way of a rotunda to their change-rooms. Beyond the rotunda the miner enters the change-rooms. Double change-rooms are provided, one for mine clothes, the other for street clothes. Between are continuous shower baths and a solarium for sun-lamp treatment.

Here the miner places his lunch kit on a travelling belt which which carries it by way of an inspection room to his individual box at the exit. He then undresses in this room, during which time the temperature is kept at approximately 76 degrees and the room free from draughts. He places his complete outfit of underground clothes on his individual hanger. Hanger and clothes are hoisted close to the ceiling by an individual pulley and rope, which is then hooked and padlocked to the top of a steel A frame which supports benches.

From the mine-clothes change-room, the miner, unencumbered by clothing or lunch-box, and naturally without high-graded gold, enters either of two duplicate shower rooms.

From the shower rooms, the miners, wearing goggles, pass by a travelling platform through a solarium for ultra-violet ray sun-lamp treatment. The importance of this to these men, whose underground work the sun's rays do not reach, can be readily realized. The entire body is here exposed to the ultra violet light from a battery of six quartz-mercury vapour lamps placed three on each side. The 50-second trip through is designed to give the equivalent of three hours total body exposure to ordinary stimulating sunshine, or more ultra-violet than a person with his clothes on could get in a whole day in the middle of July. When the miners step from the solarium-conveyors their skin is tingling, the tiredness gone, and they feel as though they could start work again.

Preliminary Notice

of Applications for Admission and for Transfer

June 23rd, 1933

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 September, 1933.

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

GIBSON—CEDRIC MARROLD, of 129 Dobie Ave., Mount Royal, Que., Born at Farnham, Que., Feb. 4th, 1895; Educ., Sherbrooke High School. Private study; 1912-13, rly. survey work, chainman, rodman, etc.; 1913-15, struct'l. steel work, tracing dfting and gen. detail work, MacKinnon, Holmes & Co., Sherbrooke, Que.; 1915-22, gen. engrg. office work, mech'l. and struct'l. dfting, also reinforced concrete and general layout work, with Canada Cement Co. Ltd., Montreal, and from 1922-32, with same company, mech'l. and struct'l. design, including reinforced concrete design, estimating work and major layout of plants and bldgs., also respons. charge of engrg. office during absence of chief engr.

References: S. Barr, C. S. Kane, D. M. Chadwick, F. A. Ritchie.

HAYMAN—HOWARD LAWRENCE, of London, Ont., Born at London, March 23rd, 1901; Educ., B.A.Sc. (Civil), Univ. of Toronto, 1923; 1917-23 (summers), with John Hayman & Sons Co. Ltd., London, Ont., and from 1923 to date, with same company as constrn. supt.

References: H. A. McKay, V. A. McKillop, F. C. Ball, D. M. Bright, S. W. Archibald, W. M. Veitch, W. R. Smith.

LeCAPELAIN, CHARLES KING, of Banff, Alta., Born at Aldershot, England, Feb. 1st, 1893; Educ., 1904-09, Duke of York's School, London, England. 1909-12, in training for Royal Army Educational Corps, Royal Military School, Dover, England; Winter 1921-22, course in higher maths., Calgary Technical School. 1912-15, I.C.S. Engrg. Course, not completed; 1915-19, overseas, C.E.F.; 1912-15, instr'man., C.P.R., Montreal terminals; 1920, instr'man., C.N.R.; 1922-26, junior engr., 1926-30, asst. engr., Dominion Forest Service, Calgary, in gen. charge, under dist. forest inspr. of engrg., mapping, and dfting for the District of Alberta; National Parks engr., (1930 to date), National Parks Branch, Dom. Govt., Banff, Alta., duties chiefly highway location, responsible to the chief engr.

References: J. M. Wardle, P. J. Jennings, O. H. Hoover, P. A. Fetterley, H. R. Carscallen.

SAUNDERS—MAX GORDON, of Arvida, Que., Born at Elgin, N.B., Feb. 23rd, 1897; Educ., B.Sc. (Mech.), N.S. Tech. Coll., 1923. B.A., 1916, M.A., 1927, Acadia Univ.; 1915-19, overseas, Can. Engrs. & R.A.F., granted commission on discharge; 1923-26, instructor in engrg., and 1926-27, asst. prof. of engrg., Acadia, Univ., Wolfville, N.S.; 1927-31, mech. engr., and 1931 to date, mech. supt., Aluminum Co. of Canada, Arvida, Que.

References: A. W. Whitaker, Jr., H. R. Wake, G. O. Vogan, A. Sutherland, F. R. Faulkner.

STEPHEN—GORDON ROBERT, of 5751 Somerled Ave., Montreal, Que., Born at Montreal, July 28th, 1900; Educ., B.Sc. (Civil), McGill Univ., 1923; Summer 1921, with New Brunswick Contracting Company; 1917-20 and 1922 to date, with Fraser, Brace, Limited, from 1926 as engr. on constrn. plant layout, constrn. schedules, costs, estimates and reports, for various hydro-electric developments and other plant erection.

References: C. E. Fraser, G. C. Clarke, J. B. D'Aeth, L. de B. McCrady, A. B. McEwen.

FOR TRANSFER FROM THE CLASS OF JUNIOR

BRADFIELD—JOHN ROSS, of Noranda, Que., Born at Morrisburg, Ont., April 5th, 1899; Educ., B.Sc., McGill Univ., 1922; 1923-24, plant engr., Acme Cement Corpn., Catskill, N.Y.; 1924-26, engrg., Buck & Sheldon Inc., Hartford, Conn.; 1926-28, asst. constrn. supt., 1928-31, constrn. supt., and at present, plant engr., in charge of constrn., and mtce. of plant and equipment, Noranda Mines Limited, Noranda, Que. (*S. 1921, Jr. 1927.*)

References: F. J. Bell, W. G. Chace, G. H. Kohl, A. Laurie, H. A. Moore, G. Morrison, G. R. MacLeod.

FOR TRANSFER FROM THE CLASS OF STUDENT

STOREY—THOMAS EDWARDS, of Slave Falls, Man., Born at Brockville, Ont., Feb. 17th, 1906; Educ., B.Sc. (E.E.), Univ. of Man., 1928; 1927 (4 mos.), instr'man., Winnipeg Hydro; 1928-29, Canadian General Electric test course; 1929-31, elect'l., dftsman., and 1931 to date, power house operator, City of Winnipeg Hydro-Electric System, Slave Falls, Man. (*S. 1926.*)

References: J. W. Sanger, E. P. Fetherstonhaugh, J. N. Finlayson, G. H. Herriot, C. T. Barnes, W. M. Cruthers, C. E. Sisson, R. H. Andrews.

Flood Control on the Mississipi*

Under new plans the great levee system of the Mississippi river remains the accepted main bulwark against overflow, but it no longer ranks as the sole protection. Similarly bank revetment has been supplemented by channel regulation through an elaborate system of spur dikes; the purpose is to eliminate channel maintenance by dredging, which has been established policy for a generation. Exceeding all other changes, the tortuous course of the river, held inviolate for a hundred years from changes by man, is being straightened by artificially cutting off outstanding loops. Each of these changes flouts a respected river tradition. Together they combine to inaugurate a new era in the history of Mississippi river engineering.

These changes have come to fruition now because of engineering direction that does not fear to experiment and because means of experimentation have been provided by one of the greatest hydraulic laboratories of the world—the U.S. Waterways Experiment Station at Vicksburg, Miss. With facilities for model experiments on scales greater than ever previously attempted, the laboratory is developing data of fundamental value on current action, detritus movement and sediment transportation that are building up a new scientific understanding of sediment charged streams. It is upon these data that much of the future work of channel deepening and slope rectification may be expected to be predicated—*Engineering News Record.*

See, "New Plans for the Mississipi" on page 795 of Engineering News Record, June 22nd, 1933.

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

Capital Wanted

Small investment required by engineer to manufacture and market newly perfected radio interference eliminating device. A number now in successful operation. Apply to Box No. 991-W.

Situations Wanted

ELECTRICAL AND RADIO ENGINEER, B.Sc., '28. Experience in the design and testing of broadcast radio receivers, including latest superheterodyne practice, and capable of constructing apparatus for testing same Also familiar with telephone and telephone repeater engineering. Thorough experience in design, and construction and inspection of municipal power conduits. Apply to Box No. 12-W.

MECHANICAL ENGINEER, Canadian, with technical training and executive experience in both Canadian and American industries, particularly plant layout, equipment, planning and production control methods, is open for employment with company desirous of improving manufacturing methods, lowering costs and preparing for business expansion. Apply to Box No. 35-W.

MECHANICAL ENGINEER, A.M.E.I.C. Married. Experience in machine shops, erection and maintenance of industrial plant mechanical and structural design. Reads German, French, Dutch and Spanish. Seeks any suitable position. Apply to Box No. 84-W.

YOUNG ENGINEER, B.A., B.SC., A.M.E.I.C., R.P.E., Ont. Competent draughtsman and surveyor. Eight years experience including design, superintendence and layout of pulp and paper mills, hydro-electric projects and general construction. Limited experience in mechanical design and industrial plant maintenance. Apply to Box No. 150-W.

PURCHASING ENGINEER, graduate mechanical engineer, Canadian, married, 34 years of age, with 13 years' experience in the industrial field, including design, construction and operation, 8 years of which had to do with the development of specifications and ordering of equipment and materials for plant extensions and maintenance; one year engaged on sale of surplus construction equipment. Full details upon request. Apply to Box No. 161-W.

STRUCTURAL ENGINEER, B.A.SC., '15, A.M.E.I.C., R.P.E., (Ont.) Married. Experience in structural steel and concrete includes ten years design, five years sales, two years shop practice and erection, and one year advertising. Available at two weeks notice. Apply to Box No. 193-W.

CIVIL ENGINEER, age 44, open for employment anywhere, experience covers about 20 years' active work, including 7 years on municipal engineering, 2 years as Town Manager, 3 years on railway construction, 3 years on the staff of a provincial highway department, 2 years as contractor's superintendent on pavement construction. Apply to Box No. 216-W.

REINFORCED CONCRETE ENGINEER, B.SC., P.E.Q., eight years experience in construction design of industrial buildings, office buildings, apartment houses, etc. Age 30. Married. Apply to Box No. 257-W.

MECHANICAL ENGINEER, B.Sc., McGill '19. Twelve years experience including oil refining power plant, structural and reinforced concrete design, factory maintenance, steam generation and distribution problems, heating and ventilating. Available at once. Location immaterial. Apply to Box No. 265-W.

ELECTRICAL ENGINEER, B.SC., '28, Canadian. Age 25. Experience includes two summers with power company; thirteen months test course with C.G.E. Co.; telephone engineering, and the past thirty months with a large power company in operation and maintenance engineering. Location immaterial and available immediately. Apply to Box No. 266-W.

PLANE-TABLE TOPOGRAPHER, B.SC., in C.E. Thoroughly experienced in modern field mapping methods including ground control for aerial surveys. Fast and efficient in surveys for construction, hydro-electric and geological investigations. Apply to Box No. 431-W.

ELECTRICAL ENGINEER, B.SC., A.M.E.I.C., AM.A.I.E.E., age 30, single. Eight years experience H.E. and steam power plants, substations, etc., shop layouts, steel and concrete design. Location immaterial. Available immediately. Apply to Box No. 435-W.

CIVIL ENGINEER, B.A.SC., A.M.E.I.C., JR.A.S.C.E., age 28, married. Experience: construction, design, cost estimating on hydro-electric and storage work, also railway. Desires work in engineering, industrial or commercial fields. Available at once. Apply to Box No. 447-W.

Situations Wanted

CIVIL ENGINEER, B.SC., A.M.E.I.C., with six years experience in paper mill and hydro-electric work, desires position in western Canada. Capable of handling reinforced concrete and steel design, paper mill equipment and piping layout, estimates, field surveys, or acting as resident engineer on construction. Now on west coast and available at once. Apply to Box No. 482-W.

MECHANICAL ENGINEER, B.SC. Age 28, married. Four and a half years on industrial plant maintenance and construction, including shop production work and pulp and paper mill control. Also two and a half years on structural steel and reinforced concrete design. Located in Toronto. Available at once. Apply to Box No. 521-W.

CIVIL ENGINEER, Canadian, married, twenty-five years' technical and executive experience, specialized knowledge of industrial housing problems and the administration of industrial towns, also town planning and municipal engineering, desires new connection. Available on reasonable notice. Personal interview sought. Apply to Box No. 544-W.

ELECTRICAL AND MECHANICAL ENGINEER, B.SC., A.M.E.I.C. Experience includes C.G.E. Students Test Course and six years in engrg. dept. of same company on design of electrical equipment. Four summers as instrumentman on surveying and highway construction. Recently completed course in mechanical engineering. Available at once. Location preferred Ontario, Quebec, or Maritimes. Apply to Box No. 564-W.

An Engineer in an Unemployment Camp

Department of National Defence,
Relief Project No......
Ontario, June, 1933.

Dear Mr. ———

Ever since I arrived in this camp I have been working steadily, and like the camp and personnel very much.

The project is now two hundred and fifty strong, with six engineers on the staff, and as many as one hundred and seven men have arrived at once so we have been kept on the hop.

My work is designing camp buildings, ordering materials and supervising erection, making layouts, organizing and superintending a carpenter shop, etc. I am to design a new building and supervise the construction of our main project. We are to quarry and crush our own stone for concrete, make our own concrete blocks for wall construction and use labour where and when we can. Mechanics and building tradesmen are scarce, and we have to break in raw material. There is also a lot of road construction and bush clearing to do on the property, and quite a bit of road repairing and building repairing for militia buildings.

Yours sincerely,

(Signed)............................A.M.E.I.C.

MECHANICAL ENGINEER, A.M.E.I.C., with twenty years experience on mechanical and structural design, desires connection. Available at once. Apply to Box No. 571-W

MECHANICAL ENGINEER, B.A.SC., '30, desires position to gain experience, and which offers opportunity for advancement. Experience in pulp and paper mill and one year in mechanical department of large electrical company. Location immaterial. Available immediately Apply to Box No. 577-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.

MECHANICAL ENGINEER, Canadian, technically trained; eighteen years experience as foreman, superintendent and engineer in manufacturing, repair work of all kinds, maintenance and special machinery building. Location immaterial. Available at once. Apply to Box No. 601-W.

CHEMICAL ENGINEER, S.E.I.C., B.SC., University of Alberta, '30. Age 31. Single. Six seasons' practical laboratory experience, three as chief chemist and three as assistant chemist in cement plant; one year's p.g. work in physical chemistry; three years' experience teaching. Desires position in any industry with chemical control. Available immediately. Apply to Box No. 609-W.

Situations Wanted

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.

CIVIL ENGINEER, A.M.E.I.C., R.P.E., Ontario; three years construction engineer on industrial plants; fourteen years in charge of construction of hydraulic power developments, tower lines, sub-stations, etc.; four years as executive in charge of construction and development of harbours, including railways, docks, warehouses, hydraulic dredging, land reclamation, etc. Apply to Box No. 647-W.

MECHANICAL ENGINEER, A.M.E.I.C., Canadian, technically trained; six years drawing office. Office experience, including general design and plant layout. Also two years general shop work, including machine, pattern and foundry experience, desires position with industrial firm in capacity of production engineer or estimator. Available on short notice. Apply to Box No. 676-W.

ELECTRICAL ENGINEER, B.SC., '29, JR.E.I.C. Age 26. Undergraduate experience in surveying and concrete foundations; also four months with Canadian General Electric Co. Thirty-three months in engineering office of a large electrical manufacturing company since graduation. Good experience in layouts, switching diagrams, specifications and pricing. Best of references. Available immediately. Apply to Box No. 693-W.

MECHANICAL ENGINEER, B.SC., '27, JR.E.I.C. Four years maintenance of high speed Diesel engines units, 200 to 1,300 h.p. Also maintenance of D.C. and A.C. electrical systems and machinery. Draughting experience. Westinghouse apprenticeship course. Practical mechanical and electrical engineer with a special study of high speed Diesel engine design, application and operation. Location in western or eastern Canada immaterial. Apply to Box No. 703-W.

COMBUSTION ENGINEER, R.P.E., Manitoba. A.M.E.I.C. Wide experience with all classes of fuels. Expert designer and draughtsman on modern steam power plants. Experienced in publicity work. Well known throughout the west. Location, Winnipeg or the west. Available at once. Apply to Box No. 713-W.

YOUNG ENGINEER, B.A.SC., (Univ. Toronto '27), JR.E.I.C. Four years practical experience, buildings, bridges, roadways, as inspector and instrumentman. Available at once. Present location, Montreal. Apply to Box No. 714-W.

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

MECHANICAL ENGINEER, age 41, married. Eleven years designing experience with project of outstanding magnitude. Machinery layouts, checking, estimating and inspecting. Twelve years previous engineering, including draughting, machine shop and two years chemical laboratory. Highest references. Apply to Box No. 723-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.

DESIGNING ENGINEER, M.SC. (McGill Univ.), D.L.S., A.M.E.I.C., P.E.Q. Experience in design and construction of water power plants, transmission lines, field investigations of storage, hydraulic calculations and reports. Also paper mill construction, railways, highways, and in design and construction of bridges and buildings. Available at once. Apply to Box No. 729-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.

CIVIL ENGINEER, M.SC., 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.

ELECTRICAL AND RADIO ENGINEER, B.SC. '31, S.E.I.C. Age 25. Nine months experience on installation of power and lighting equipment. Eight months on extensive survey layouts. Two summers installing telephone equipment. Specialized in radio servicing and merchandising. Available at once. Location immaterial. Apply to Box No. 740-W

CIVIL ENGINEER, graduate '29. Married. One year building construction, one year hydro-electric construction in South America, fourteen months resident engineer on road construction. Working knowledge of Spanish. Apply to Box No. 744-W.

SALES ENGINEER, B.SC., McGill, 1923, A.M.E.I.C. Age 33. Married. Extensive experience in building construction. Thoroughly familiar with steel building products; last five years in charge of structural and reinforcing steel sales for company in New York state. Available at once. Located in Canada. Apply to Box No. 749-W.

Situations Wanted

DESIGNING ENGINEER, graduate Univ. Toronto '26. Thoroughly experienced in the design of a broad range of structures, desires responsible position. Apply to Box No. 761-W.

MECHANICAL ENGINEER, graduate, '23, A.M.E.I.C., P.E.Q., age 32, married. (English and French.) Two years shop, foundry and draughting experience; one year mechanical supt. on construction; six years designing draughtsman in consulting engineers' offices (mechanical equipment of buildings, heating, sanitation, ventilation, power plant equipment, etc.). Present location Montreal. Available immediately. Montreal or Toronto preferred. Apply to Box No. 766-W.

CIVIL ENGINEER, S.E.I.C., B.Sc. Queen's Univ '29. Age 25. Married. Three years experience as construction supt. and estimator for contracting firm. Experience includes general building, bridges, sewer work, concrete, boiler settings, sand blasting of bridges and spray painting. Available at once. Apply to Box No. 767-W.

ELECTRICAL ENGINEER, B.Sc. (McGill Univ. '29), S.E.I.C. Married. Experience in pulp and paper mill mechanical maintenance, estimates and costs and machine shop practice. Desires position with industrial or manufacturing concern. Location immaterial. Available on short notice. References. Apply to Box No. 770-W.

ELECTRICAL ENGINEER, Queen's Univ. '24, JR.E.I.C., age 32, married. Experience includes, student Test Course, Can. Gen. Elec. Co., four years dial system telephone engineering with large manufacturing company. Available at once. Apply to Box No. 772-W.

CIVIL ENGINEER, B.Sc., '25, JR.E.I.C., P.E.Q., married. Desires position, preferably with construction firm. Experience includes railway, monument and mill building construction. Available immediately. Apply to Box No. 780-W.

DRAUGHTSMAN, experience in civil engineering, forestry engineering, land surveying and house construction. Good references. Apply to Box No. 781-W.

ELECTRICAL AND SALES ENGINEER, S.E.I.C., grad. '28. Experience includes one year test course, one year switchboard design and two years switchboard and switching equipment sales with large electrical manufacturing company. Three summers Pilot Officer with R.C.A.F. Available at once. Apply to Box No. 788-W.

SALES REPRESENTATIVE. Electrical engineer with ten years experience in power field interested in representing established firm for electrical or mechanical product in Montreal territory. Excellent connections Apply to Box No. 795-W.

CIVIL ENGINEER, S.E.I.C., graduate '30, age 23, single. Experience includes mining surveys, assistant on highway location and construction, and assistant on large construction work. Steel and concrete layout and design. Apply to Box No. 809-W.

CIVIL ENGINEER, college graduate, age 27, single. Experience includes surveying, draughting concrete construction and design, street paving both asphalt and concrete. Available at once; will consider anything and go anywhere. Apply to Box No. 816-W.

CIVIL ENGINEER, B.E. (Sask. Univ. '32), S.E.I.C. Single. Experience in city street improvements; sewer and water extensions. Good draughtsman. References. Available at once. Location immaterial. Apply to Box No. 818-W.

CIVIL ENGINEER, S.E.I.C., B.Sc. (Queen's '32), age 21. Three summers surveying in northern Quebec. Interested in hydraulics and reinforced concrete. Available at once. Location immaterial. Apply to Box No. 822-W.

CIVIL ENGINEER, B.Sc., A.M.E.I.C., with fifteen years experience mostly in pulp and paper mill work, reinforced concrete and structural steel design, field surveys, layout of mechanical equipment, piping. Available at once. Apply to Box No. 825-W.

ELECTRICAL ENGINEER, S.E.I.C., grad. '29, age 24, married; experience includes one year Students Test Course, sixteen months in distribution transformer design and eight months as assistant foreman in charge of industrial control and switchgear tests. Location immaterial. Available at once. Apply to Box No. 828-W.

SALES ENGINEER, M.E.I.C., graduate civil engineer with twenty years experience in the structural, sales, and municipal engineering fields, and as manager of engineering sales office. Available at once. Apply to Box No. 830-W.

CIVIL ENGINEER, B.A.Sc., D.L.S., O.L.S., A.M.E.I.C., age 46, married. Twelve years experience in charge of legal field surveys. Owns own surveying equipment. Eight years on technical, administrative, and editorial office work. Experienced in writing. Desires position on survey work, assisting in or in charge of preparation of house organ, on staff of technical or semi-technical magazine, or on publicity, editorial or administrative office work. Available at once. Will consider any salary, and any location. Apply to Box No. 831-W.

AERONAUTICAL ENGINEER, B.Sc. (McGill), M.Sc. (Mass, Inst. Tech.). Canadian. Age 26, recent graduate. Capable of aeroplane design and stress analysis. Apply to Box No. 838-W.

Situations Wanted

CIVIL ENGINEER, M.Sc., R.P.E. (Sask.). Age 27. Experience in location and drainage surveys, highways and paving, bridge design and construction city and municipal developments, power and telephone construction work. Available on short notice. Apply to Box No. 839-W.

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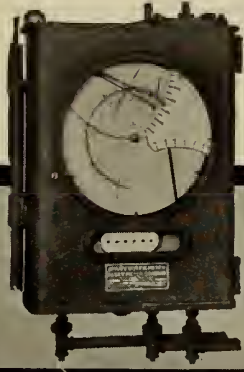

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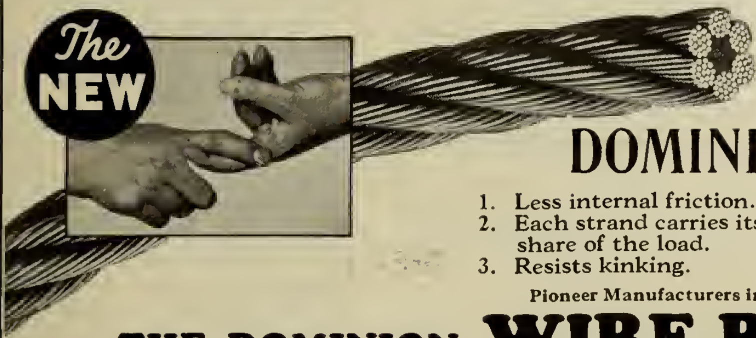

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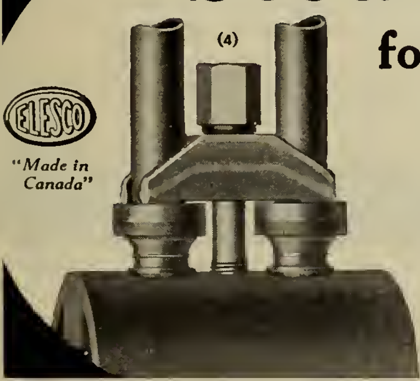

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THE ENGINEERING JOURNAL

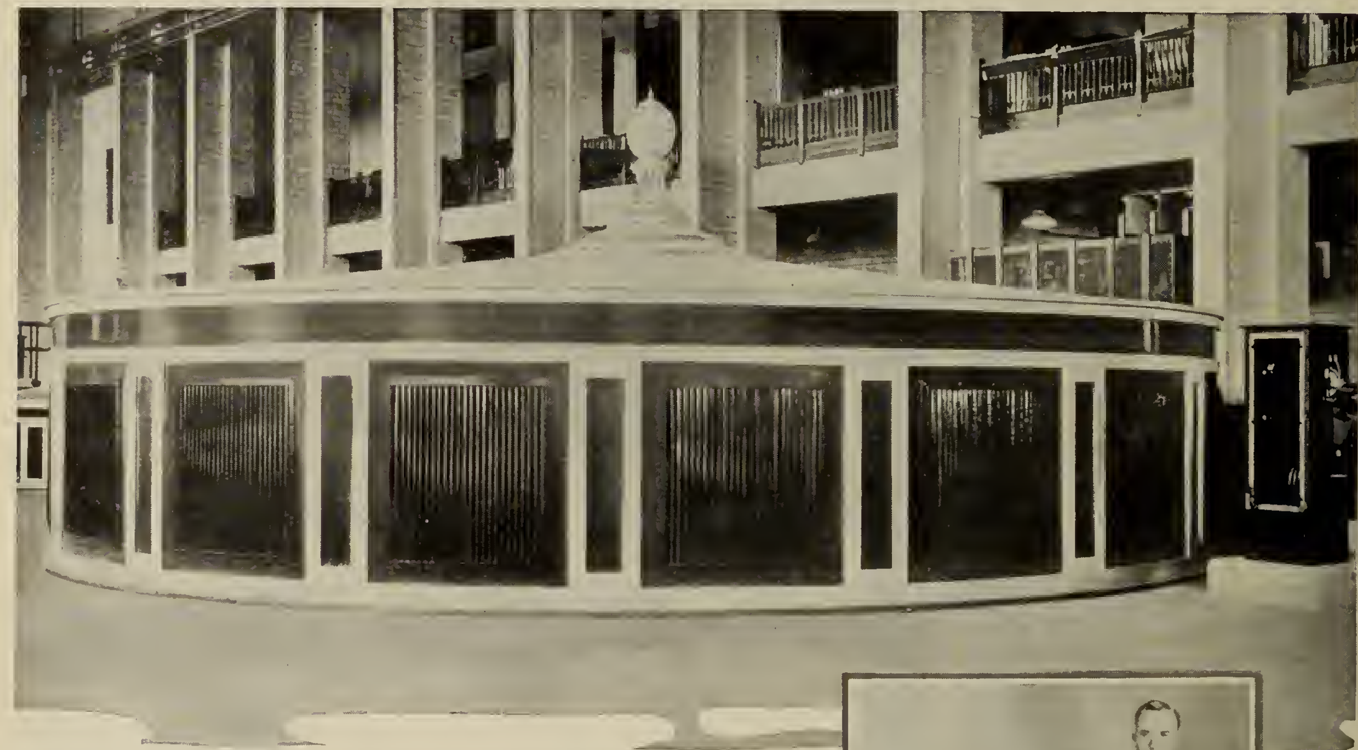
VOL. XVI
No. 8

AUGUST
1933

In this issue

PUBLISHED MONTHLY BY
THE ENGINEERING INSTITUTE *of* CANADA

GENERAL ELECTRIC
VERTICAL-SHAFT WATERWHEEL-DRIVEN
GENERATORS



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August 1933 — Volume XVI, No. 8

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The Structure of Concrete Mixtures

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Paper presented before the Junior Section of the Montreal Branch of The Engineering Institute of Canada, April 5th, 1933.

SUMMARY.—This paper treats of the physical structure of concrete mixtures. The author refers to previous investigations on methods of grading and using aggregates; he gives examples of the results obtained by their use; and notes various causes of loss of strength of the resulting concrete, due to the effect of lack of uniformity in materials, bridging of the aggregate particles and other factors. Methods of designing concrete mixtures, which have been based on the water-cement ratio, surface area and cement space ratio are discussed, and the author suggests a method of applying the principles outlined in these theories, giving an example of the specific results obtained by his method.

The proportioning of concrete mixtures is often effected, in a more or less satisfactory manner, by adopting the old established practice of mixing one bag of cement with so many parts of sand and so many parts of coarse aggregate, adding enough water to enable the mixture to run down a chute, and calling the resultant product concrete. Under such conditions, it may or may not be concrete; but the probabilities are that it will not be particularly good concrete.

Before proceeding to any consideration of methods of proportioning, it is well to have some common understanding as to what is the physical structure of a concrete mixture. It is an intimate arrangement of three component materials; aggregate, cement, and water; the first of these, for purely natural reasons, being generally divided into two classes, fine and coarse. The cement and water, besides fulfilling other functions in a mass of fresh concrete, react to form the binding medium by which, through chemical action, the whole is cemented into a cohesive mass.

A popular conception of the internal arrangement of the components of a concrete mixture is that the stone forms the basis of the structure, the sand fills the void spaces in the contacted stone mass, and the cement fills the void spaces in the contacted sand mass; while the water performs the dual function, in a freshly mixed concrete, of filling the void spaces in the contacted cement and also acting as a lubricant. This conception is, in the opinion of the author, entirely erroneous, and, directly or indirectly, has been responsible for the production of more bad concrete than possibly any other cause.

A more rational conception of the structure of a concrete mixture is that the water and cement together form a paste, fluid, or vehicle, in which the sand particles are carried in temporary suspension. This water-cement-sand mixture in turn acts as a vehicle in which the stone particles are carried in suspension. The sand particles, in a plastic mixture, are suspended sufficiently apart from each other in the cement-water vehicle to permit of reasonably free movement past one another; and, in like manner, the stone particles are suspended in the sand-mortar vehicle.

Inferentially, it follows that the proportion of mortar in a satisfactory concrete mixture must be sufficient not only to fill all the voids in the coarse aggregate, but also to separate appreciably the particles of coarse aggregate one from the other.

To demonstrate that this conception of the arrangement of the internal structure of a concrete mixture is probably the correct one, let us examine such a simple mixture as is represented in Fig. 1. The component materials are cement, water, sand, and coarse aggregate consisting of gravel passing the one inch and held on the three-quarter inch screen. By trial, this mixture contains

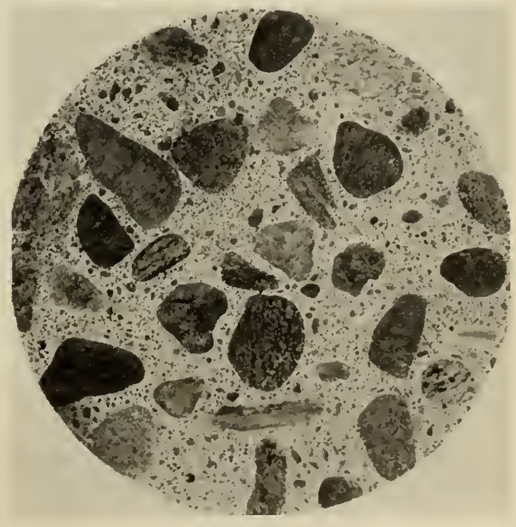

Fig. 1—Mixture No. 1—Scale: About one-half full size.

just enough mortar to produce a workable concrete; yet it contains only 43.4 per cent by absolute volume of coarse aggregate. The balance of 56.6 per cent consists of mortar and a small percentage of air voids. As the voids in the original compacted gravel measured 34.6 per cent, this means that, to produce a workable concrete, these voids had to be filled to the extent of 247 per cent.

The excess of mortar over the amount required to fill the voids in the separately compacted coarse aggregate is used in separating adjacent particles. The extent of separation of the coarse aggregate particles for any specified degree of plasticity of the concrete depends on:

1. The mean diameter of the next smaller size particles,
2. The fluidity of the mortar,
3. The surface characteristics of the aggregate.

The coarsest particles must be separated by a distance at least equal to the mean diameter of the next smaller size fraction, in order that these smaller particles may pass freely between the larger ones. If the quantity of mortar present between the coarse aggregate particles is insufficient to meet this requirement, the mixture will have a tendency to be harsh in handling. Further, some of the largest particles of the next finer size fraction will become wedged between adjacent particles of the coarser size and cause "bridging."

With contraction of the mortar in the process of setting, and separation of water from the cement paste without its subsequent removal from the mix, void spaces will be created under the bridged particles, and the bond of the mortar at these points will be destroyed.

Such mixtures exhibit, on test, compressive strengths considerably below those which might be expected. The weakening of the bond between the mortar and the surfaces of the coarse aggregate particles is probably only a secondary cause of the decrease in strength, the primary cause being the concentration of loading at the points of contact of the smaller wedged particles which act as the bridge supports.

A condition such as the above existing in the coarser sizes is readily indicated by the evident harshness of the mix; but a similar condition could obtain in the smaller sizes, due to bad grading of the sand aggregate, or, conceivably, of the cement itself, where it would not be so readily apparent by inspection.

The fluidity of the cement-water paste also has a direct bearing on the extent to which the aggregate particles must be separated before plasticity is obtained. The coarser particles of cement are in the size range of fine sand, and undoubtedly act in the mixture as such. The finer particles are of such small size that with water they form a suspension. As the concentration of the cement in the cement-water paste is increased, the mixture passes from the class of a liquid of decreasing fluidity to that of a solid of decreasing plasticity.

There seems to be no information available as to the concentration of cement in the cement-water paste which marks the line of demarcation between the liquid and solid condition; though extensive researches have been carried out in connection with similar problems in the paint industry. It seems probable that, except in very rich, dry mixtures, the concentration of cement is such that the cement-water paste acts as a liquid rather than as a plastic solid.

Whether the paste be liquid or solid, it is evident that the mobility of the mixture will vary with the fluidity or plasticity of the paste, with the thickness of the paste film between adjacent aggregate particles, and also, probably, in some manner, with the surface characteristics of the aggregate particles themselves. For any specific aggregate, the last mentioned variable is a constant.

As regards the two first mentioned variables, it is self-evident that the mobility of such a mixture can be increased by the addition of more water, which increases the fluidity, and, at the same time, the volume of the cement-water paste. It is also evident that, by removal of a part of the cement from the mix, the mobility may be increased, because of the fact that the fluidity of the cement-water paste is increased.

Admittedly, in such case, the resulting lesser volume of cement-water paste in the mixture will operate against this effect; but observation of the behaviour of mixes indicates that, in the majority of cases, the primary effect will more than offset the secondary, and the mix will become definitely "wetter."

It is hardly necessary to point out that either the addition of water or the removal of cement will result in lower strength concrete.

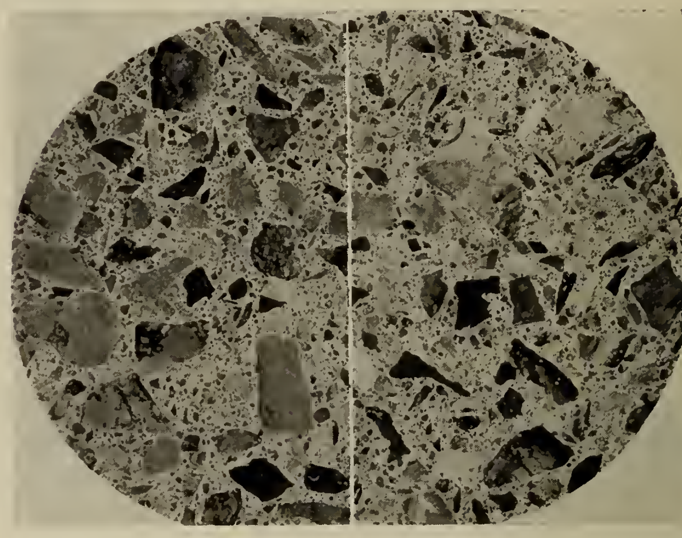

Fig. 2—Mixture No. 2. **Fig. 3—Mixture No. 3.**

As yet, no method of evaluating the relative effects of these two variables has been developed in regard to concrete mixtures; but, in the majority of cases, this is perhaps not necessary, since most of the generally accepted methods of design, as far as strength is concerned, fix the fluidity of the cement-water paste by specifying, directly or indirectly, what the relative proportions of each constituent shall be. In such case, with specific materials, the mobility of the mixture is dependent entirely upon the extent to which the adjacent particles are separated by the cement-water vehicle.

It may be said that the average minimum distance between the surfaces of the coarsest size particles in any mixture should be equal to $D_1 + 2C$, where D_1 is the mean diameter of the next smaller size aggregate fraction, and C is the thickness of the cement-paste film of specified plasticity required to produce the desired degree of mobility of the concrete mixture.

Methods of Grading

It has long been recognized that the grading of the aggregates affects the strength of a concrete mixture as well as its plastic properties.

Some thirty years ago, Mr. William B. Fuller carried out an investigation of the effect of grading of aggregates on the physical properties of concrete. Fuller's investigations led him to the conclusion that, for any specific group of materials, that arrangement of sizes which would give the densest concrete would also give the strongest concrete. Following from this, he developed aggregate grading curves to produce concrete of maximum density. The general shape of the curve was a combination of an ellipse and a straight line; the elliptical portion being the lower part of the curve covering the cement-sand mixture.

Fuller's researches were extremely valuable; but, unfortunately, his work was done during the pre-machine era of the art, when the general practice was towards rather harsh, stiff mixtures, which could only be placed by the expenditure of a considerable amount of labour. Conditions have changed since then. Cement now being relatively much cheaper than labour, contractors today favour mixes which can be placed with a minimum amount of effort. Consequently, Fuller's method of proportioning, while still applicable, can only be used by adjusting the position of his grading curves to meet present day requirements as to workability.

Fuller's method requires the use of aggregates uniformly graded from coarse to fine; and such a mixture produces a concrete of excellent workability, provided there is a sufficient amount of fine material present.

The problem of grading of concrete aggregates has also been considered by others.

Talbot-Richart investigated a large series of concrete mixtures in which the grading was represented by the formula $P = 100 \left(\frac{d}{D}\right)^n$; in which P is the percentage of material passing a given sieve having openings of width d, D is the maximum size of aggregate, and n is a variable exponent. When the Tyler screen scale is used for sizing particle groups, the ratio between the diameters of successive particle groups is $\sqrt{2}$; and, if alternate screens only are used, the ratio becomes 2. Under the latter condition, it was found experimentally by Talbot-Richart that, for workable mixtures, the volume relation of successively larger particle groups varied between 1.0 and 1.50; depending upon the characteristics of the aggregate and the amount of cement in the mix.

Furnas, in a mathematical analysis of the problem, developed an equation of the grading of sized particles to produce mixtures of maximum density, of the form $r = \frac{1}{V^{\frac{n}{m}}}$, in which V is the proportion of voids expressed as a decimal, in a bed of sized material, n is one less than the number of component sizes for maximum density in an intermittently graded system, and m is the number of screen size intervals of ratio 2 included between the size limits of the system. In this instance, r represents the volume relation of successively larger particle groups; and, for normal aggregates, varies between 1.1 and 1.25.

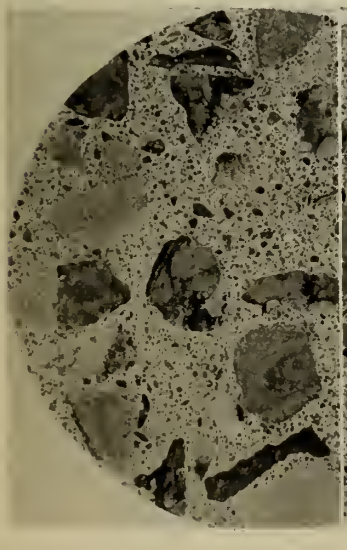
Fig. 4—Mixture No. 4.

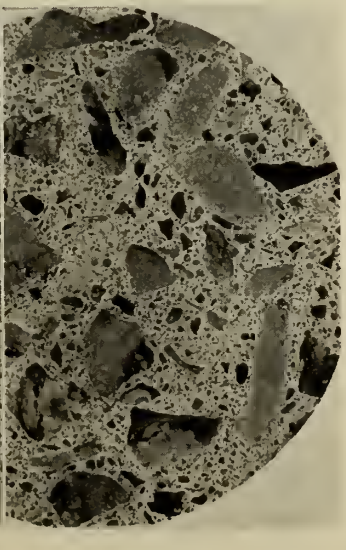
Fig. 5—Mixture No. 5.

Weymouth has developed a method of calculating the volume relations of successive sized particle groups by a mathematical consideration of the proposition that the dispersion of the coarsest size particles in the mix must be such that they are separated by a distance at least equal to the mean diameter of the next smaller size particles plus the thickness of the cement films between adjacent particles. By extending the argument all down the scale of sizes to the very smallest particles, the absolute volume of each size in the mix can be determined, and the relative volume of successive sizes obtained.

Weymouth's method takes cognizance of the fact that the thickness of the cement film of specified plasticity has a direct bearing on the necessary degree of separation of aggregate particles; with the result that the values of the reciprocals of r, determined by his method, decrease as the particle groups decrease in size. For the coarsest sizes, where the diameter of the aggregate particles is very large compared to the thickness of the cement film, the volume relation of successive groups approximates the value r in the Furnas equation.

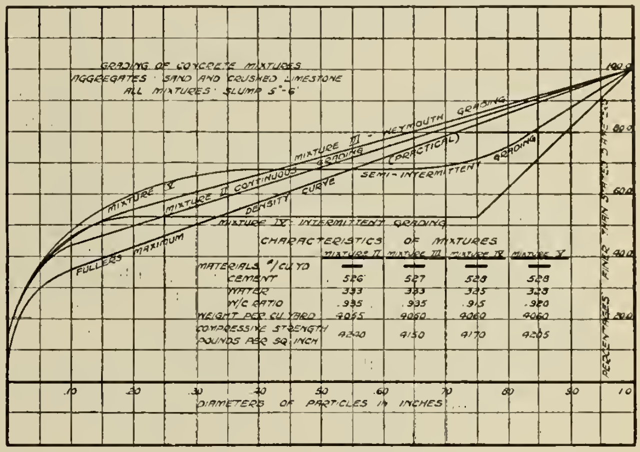

Fig. 6—Mixture Gradings.

Examples of Grading

It must be recognized, however, that concrete mixtures of equal strength and density can be obtained by the use of aggregate gradings quite different from those developed in accordance with the principles of continuous grading. This is indicated by the next five Figs. 2, 3, 4, 5 and 6.

Fig. 2 is a cross-section of a concrete mixture in which an adaptation of Fuller's continuous grading was used. Since the true Fuller grading was found to be too harsh for good workability, this mixture contains a somewhat larger proportion of sand.

Fig. 3 is a cross-section of a concrete mixture in which the grading of the aggregate is obtained by calculation according to the Weymouth method. This mixture is satisfactory as to workability, and has a strength equivalent to that of the mixture in which the revised Fuller grading was used.

Fig. 4 is a cross-section of a concrete mixture the aggregate of which is, in part, intermittently graded, the coarse aggregate consisting of one sized stone particles. With the materials in question, this type of aggregate grading produced a concrete, in comparison with the previous examples, of equal strength and density; but with some tendency to segregate, particularly if the mixture were at all wet.

Fig. 5 is a cross-section of a concrete mixture the grading of the aggregate of which is of a type that lies between those of the two previous examples. There is a decided gap in the grading of the coarse aggregate; which consists of 65 per cent of the coarsest size, and 35 per cent of the size between ⅜ and 4 mesh. This mixture is satisfactory as to workability; shows comparatively little tendency to segregate in handling; and, in strength and density, is the equal of the other three.

Fig. 6 is a graph which shows the gradings of these four mixtures compared to Fuller's maximum density curve for like materials. The only difference between the mixture 2 and the Fuller mixture is in the larger proportion of fine material required in the former to produce workability. Mixture 3 has a grading somewhat similar to that of the revised Fuller mixture. Both mixtures 4 and 5, because of the larger proportions of voids in the coarse aggregate, contain a correspondingly larger amount of fine material than does the modified Fuller mixture. Yet all four of these mixtures are practically identical in density and in compressive strength.

The continuous method of grading as applied to coarse aggregate requires the separation of the coarse particles into three or more successive sizes, depending on the maximum size, and the recombination of these separate sizes in a fixed ratio relation. This entails additional cost in handling the separate sizes; the possible rejection of a part of the product of the crushing plant; and very great care in recombining the several sizes, since any deviation from the proper relation, especially in the intermediate sizes, is almost certain to unbalance the mix.

In the examples given, no advantage was gained by applying the continuous grading principle to the design of the mix. This conclusion is not, of course, generally applicable. For example, it is probable that, had the mixture contained only four bags of cement per cubic yard in place of six, or had the maximum particle size been greater, with a correspondingly greater difference between the size of the coarse aggregate and the size of the sand particles, the continuous gradings would have shown up to advantage as compared to the other two.

It does indicate, however, that satisfactory concretes can be obtained with aggregates of widely different grading; and that it is not always wise to specify exclusively some particular grading, when equally satisfactory results might be obtained more economically by other means.

Before leaving this discussion of the grading of aggregates it is desirable to make special reference to the effect produced by the presence of an excessive amount of any one sized particle group in the mix.

This has been recognized by a number of investigators as an undesirable condition. Weymouth, in an article

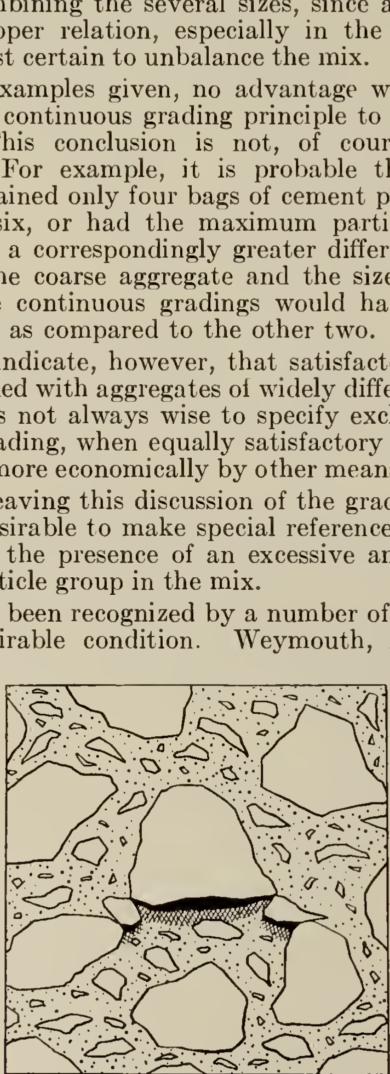

Fig. 7—Diagrammatic Representation of Particle Interference.

in Rock Products for February, 1933, has analysed a number of series of concrete tests, and has demonstrated that the apparently inexplicable strength results obtained may be due to the effect produced by the presence of an excessive amount of one sized particles in the mix. He designates this effect by the term "Particle Interference," corresponding to the "wedging" or "bridging" action referred to earlier in this paper.

To demonstrate the effect of this particle interference, a mixture was made up in which there was insufficient mortar to satisfy the requirement that the coarsest particles must be separated by a distance greater than the mean diameter of the next smaller size particles.

The grading of this mixture is of a type similar to that represented by the mixture of Fig. 5, the coarse aggregate consisting of ¾-1-inch stone with a proportion of ⅜-4 mesh size. This mixture as made up was harsh,

Fig. 8—Surface Cracks due to Particle Interference.

but not so harsh that proper placing, at least in mass work, could not have been carried out. As a matter of fact, the author has seen mixtures even harsher than this used in actual construction.

Fig. 7 is a diagrammatic representation of what occurs when particle interference is present. Three of the large aggregate particles shown in the plane diagram are separated by two particles of the next smaller size which are wedged in between them. In a corresponding space diagram, the wedging particles would number three or more. Since the upper coarse aggregate particle is resting on the wedges, and not on the mortar below it, the shrinkage of the mortar on setting produces a void space underneath the supported particle which is at first filled with water separated from the mortar.

Fig. 8 is a photograph of the face of a cylinder made from the mixture referred to, in which severe particle interference occurred in the coarser sizes. There is in this photograph no evidence of "honeycombing"; but small horizontal cracks can be perceived on the face of the specimen. These are undoubtedly extensions of the void spaces under the coarser aggregate particles which have carried through to the vertical surface.

Fig. 9 is a vertical section of the same specimen. Though no actual bridging points are discernible, in several instances the void spaces underlying the coarser particles can be distinctly seen. By grinding down another face of the same specimen, some apparent bridging points were revealed, but unfortunately, during the grinding process, the void spaces were filled up with slurry, so that with the equipment available it was impossible to obtain a section which would reveal, in a photograph, both bridging points and void spaces. Moreover, as the bridging points occur in a space arrangement, the reader will appreciate the difficulty of obtaining a plane section showing more than one of these related points of contact.

Fig. 10 shows the volume proportions of this mixture compared to the mixture previously shown in Fig. 3, which represents the Weymouth mixture without particle interference. The strength of the mixture in which particle interference occurred is only about 70 per cent of the strength of the other; though the water-cement ratio in both cases is approximately the same, and though the first mix has a somewhat higher density.

Water-Cement Ratio Method

The grading of aggregates, while important, is only one of a number of factors which affect the qualities of concrete mixtures. Other factors which affect the characteristics of concrete are:

1. Chemical and physical properties of the cement,
2. Quantity of cement,
3. Quantity of water,
4. Physical properties, and especially the surface condition, of the aggregates.

In 1914, an extensive investigation of the properties of concrete was begun in the laboratories of the Lewis Institute in Chicago. This work was sponsored by the Portland Cement Association, and conducted under the supervision of Professor Duff Abrams. In 1919, the first progress report was issued; and, during the next ten years, the publicity department of the Portland Cement Association distributed widely a series of further bulletins.

In these publications extensive publicity was given to the water-cement ratio law. This law was to the effect that the controlling factor in determining the strength of a concrete mixture was the relation of the quantity of water to the quantity of cement in the mix; and that all the other factors, already enumerated as affecting the strength of concrete, were of very minor importance except in so far as they affected this water-cement relation.

This theory was delightfully simple. All one had to do was to refer to the charts and tables, determine the water-cement relation required to produce concrete of the desired strength, make up a mixture of cement and water in these proportions; then add as much aggregate as could be gotten into the mix while still preserving the necessary workability.

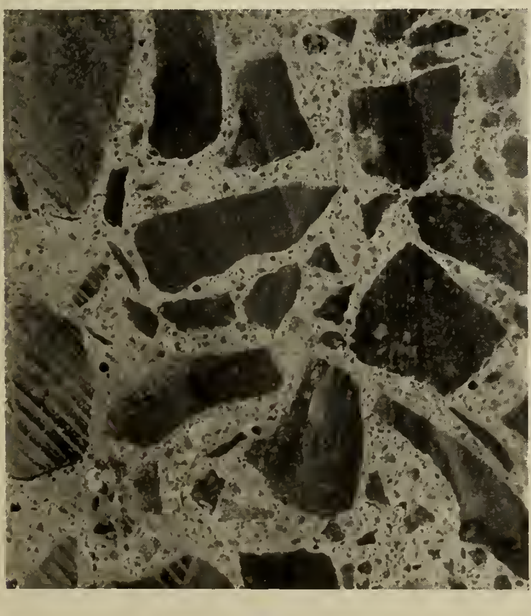

Fig. 9—Section Showing Void Spaces due to Particle Interference. Scale: Full size.

A further development was the "fineness modulus" method of proportioning the aggregates so as to ensure workability. This fineness modulus is an arbitrary means of expressing the relative size of particle groups. As most mixtures proportioned on the basis of the fineness modulus method are somewhat over sanded, the method was of considerable value in precluding the use of harsh, unworkable mixtures.

Fig. 11 shows the strength-water-cement ratio relation developed as a result of the studies of concrete made at the Lewis Institute. The relation of strength to water-cement ratio is expressed by the general formula $S=\frac{A}{B^x}$, in which A and B are constants, the values of which depend on the characteristics of the aggregates and cement, and x is the water-cement ratio. The upper curve shown is that

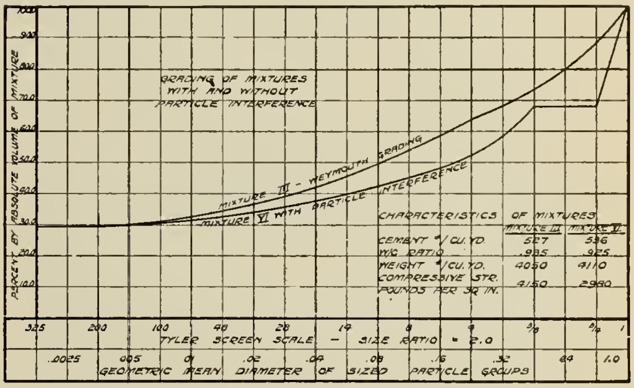

Fig. 10—Characteristics of Mixtures with and without Particle Interference.

represented by the formula $S=\frac{14,000}{7^x}$, and is that recommended by the Portland Cement Association for the general design of mixtures.

Obviously, if the values chosen for A and B in the equation $S=\frac{14,000}{7^x}$ are not the true values of these

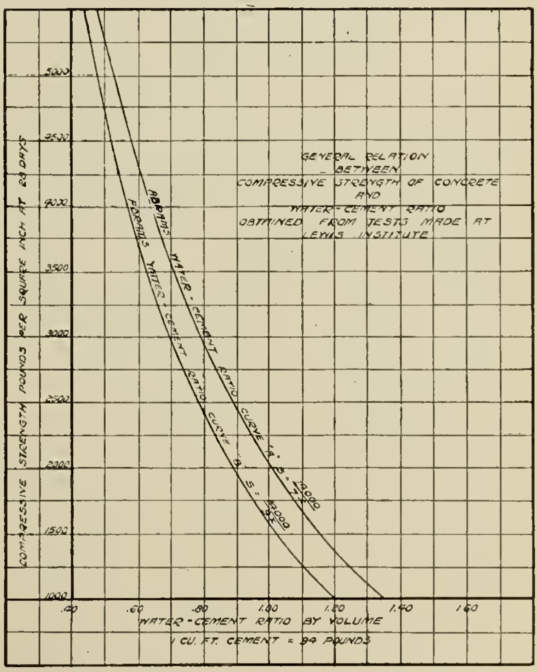

Fig. 11—Portland Cement Association Strength-Water-Cement Ratio Relation.

constants for the materials used, the strengths actually obtained may be quite different from those indicated by the formula. This is demonstrated in Fig. 12, which shows the strength-water-cement ratio relation obtained from a number of series of test mixtures prepared by the author during the past two years.

This chart discloses the interesting fact that all of the mixtures examined developed strengths higher than those which, by application of the general formula, would be expected from the water-cement ratios used. Most of them gave strengths considerably higher than would be anticipated, and some of them gave strengths as high as 250 per cent of the formula value.

A part explanation of the high strength values obtained is undoubtedly the comparatively high strength quality of the average cement produced by the No. 1 mill of the Canada Cement Company during this period. The balance

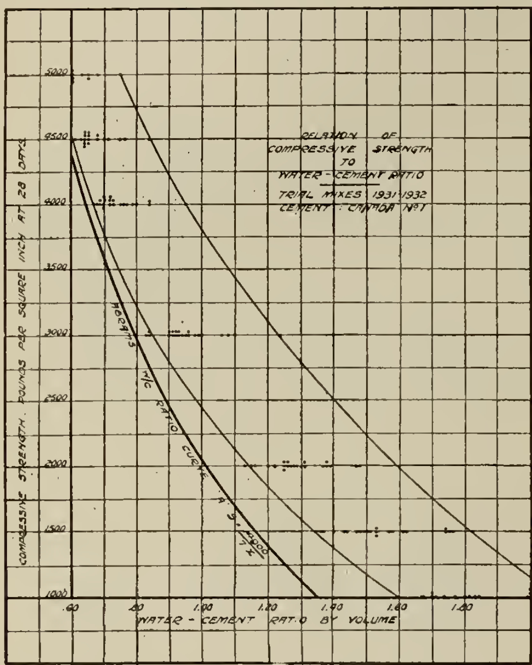

Fig. 12—Actual Strength-Water-Cement Ratio Relation from Series of Trial Mixes.

of the difference between the actual and predicted strengths can readily be understood by considering the view-point of the sponsors of the theory; who were, in effect, the manufacturers of cement. For the variables entering into the problem, such values had to be chosen as to insure the specified strength under the most adverse combination of conditions which might occur.

The wide-spread application of the methods of design sponsored by the Portland Cement Association constituted a distinct improvement over the former methods of arbitrarily proportioning the materials. Mixes designed in accordance with these methods contained, in general, an excess of fine aggregate, insuring workability; and a surplus of cement, insuring the necessary strength.

These methods of design were satisfactory in that they insured the production of reasonably good concrete from even comparatively poor materials. They were unsatisfactory in that no notice was taken of the economic aspect of the question, good materials being penalized at the expense of poorer ones.

Surface Area Method

At about the same time that the Portland Cement Association was investigating the question of design of concrete mixtures, the problem was being attacked by a number of independent investigators along rather different lines. The published literature of the period contains records of a number of these investigations, only two of which will be discussed here.

The first of these, in point of time, was the Edwards-Young surface area method; and the second, the cement-space ratio method of Talbot-Richart.

The surface area theory was founded upon the apparently reasonable assumption that, since the strength of a concrete mixture was fundamentally due to the cohesion between adjacent aggregate particles induced by the action of the cement-water paste in setting, this strength should be proportionate to the strength of the induced bond. This, in turn, would be dependent on the degree of dispersion of the cement in the cement-water paste between adjacent aggregate particles. Consequently, for equivalent cement content, the greater the area of the surfaces to be cemented together in a unit volume of concrete, the weaker in strength the concrete would be.

The only fallacy in this theory is that, with equal cement content for unit volume, the dispersion of cement in the cement-water paste is not dependent entirely upon the area of surfaces to be cemented together, but also, in part, upon the proportion of voids in the original mixed aggregate; since the cement-water paste must both provide the films separating the particles and fill the voids between them.

In lean, coarse mixtures, the volume of cement particles is substantially less than the amount required to fill the aggregate voids and supply the excess of paste necessary to insure the separation of the next larger size particles by an amount somewhat greater than the average diameter of the smaller sized cement particles. The balance of the required volume of the cement-water paste must be supplied by the addition of water until workable plasticity is obtained. In such case, the total water in the mixture is much greater than that required merely to reduce the cement to a paste of workable quality.

Suppose now that the cement quantity per unit volume of concrete is increased. If the same amount of water were retained in the mixture, the quality of the cement paste, and its consequent bonding power, would be improved proportionately to the extent that the cement factor in the cement-water paste was increased. One of the immediate effects of the addition of cement to such a mixture is that the quantity of water required to induce plasticity is decreased, some of the added cement displacing some of the free water out of the voids. This results in an increase in the concentration of the cement-water paste which is wholly disproportionate to the quantity of cement added.

Suppose that, instead of adding cement to such a mixture we add very fine sand of such small size that it produces an effect comparable to that of cement in displacing water from the voids. Admittedly, the surface area per unit volume of the inert material to be cemented together is greater than that of the original mixture; but this is more than offset by the fact that the cement-water paste is vastly improved in cementing quality by the elimination of a part of the free water.

Under such circumstances as these, fine material acts as a diluent to the cement-water paste, decreasing its cementing power in direct proportion to the volume added; but increasing its cementing power in logarithmic proportion to the volume of water displaced by its addition.

Physical evidence of the actual operation of the above train of events can readily be obtained by adding very fine sand to lean, coarse concrete mixtures, while maintaining equal consistency and cement factor, and noting the resultant improvement in density and in strength.

In comparatively rich mixtures, or in ideally graded lean mixtures, where the cement-water paste of normal consistency is sufficient in volume to more than fill the voids and insure plasticity, it is found that an increase in the surface area of the aggregate for unit volume increases the amount of water required for equal plasticity.

The reason for this is, that if the volume of paste in a unit volume of such a mixture is kept constant, any reduction in the size of particles reduces the thickness of the films separating them, and additional water will be required to increase the fluidity of the cement-water paste to the point where the mixture as a whole will have equal mobility.

This added water weakens the strength of the mortar, and brings about a decrease in the strength of the concrete.

Under such conditions, the quantity of water required to be added to maintain a plastic mix with increasingly fine aggregates is undoubtedly a function of the increase in surface area, and the lower strengths obtained from the finer mixtures can be accounted for by the higher water-cement ratios employed. To maintain the strength of the concrete uniform, more cement would have to be added in proportion to the increase in water content.

Consequently, if the water varies as the surface area, and the cement varies as the water, the surface area theory of proportioning for strength is a reasonable one for rich or exceptionally well-graded mixtures, and, for these conditions, corresponds to the water-cement ratio theory. However, such a large proportion of concrete used is of the type covered in the first part of the argument, where the cement paste of normal consistency is insufficient in volume to float the aggregate particles freely, that the successful application of the theory is limited to only a proportion of the mixtures used in practice.

Cement Space Ratio Method

The Talbot-Richart cement-space ratio method of designing concrete mixtures was based upon the results of very considerable series of tests made on sand-cement mortars, which indicated that the strength of the mortar was a function of the relation between the absolute volume of cement in the mixture and the total volume of voids, partly water-filled. The relation was expressed by the equation $S = 32000\left(\frac{C}{V+C}\right)^{2\cdot 5}$ the constant varying with the quality of the cement used.

In applying this method to the strength design of concrete mixtures, the coarse aggregate was considered to be merely a bulking agent, and the strength of the mortar was held to represent the strength of the concrete.

A number of observations in regard to the method immediately suggest themselves. The first of these, of course, is that, in a plastic concrete such as we have been discussing, the voids are filled with water,—with the exception of a small amount of air-bubbles accidentally entrapped. Consequently the void volume is a measure of the water in the mix; and the formula, though the notation is different, corresponds to that for determining the strength of concrete by the water-cement ratio method.

The assumption that the character of the coarse aggregate has no effect on the strength of the concrete is not in accordance with the facts recorded by a number of observers. As an illustration, let us analyse the gravel and stone concretes previously shown in Figs. 1 and 4. These mixtures had the characteristics shown in Fig. 13.

	Gravel Concrete No. 1	Stone Concrete No. 4
Weight in lbs. per cubic yard......	4060	4060
Cement in lbs. per cubic yard......	530	528
Water in lbs. per cubic yard.......	270	325
Water-Cement Ratio..............	.77	.92
Cement-Space Ratio..............	.381	.364
Compressive Strength, lbs. per square inch....................	4200	4170

Fig. 13—Mixture Characteristics, Gravel and Stone Concretes.

The gravel concrete has a lower water-cement ratio and a higher cement-space ratio than the stone concrete. Both of these indicate that the strength of the gravel concrete should be higher than that of the stone concrete. The cement and fine aggregate in both mixtures were the same. Obviously, the better quality of the mortar of the gravel concrete, which should have given higher strength, was offset by some characteristic peculiar to the gravel,—probably a surface condition which provided a poorer bond for the mortar than did the crushed stone aggregate.

Results obtained from two series of concrete mixtures using, as coarse aggregate, in the one case, smooth surfaced water-worn gravel, and in the other, crushed limestone, indicate, as might be expected, that the effect of surface characteristics of the coarse aggregate particles on the strength of the mix is much more pronounced in the case of rich mixtures than in lean ones.

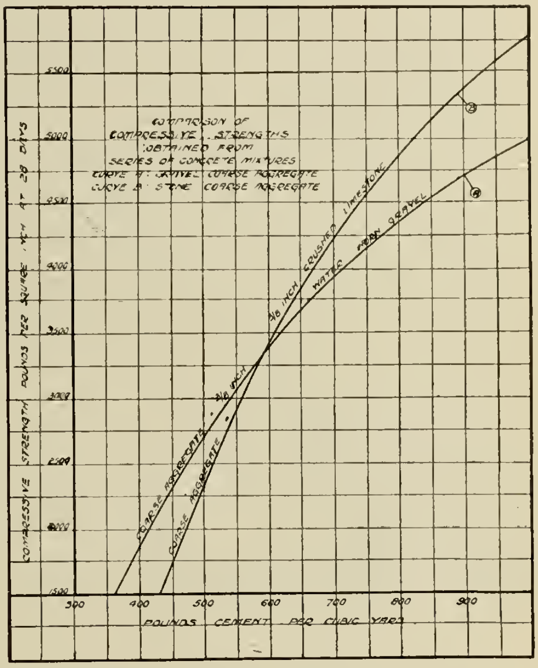

Fig. 14—Strength Curves, Gravel and Stone Concretes.

Fig. 14 shows the relation between compressive strengths and cement contents of these two series of mixtures. The higher strength of the gravel concrete in the lean mixture range is accounted for by the closer packing property of the gravel aggregate as compared to crushed stone. For the former, less mortar is required to produce a workable mix, and, consequently, for equal cement content, the mortar is of better quality. As the cement content of the mix is increased, the strength curves for the two types of mixtures approach one another, and, at a cement content of 590 pounds per cubic yard, they cross. For cement contents greater than this, the mixtures in which the gravel is used as coarse aggregate develop less strength than the corresponding stone mixtures, indicating that the increasing effect of the weakness of the bond between the gravel and cement-water paste more than offsets the advantage accruing from the better quality of the paste in the gravel concrete. The trend of the curves indicates that the maximum strength obtainable with mixtures of this type, using this gravel as coarse aggregate, is in the neighbourhood of 5300 pounds per square inch, while with limestone as coarse aggregate, a maximum strength of over 6500 pounds per square inch can be reached.

This, of course, is an isolated example, and not all gravels present the same characteristics. The ideal aggregate for concrete would be one composed of particles rounded, but of irregular shape, so as to provide close packing; and possessed of rough surfaces, so as to permit of efficient bonding with the cement-water paste. While natural gravels which possess, to a high degree, both of these desirable characteristics do occur, they appear to illustrate the exception rather than the rule; since the processes of attrition by which such materials are naturally formed tend towards the production of smooth, polished surfaces.

Finally, experience with the practical application of the cement-space ratio method of controlling the strength of concrete mixtures indicates that widely different results may be obtained from different aggregate materials, and from different cements. Even with the same materials, a comparison of the results obtained from very wet mixtures

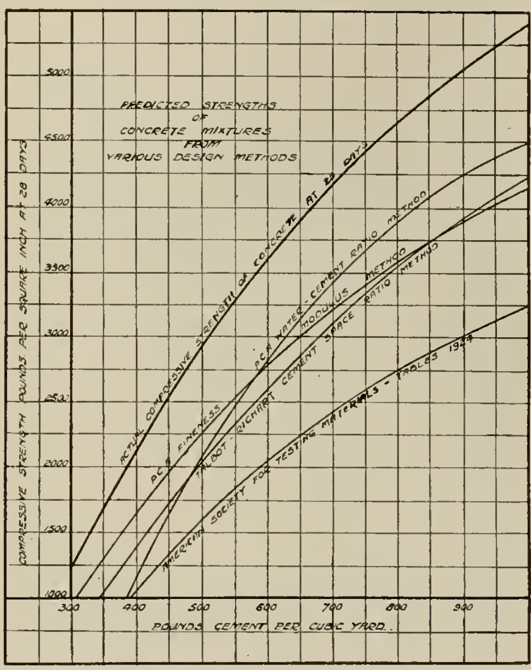

Fig. 15—Actual and Predicted Strength Values for Various Design Methods.

as against drier ones indicates that in the case of the wet mixtures a reduction factor has to be applied to the strength equation to make it agree with the recorded facts.

In short, the method is open to all the objections to the generalized water-cement ratio method,—with the further disadvantage that it is more cumbersome to use.

Variance Between Different Methods of Design

All three of the previously described methods of design, as far as they are operative, are based upon the volume relation of water to cement in the mix. In view of the immense amount of accumulated evidence supporting it, the soundness of the fundamental relationship cannot be denied. Analyses of a mixture might, and frequently do, indicate the three methods of design to be at variance with one another. That the different methods do not agree in detail is due to the fact that the constants chosen for the general equations are not equivalent in value. If the analytical method of comparison is extended still further to include methods of proportioning not based upon the water cement relationship, even wider variations in predicted strengths can be obtained.

Fig. 15 shows the actual strength curve, plotted against the cement content, of a series of concrete mixtures made up with a specific set of aggregates, applying the principles of proportioning explained in the following sections of this paper. It also shows curves of the strengths which would be predicted by applying the general values established for a number of different methods of design.

The strengths actually obtained were higher than those which would be anticipated by the application of any of the design methods indicated. Where the difference is very great, as in the case of the A.S.T.M. tables for proportioning, the cost of a strength concrete with these materials would be unnecessarily high.

Application of Principles

At this point the reader will naturally ask two questions:—

What information do we possess relative to the principles of the art of making concrete?

And, how may this available information be applied to the design of concrete mixtures with some reasonable assurance that the results will approximate those desired?

In the opinion of the author, only two factors, apart from the inherent peculiarities of specific materials, are of any serious importance in fixing the strength of concrete mixtures. They are:

1. The fact that excessive amounts of any one particle size in the mix will produce particle interference with consequent loss of strength.
2. The fact that for combinations of specific aggregate materials with an individual cement, the resultant mixtures being free from particle interference, and within the range of normal consistencies, the strength of the mix is a function of the volume relation of water to cement.

To apply the first of these to the basic design of a concrete mix, we may use the Furnas equation for determining the ratio "*r*" between volume amounts of aggregate for successive screen sizes, and so develop the required grading; or we may use the Weymouth method of calculating absolute volumes in the mix. If we apply the latter method to the development of the mix represented by Fig. 3, we arrive at proportions, shown in Fig. 16, for what we may designate as the basic mix.

The cement used in this basic mix of Fig. 16 was the Canada XXX high early strength cement, which is quite finely ground. The aggregate grading was carried down to meet the coarsest cement particles, which accounts for the somewhat unusually large proportion of material passing the 100 mesh screen.

This mix was made up in the proportions shown in Fig. 16, had a slump of 5 to 6 inches, and a weight per cubic yard of 3990 pounds, indicating an accidental air void volume of about one per cent. This, of course, is a very lean mixture, contains only 3.3 Canadian bags of

Size Fraction	Absolute Volume in Mixture	Proportions Lbs./Cu. Yd.
1″- ¾	.1100	502
¾ - ⅜	.1275	582
⅜ - 4	.1088	496
4 - 8	.1120	508
8 - 16	.0904	410
16 - 30	.0718	326
30 - 50	.0543	246
50 -100	.0390	177
100 -200	.0246	112
200 -	.0078	35
Cement	.0556	292
Water	.1982	334 + 7
Total	..........1.0000	4027

Mix proportions by application of Weymouth formula for dispersion of particle sizes.

$$d_a = \frac{d_o}{\left(\frac{t + D_n}{D_n}\right)^{\frac{1}{3}}}$$

where

$$t = D_1 + 2C$$

and

$$C = .001 \text{ inches}$$

Fig. 16—Proportions for Basic Mix by Weymouth Formula.

cement per cubic yard, and had a strength at seven days of 1050 pounds per square inch; but it will serve as a starting point for the design of other mixtures.

The strength of such a mixture can be increased by the addition of cement, which has the effect of stiffening the cement-water paste. The larger volume of paste resulting will increase the thickness of the paste film separating the aggregate particles, tending to increase the mobility of the mix, but this will be more than offset by the contrary effect of the stiffer paste, and the mixture as a whole will become less mobile unless more water is added.

As the paste films become thicker with the addition of cement, the usefulness of the finest aggregate particles in the mix is lost. Instead of acting as space filler, displacing water, these are now absorbed in the paste, and act as a diluent. Consequently, as the cement is progressively increased in quantity, it would seem desirable to remove, in like manner, the finest aggregate particles from the mix.

As the quantity of cement, and, necessarily, the quantity of water is increased, the effect of particle interference due to the presence of an excessive amount of any one size should begin to disappear. The reason for this is that, with increasing quantities of very fine material in the mix, the frequency of the interfering particles, and the likelihood of "bridging," diminishes.

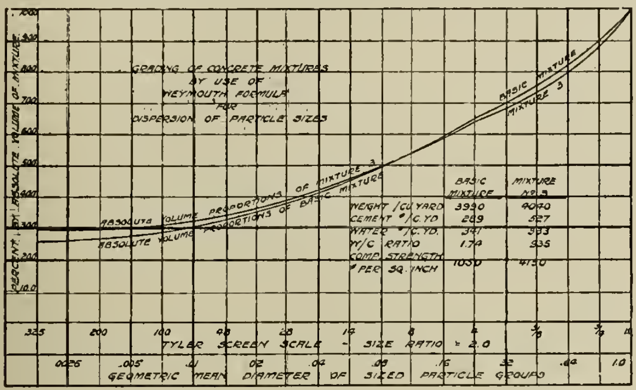

Fig. 17—Gradings of Mixtures by Weymouth Formula.

This indicates that, as the cement content of the mixture progressively increases, very considerable changes should occur in the grading of the aggregate along the following lines:

1. The finest sand fractions should be progressively eliminated.
2. The ratio between absolute volumes of successively larger particle groups should become greater.

This means, in simple language, aggregates of increasing coarseness in which the finest sizes are progressively eliminated, while the next finer sizes are decreased and the coarsest sizes increased in absolute volume.

The grading of the basic mixture of Fig. 16 is shown graphically on the horizontal scale of Fig. 17, where it appears, at the left-hand side, as the lower of the two curves. The upper of the two curves shows the grading for the mixture of Fig. 3. Here a cement content of 527 pounds per cubic yard and a water-cement ratio of .935 was assumed, giving an absolute volume of cement-water paste of .2950.

The grading of the aggregate used in the mixture of Fig. 3 was obtained by starting our curve at this point, and changing the shape of the curve to eliminate the 200-325 mesh sand, and to provide a somewhat larger proportion of the coarsest sizes. As already indicated, this mixture was of satisfactory workability, density and strength.

The above is a rather involved case in which it is presumed that the designer is free to change the grading as he will, anticipating that the contractor will be able to duplicate the grading actually settled upon. This hardly ever happens. In most cases, the designer is presented with samples of the materials available, and is instructed to develop the required proportions for strength mixes in which these materials are to be used as aggregates.

Specific Application

Generally, in the Montreal region, the problem resolves itself into the design of mixes using one coarse aggregate with one of two or more available sands.

During the past three or four years, a standardized method of procedure for the examination of aggregates and design of mixes has been developed by the author. The greater part of the information which has been presented in this paper in regard to the characteristics of concrete mixtures has been gained as a result of the examination of mixes by this method.

Screen analyses of the sands are made, and possible particle interference is determined by inspection of the grading curves obtained. Sands in which severe particle interference occurs can be detected and eliminated; or, where the necessary equipment is available, the condition can often be corrected by the supplier. In cases where the fault in the grading lies in a deficiency of fine material, this can sometimes be corrected by blending with a finer sand, either at the source of supply or at the site of the work.

Once the fine aggregate is selected, a series of trial mixes is made up, starting with a basic mix corresponding somewhat to the basic mix of Fig. 16. A convenient cement content is 10 per cent of the aggregate weight, corresponding to approximately 300 to 335 pounds per cubic yard. The fine and coarse aggregates are proportioned so that there will be no particle interference in the coarser sizes. The quantity of water required to produce the desired degree of mobility is noted, as well as the weight per unit volume of the concrete.

Further mixtures are made up, with progressively larger quantities of cement, until the cement content approximates 25 to 30 per cent of the aggregate weight. As the cement is increased, the proportion of sand is somewhat decreased, and the proportion of stone correspondingly increased; care being taken not to carry this to a point where particle interference in the coarser sizes results. When the series of trial mixtures has been completed, the mix proportions, and, eventually, the compressive strength test results obtained, are plotted on a graph similar to that shown in Fig. 18.

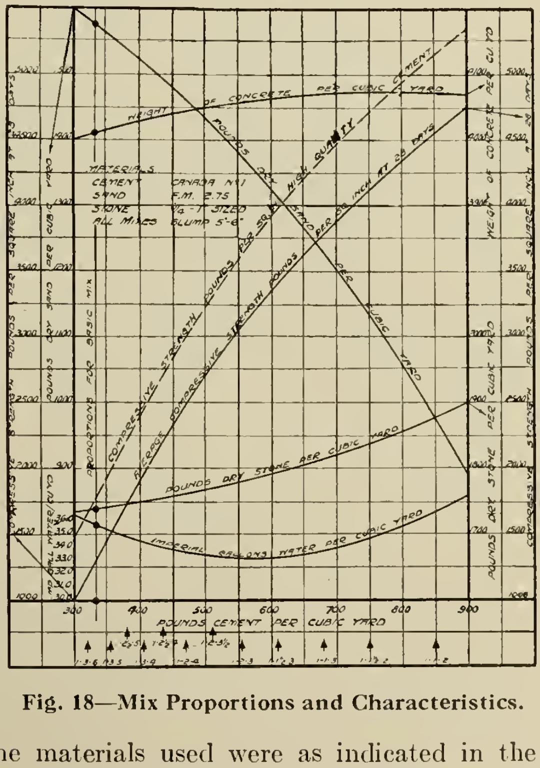

Fig. 18—Mix Proportions and Characteristics.

The materials used were as indicated in the graph. All quantities are plotted against cement content; and, for convenience, these are recorded in pounds per cubic yard instead of in absolute volume. The general changes in the mix resulting from the increase in cement content are indicated in the graph.

As the cement proportion was increased the sand proportion decreased, the stone proportion increased slightly, and the weight per cubic yard also increased slightly.

The water content required to produce a slump of five to six inches decreased from a maximum of 36½ gallons per cubic yard at 300 pounds cement content to a minimum of 33 gallons per cubic yard at 550 to 600 pounds cement content, after which it increased again. This feature is worthy of some comment, though the explanation is perfectly simple.

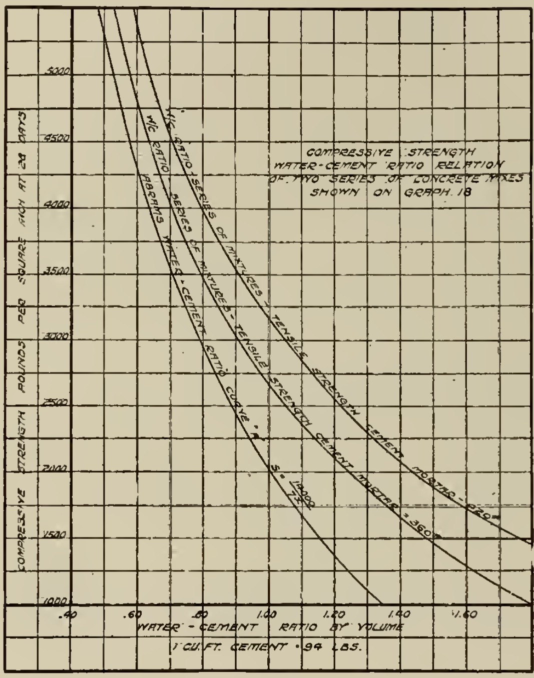

Fig. 19—Strength-Water-Cement Ratio Relation for Mixtures of Fig. 18.

From what has been said already, it is obvious that, for any specified cement content, there is an ideal sand grading which will produce optimum results. The sand in question is so graded that the "ideal mixture" has a cement content of 550 to 600 pounds per cubic yard. For cement contents less than this, the sand is deficient in fine material; and for cement contents greater than this, the sand contains an excess of fine material for optimum results.

For mixtures leaner than those having a cement content of 550 pounds per cubic yard, some improvement in the density and strength of the concrete could be obtained by increasing the proportion of the finest sizes in the mix, and so substituting sand for water as a void filler. In this particular case, except in very lean mixtures, the possible improvement is not very great.

Two strength curves are shown on the graph. The lower one represents the strengths obtained from a series of trial mixtures in which the cement used was below the average of the output of this mill in tensile strength. The twenty-eight day tensile strength of 1 to 3 Ottawa sand briquettes made with this cement was 360 pounds per square inch,—which is well over the specification requirement of 325 pounds. The upper curve represents results obtained on a similar series of trial mixtures, made some eight months previous to the second series, in which the aggregates were the same as those of the other series, but in which the cement used had a tensile strength at twenty-eight days of 420 pounds per square inch.

The strength difference of the two cements is directly reflected in the compressive strengths of the two series of trial mixes, and indicates variations which can be obtained in the strength of concrete made with cement from a single mill. Even wider variations might occur in concretes made with cements having still greater differences in tensile strength.

From the weights of cement and water, corrected for absorption of aggregates, shown in the graph of Fig. 18, the strength-water-cement ratio relation for each of the series of strength test results obtained was calculated. These are plotted in the graph of Fig. 19, where they are compared to the Abrams water-cement ratio curve "A". If we know the tensile strength characteristics of the actual cement to be used in the work, we can use one of these curves, or some other similar curve, obtained by interpolation, for the strength design of the mix;—keeping in mind the limitations of application of the method which have been referred to earlier in the paper.

This would necessitate having available twenty-eight day tests on the cement before it was used in the work. Except in very large construction work, where the cement is drawn from designated bins at the mill, twenty-eight day tests are hardly ever available. Where such information is not available, it would seem desirable to use the lower of the two curves.

Uniformity Imperative

It has been demonstrated that the success of the application of any theory of design of concrete mixtures lies in the appreciation and control of the variables which enter into the problem.

A normal variation in the quality of the cement alone can produce a corresponding variation in the strength of concrete amounting to 500 pounds per square inch, while differences in the gradings or characteristics of the aggregates may produce even wider variations in strength.

The prime essential for the production of concrete of uniform quality is the use of materials uniform as regards both quality and amount. Too often, especially in these days when price is the main factor governing the purchase of materials, this is lost sight of, with the result that aggregate materials delivered to a single job may vary in quality from hour to hour, and even from load to load.

The concrete technician who could anticipate the effect on the concrete of these variations in the quality of materials and compensate for them by changing proportions from batch to batch, would be a magician indeed.

The author cannot stress too strongly the fact that no method of design is worth the paper upon which it is written, unless, in the field application of it, every effort is made to limit variation in quality, grading, and quantity of materials entering into the mix.

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The Development of Telephone Service in Montreal

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SUMMARY.—After giving statistics as to the number of telephones, buildings and exchanges and the extent of the telephone plant in Montreal, the author discusses telephone plant investment, and describes the manner in which plans for future extension are prepared. He deals with the changes in building design and requirements due to the replacement of manual by dial equipment, the increased investment per telephone as the service is extended, and the effect of requirements for long distance service upon the nature of the equipment to be installed. Notes are also given as to maintenance, and a number of typical central office buildings are analysed as regards their volume, floor area, capacity, etc.

Introduction

The telephone has become such a commonly used piece of equipment, both in the office and the home, that the average user gives little thought to the size and the nature of the actual plant involved in the overall system that renders the service.

He can visualize the station instrument and he knows that his voice by some electrical translation is carried over wires to the party at the other end of the line. That part of the plant involved in the establishment of his connection which lies beyond his vision is not very familiar to him and his knowledge of it is usually based on more or less general impressions.

This situation is a natural one since the Telephone Company is selling *service* and not an instrument, with permission for its use with the various other parts of plant required in the rendering of this service. If the service should fail, the subscriber's prime object is to have it restored as quickly as possible and he is not much interested in the physical cause of the interruption nor in the procedure taken by the company in its restitution.

However, to a group of engineers not directly associated with the telephone business it may be of interest to obtain some insight into the plant and the problems that confront a telephone company in the rendering of service in a large city, the remarks being confined to the plant within the city of Montreal.

Summary of Plant

A rough summary of the plant involved in rendering telephone service for the city of Montreal might be shown by the following items. This plant is as existing at the end of last year. (December 1931.)

Land: twenty-one properties involving 450,000 square feet or about 10 acres.

Building: nineteen structures with approximately 16,800,000 cubic feet or 1,000,000 square feet of floor area.

Central Office Equipment: six multi-office dial centres with 133,000 terminals installed,
seven manual offices
one toll office for long distance service.

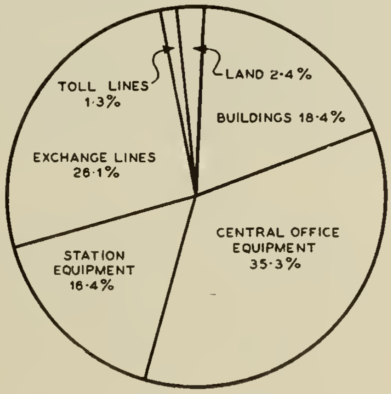
Station Equipment: total stations	192,302
including hand sets	27,037
P.B.X. (non multiple)	1,392
dial stations	142,166
Exchange Lines: conduit trench miles	240
duct miles of conduit	1,250
poles-miles of pole lines	355
wire miles in aerial cable	116,197
" " " underground cable	742,241
" " " drop wire	5,503
Total wire miles	863,941

It may be of interest to note that this mileage of wire is equivalent in length to one hundred and three physical circuits from Halifax to Vancouver.

Distribution of Telephone Plant Investment

A picture that should always be remembered by one associated with the work of developing a telephone plant is the distribution of the investment into the various parts of the Bell Telephone Company's plant that form a complete system. This distribution as existing at the end of last year in Montreal is shown in Fig. 1.

It will be noted that the largest item is central office equipment which comprises 35 per cent of the total plant investment. This distribution has been changing somewhat from year to year. If a similar chart were prepared for conditions existing ten years ago, it would be found that both buildings and central office equipment would have represented a smaller percentage. The conversion from manual to dial service has been a factor in the change of percentages of these items. The station equipment percentage has remained about constant at 16 per cent while exchange plant percentage has been decreasing. However, it should be noted that in all divisions of our plant the actual investment per station in service has materially increased with the growth of the city. Some of the causes for this condition will be explained in more detail in this paper.



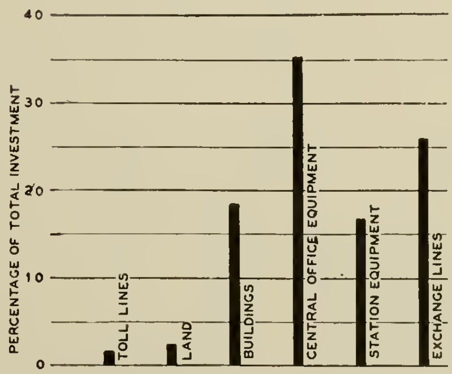


Fig. 1—Distribution of Telephone Plant Investment in Montreal, December, 31st, 1931.

Fundamental Plans

It has been the aim of the company to precede the demand for service by the construction of the necessary plant so that when a subscriber requests service from any point in this city it can be furnished with the least possible delay. The large moving activities that take place in Montreal around May and October 1st of each year could never be handled unless this advance work were done.

Recently, a gentleman in introducing a speaker who was giving a talk over the radio on town planning, opened his remarks by stating that Montreal for the past three hundred years has been growing like "Topsy." Those in the telephone business, for at least the past thirty years, have been attempting to find out if there is any system behind "Topsy" growth and to develop some means by which results might be measured and conditions anticipated in advance of actual facts.

Such a study is known as the "fundamental plan" and it is based upon a market and development survey. The

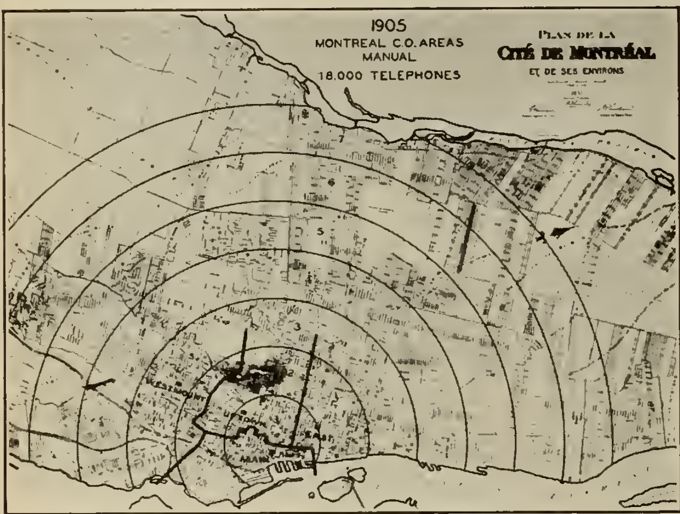


Fig. 2—1905.

methods of making such a survey and various information used and the procedure taken to arrive at a programme for plant extension plans have been very ably described in a recent paper presented by A. M. Reid, A.M.E.I.C., division plant engineer of the Bell Telephone Company of Canada, at Toronto, which appeared in The Engineering Journal for September 1932. Similar information as illustrated in that article has been developed for Montreal.

On reviewing, these forecasts at any cross section point in such a study may indicate results that vary somewhat from actual conditions existing. But it has been found that the results forecast over a period of years have proved to be surprisingly accurate. For example, in the original survey for Montreal prepared in 1924 the number of telephone stations estimated at the end of 1930 were lower than those actually existing at that time by about 4 per cent, while the cross section point taken at the present time would indicate a condition of about the same order on the high side.

Fundamental plans once made should not be considered a finished product. They should be revised at intervals and any new conditions that have developed since their inception should be weighted into the picture. The same methods of procedure, the same treatment of the data, the same curves of past growth in population and stations, are set down and from present levels these plans are reconstructed. This is done for the simple reason that no better tools are known, it being believed that such a survey based on sound engineering principles will develop a plan that will forecast "Topsy" growth with a good degree of accuracy.

The long term period or the ultimate of a fundamental plan is usually a period in the future of between twenty and twenty-five years. It gives a general control plan and a definite overall ultimate design of the plant towards which all extensions are directed. A more detailed picture is made for the first six or eight years in advance from which are determined the items that will comprise the programme as to location of new office centres and cable plant extensions. As the time approaches when each item of this programme must be undertaken, they are developed so that they not only form part of an ultimate net-work, but at the same time will fit in with the existing plant and thus ensure an economical layout. Cost analyses of each major step are made and in this way any existing plant is not unduly sacrificed in the approach to the ultimate. Of course, with the changes in the art which are continually going on, resulting in inadequacy and obsolescence, plant is sometimes required to be displaced perhaps before it has served its normal life. But the losses made with such a step are properly weighed in the cost study against the proposed plan.

The intervals required for the manufacture and the installation of the plant are often long. For example, to complete a new central office unit, from the time a decision is made to proceed with the project until the equipment housed within its building is actually placed in operation, may vary from eighteen to thirty months. Under present conditions, with manufacturing and construction activities at a low point, the effect has been to lengthen rather than to reduce these intervals. Outputs have not only been reduced but they have been spread over greater periods to prevent complete layoffs. Plant extension plans have been found to be exceedingly helpful in regulating such efforts to produce a smooth rather than a fluctuating programme.

Growth of Central Offices in Montreal

To illustrate the growth of the Montreal telephone plant, diagrams showing the central office areas have been prepared of the actual conditions existing at intervals starting in 1905 up to 1930. See Fig. 2, 3 and 4.

In 1905 four offices served the 18,000 telephones existing at that time. Two of these offices were on the common battery principle, while the other two (Uptown and Westmount) were branch terminal offices on a magneto basis. The majority of the stations served were well within a three mile circle.

Five years later, 1910, these two magneto offices had been converted to common battery and to meet the growth to the north the Belair office was opened during this period.

By 1915 there were eight offices, three new ones having been added—Clairval in the east, Atlantic in the north and York in the southwest. During this ten year interval the number had grown from 18,000 to 51,000 telephones.

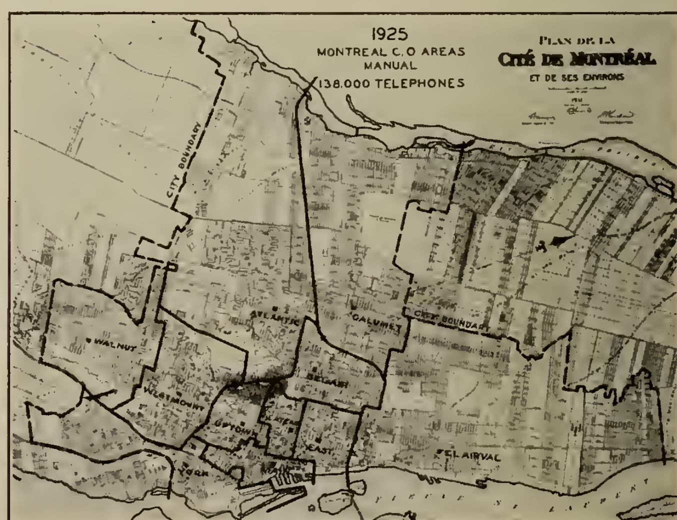


Fig. 3—1925.

Two additional offices, making a total of ten, were working at 1920. Calumet had been installed to meet the growth in the north and Walnut in the west.

The picture at 1925 with eleven manual offices serving 138,000 telephones represents the condition just prior to the introduction of dial equipment. During this period the business section of the city had grown so that an additional office, Plateau, was opened to relieve the existing offices which had reached their capacity. It was during this year

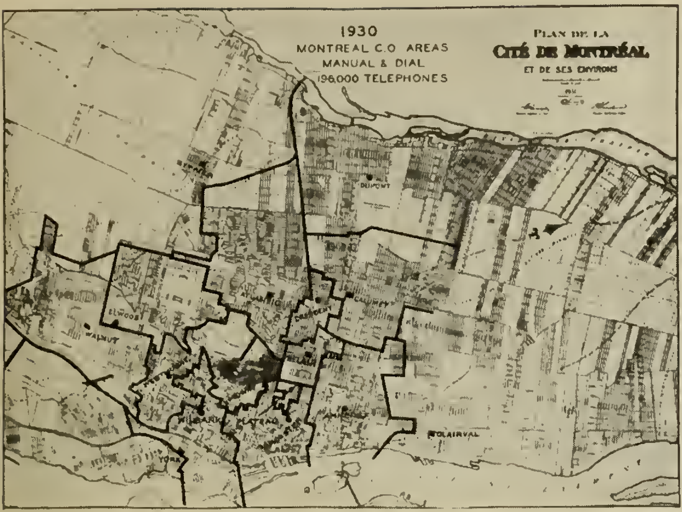


Fig. 4—1930.

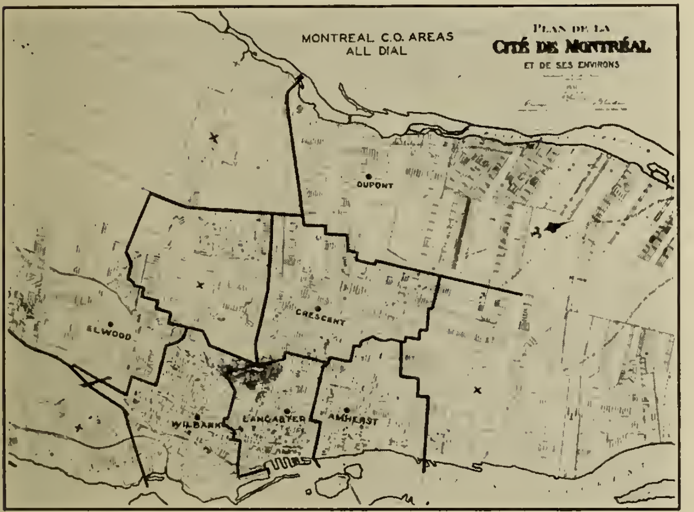


Fig. 5—Future Condition when Montreal will be served from ten dial centres.

that the first dial equipment was installed in the Lancaster building and plans were formulated to ultimately convert the entire city to dial service.

The multi-unit central offices came into being with the dial equipment and this changed entirely the picture of manual central office areas. The jig-saw puzzle represented in the picture for 1930, with ten manual offices and six dial centres in operation, illustrates clearly the conditions existing when a point had been reached about mid-way in this conversion programme. The Main and East offices had disappeared from service while another manual office, Bywater, had been opened to meet the growth back of Mount Royal. During this five year period six dial centres at Lancaster, Willbank, Amherst, Crescent, Dupont and Elwood building had been opened.

Fig. 5 indicates a future condition when the entire city will be served from ten dial centres. The jumbled arrangement of 1930 straightens itself out very nicely and the areas each centre serves are well defined. Should the density of telephones in any area grow beyond the ultimate capacity of these multi-unit buildings, then a further division will be made and a new centre established.

It is of interest to note that Mount Royal forms the apex of the four areas serving the central portion of this city. This natural park in the centre of the city, although a real asset from many standpoints, constitutes a large unproductive area from the telephone development standpoint, which must be built around and it has had the tendency to increase the investment in plant.

Growth in Outside Plant

A similar series of diagrams might be prepared to illustrate the growth that has taken place in the outside plant and Figs. 6 and 7 represent the existing underground conduit routes in 1905 and 1930.

In 1905 these routes existed wholly to the south of Mount Royal and extended east and west about three miles from the centre of the business section.

The picture at 1930 shows the network completely around Mount Royal and extending north almost to the Back river, while it covers the city limits from east to west.

As the number of central offices increase so the trunking plant for handling the inter-office calls will increase. At the present time with sixteen dial units installed at the six multi-office dial centres, nine manual offices including Long Distance and Information, there exists a total of about 17,500 of these trunks. Of this total, about 7,900 are three wire trunks between units within the same building. These trunks might be represented as the telephone tramways that transport messages around the city. When one of them is engaged in service there is, however, only one passenger during the time of the conversation. Telephone calls must be handled on an individual basis and not in bulk and this made-to-order service is one of the reasons for the investment per telephone increasing instead of decreasing, as the number of telephones within an exchange area grows.

Growth in Telephone and Population

Fig. 8 expresses in logarithmic scale the growth in Montreal of the number of telephones in relation to the population. Over the past twenty years, 1910-1930, Montreal has grown in population at an average annual rate of 3.2 per cent. During this same period the telephones have increased at the rate of 9.6 per cent per year. Thus the development in telephones per 100 population has increased from 6.0 to 20.9. Comparing this development with similar large cities on this continent, Montreal ranks thirteenth from the top, so it would appear that the saturation point has not been reached.

Growth in Plant Investment

The growth in plant investment in relation to the growth in telephones for Montreal is shown graphically to equivalent logarithmic scales in Fig. 9 for the period

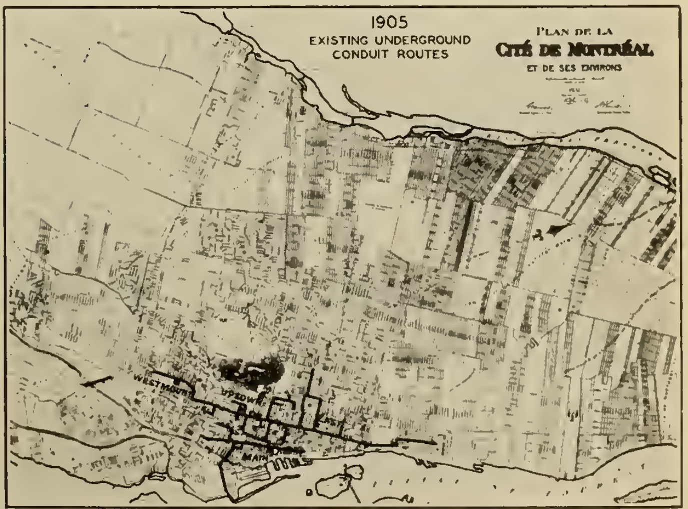


Fig. 6—1905, Existing Underground Conduit Routes.

1911-1930. The investment per telephone during the period 1911-1925 under manual operation shows an increase of 1.5 per cent per year. This increase becomes greater during the period 1925-1930 and it might be thought to be due to the introduction of the dial service. However, it has been determined beyond doubt that apart from the change in the type of service this increase in the investment would have been even greater and the cost of operation greatly increased had the growth in telephones during this period been taken care of by manual operated telephones. These illustrations of increase of central offices, the expansion in the geographical area served, coupled with the increase in calling rates, or the usage made of the telephone as the city grows larger, are the essential basic items behind this phenomenon of the increase in our investment per telephone. This is not generally understood either by the public at large or perhaps by a group of engineers in other industrial concerns. In most cases the relation of the investment and

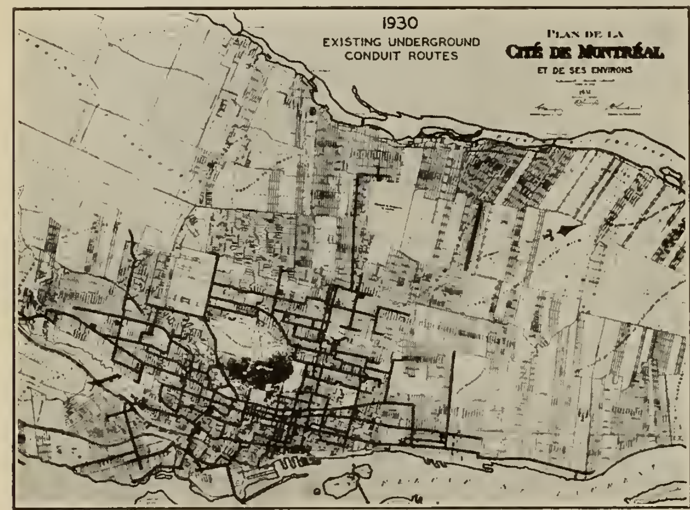


Fig. 7—1930, Existing Underground Conduit Routes.

output usually results in a condition where the investment per unit produced will decrease as these units increase, but in the telephone business no material article or unit of power is being sold but calls which are handled individually on a made-to-order basis.

Land

Having developed the fundamental plan and a plant extension programme, a forecast is available of when and where land will be required for a central office. Many points are involved in the choosing of a suitable plot of land which may be mentioned as follows:—

(1) Located on or near to the wire centre of the area to be served.

(2) The lot should be of sufficient size to allow the erection of a building to meet the ultimate requirements.

(3) This land should be situated on a street which carries the main conduit runs. In this connection with large dial centres where cable pairs entering the building may be upwards of 100 full size cables, (1,212 wires are assumed as a full size) it would prove an advantage to have a lot running through from one street to another or a lane in order that two cable entrances to a cable vault may be obtained to avoid congestion in the duct structure and cable plant at this point.

(4) Due to the heavy loads placed on the floors of an equipment building the nature of the subsoil for the necessary footing should be determined either by the boring of test holes or prior knowledge of these conditions from building construction in the neighbourhood. This point is of particular importance in parts of Montreal where subsoil of a shifting blue clay is often present.

(5) Although the buildings are always built of fire-resisting material the surrounding properties should be studied from a fire hazard standpoint and sufficient land purchased to render physical clearances on all sides to minimize any danger from this source.

(6) A rectangular lot is preferable to an irregular shaped lot. The equipment is designed to mount on bays that fit between column centres of 16 or 20 feet. It is difficult to lay out the equipment in irregular bays without some sacrifice in the square foot of floor area and increased equipment cost. Also local ordinances often require a certain set back of the building from the sidewalk line which may result in a poor percentage of usable building area on the lot.

Recalling Fig. 1, it is seen that for every dollar invested in land a building is erected which has about eight times the land value. An error made in the selection of a site will reflect itself in the future investment either in the building, central office equipment or the exchange lines plant. The magnitude of such excessive investment may amount to figures far exceeding the original value of the land. For this reason it is essential that very careful study based on the principles outlined above should be made before a purchase is made. A piece of land can seldom be found that will be ideal from all standpoints but the advantages are properly weighed against the disadvantages and the final selection based on a location that will produce the most economical ultimate investment of the overall plant.

Buildings

Telephone central offices are public buildings in the true sense in that millions of calls from citizens in all walks of life are handled either by the operators or the equipment housed within their walls. The average number of local calls made each day in Montreal is about one million six hundred thousand, or about 1.6 calls for each person in the city or an average of nine calls per telephone.

Due to the important part that telephone service plays in the present day business and social life of a city it is indeed fitting that a building erected for such a service should be designed and constructed along principles based on stability and efficiency. It should also adorn the neighbourhood and symbolize the service to which it is dedicated.

It has been the aim to construct buildings that will reflect permanence and attractiveness in the locality in which they are situated and in this way to do credit to the community which is being served. It might be thought that to decorate the exterior of a building to produce this effect may result in excessive expenditures, but an analysis of building costs reveals the fact that a building pleasing in appearance is not the most expensive. The key to the cost of a building lies not in its façade but in its fundamental plans. If the cubic contents and its floor areas are not properly designed then the investment when estimated in terms of some units of service such as stations served will be high.

To illustrate a method of procedure in an engineering analysis of a building study that may be followed but is not recommended, the following case might be cited.

An equipment floor plan has been prepared showing the layout of the apparatus, the column centres and ceiling heights. The architect then designs the structure to properly house this unit. When such a study is completed and an estimate of the cost of the building is made it may be found that the cost is too high. Attempts are then made to reduce this cost, usually by a paring down process. This process often starts from the outside by the elimination of some decorative features which are closely associated with the ideals of the architect or the removal from the interior of some conveniences and comforts provided for the occupants. Such a method does not usually strike at the true source of the high cost and therefore it does not accomplish the best results.

A better approach to this problem might be made by obtaining some yard stick based on the volume of the building or its square feet of floor area per unit of equipment it is designed to house. If such a yard stick could be found based upon the maximum number of lines to be served within the building and the amount of equipment required, which is a direct relation to the calling rate and holding time, then the volume of the floor areas required would be known before floor plans or building sketches are prepared. If an analysis is made along these lines it would be striking at the fundamentals that are involved in the cost of the building. Original plans that do not meet these requirements should be discarded and a new layout made which contains the volume or square feet of floor area that will produce a result more in line with this yard stick factor. The outcome of such a procedure would certainly be convincing if the costs are brought within balance without a paring down process and robbing from the structure the dollars in the wrong place.

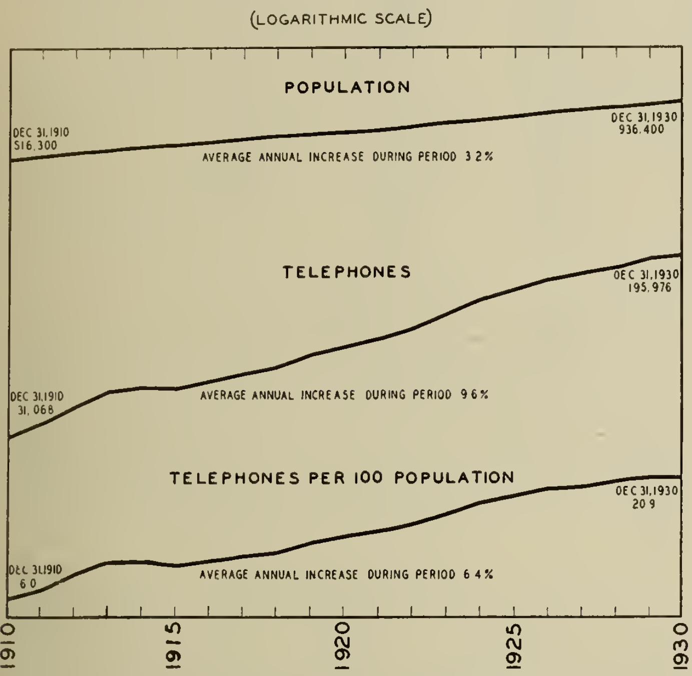


Fig. 8—Population Telephones and Telephone Development in Montreal Exchange Area 1910-1930.

In an attempt to arrive at such a measuring unit an analysis of six manual and six dial office buildings in Montreal has been made and the results are shown on Table 1.

The buildings have been listed in the order of their erection. Where an individual building appears out of line it is worthy of analysis to determine if the overall design in volume or the layout of the equipment on the floors, is the most economical. In a small unit it may be difficult to approach a figure in line with the larger job of two or more units in which case the ultimate design of the structure should be tested in this way rather than the first stage of the building erected.

Standard layouts for the equipment must, of course, be followed which will allow of proper conditions for operation and maintenance. An attempt to approach a lower factor in this analysis by crowding up the equipment would defeat its own end. One of the results that might appear surprising in this table is that the use made of the building space in dial units shows a saving of only from 10 to 15 per cent over the manual offices.

A building is one of the "long lived" items in the plant. The initial building is usually erected to meet the requirements for a period of about eight years. It then follows that there may be three or more extensions to this initial building before the final completed structure is reached. The architect, therefore, has a special condition to meet in his design in that the building should have a pleasing and well proportioned appearance at each of its different stages from the initial to the ultimate condition.

For buildings with an ultimate of six or eight stories it has been found more economical to use reinforced concrete design. Such construction employs material that is wholly manufactured in Canada. It may be somewhat less flexible when extensions are required but such difficulties are not serious. An example of this condition has been the extension of an additional story to the Wilbank building on Atwater avenue at St. Antoine street. In this case the existing roof had to be cut to extend thirty-six columns. A water-tight condition was maintained although the work was started during the month of April when weather conditions were inclined to be showery. No interruptions of a serious nature were experienced to the services of about twenty thousand stations receiving their dial calls on the floors below.

Some constructional features in central offices differ quite materially from the average business type of building. First the ceiling heights are much higher and vary from 13 to 17 feet in height depending on the type of equipment to be installed on the floors. Secondly the required floor loads are very much heavier than is usual in other office buildings. The columns, girders, beams and floor slabs are designed to carry from 150 to 175 pounds per square foot dead load on all equipment floors and often exceed this amount up to 300 pounds where apparatus weights are excessive such as in battery rooms. These conditions must be carefully computed in the design and they result in more massive and heavier structures and the higher costs are reflected in meeting these conditions.

As a large part of the equipment in the offices is built in units at the factory and shipped to the job, it follows that strict dimensional limits must be followed during the erection of the building. Otherwise expensive alterations are required to make the equipment fit in the space allotted. The design and specifications work on the equipment very often precedes the start of building and the apparatus units are well advanced on the floors of the factory before the building is finished. Column centres are in multiples of four feet and usually spaced either 16 or 20 feet apart. Larger spans result in uneconomical design of girders and floor beams. Clear spaces under girders are governed by the heights required for the equipment framing including the

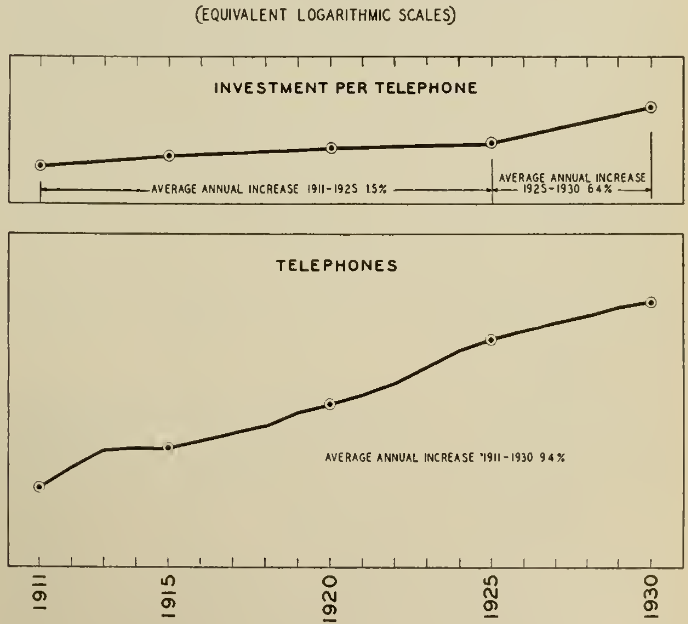


Fig. 9—Relative Rates of Increase in Telephones and Investment per Telephone in Montreal.

cable runways at the top. Cable slots in floor slabs must be accurately laid out. Lighting outlets bear a fixed relation to the equipment especially where runs of switchboard are concerned.

For attaining such dimensional limits the scale of one-quarter inch to the foot has been favoured rather than the one-eighth scale on all plans including the larger buildings. This procedure may cause the handling of large

Table I
Analysis of Typical Central Office Buildings-Montreal

Office 1	Volume Cubic Feet 2	Floor Area Sq. Ft. 3	Capacity Max. Work. Main Stns. 4	Usage Call Seconds Busy Hours 5	Cubic Feet Per Usage Per 100 M.S. $2 \div \frac{4}{100} \times 5$	Square Feet Per Usage Per 100 M.S. $3 \div \frac{4}{100} \times 5$
Manual						
Westmount	216,877	13,848	10,500	160	12.9	0.83
Clairval	195,115	11,619	11,000	108	16.4	0.98
York	201,395	11,925	12,500	111	14.5	0.86
Atlantic	218,387	12,504	10,500	151	13.8	0.79
Calumet	251,762	14,640	12,300	127	16.1	0.94
Walnut	230,911	13,510	10,800	161	13.3	0.78
Total	1,359,447	78,046	67,600	135	14.9	0.86
Dial						
Lancaster	*1,369,500	82,800	51,600	244	10.9	0.66
Amherst	620,992	39,050	36,000	118	14.6	0.92
Crescent	526,205	31,874	27,000	135	14.5	0.87
Wilbank	645,000	38,313	36,000	148	12.1	0.72
Dupont	252,539	14,455	9,900	103	24.7	1.42
Elwood	509,028	30,123	27,300	159	11.7	0.69
Total	3,923,264	236,615	187,800	166	12.6	0.76

*Part Usable for Dial Equipment.

blueprints on the job but it gives the contractor much better and clearer data to follow in his work and reflects itself in better results in the finished building.

The superseding of manual equipment by dial has meant a complete change in the building design. The multi-office building which replaced the single unit one, has resulted in fewer buildings but of a much larger capacity. With fewer employees in a dial office it has changed the requirements of space for such things as rest rooms, cafeterias, locker rooms, lavatories, etc.

Referring again to Fig. 1 the investment in equipment compared with buildings is in the ratio of two to one. However, if the buildings such as office, storerooms, garages, etc. in which there is no working telephone apparatus are eliminated, this ratio is increased to five to one. As the balance of the Montreal service is converted from manual to dial this ratio will be further increased so that it can be assumed that for each dollar invested in a central office building it will have the capacity and there will be installed within it about six dollars worth of equipment. This fact leads to another important point in the design namely that of the use of fire resisting materials throughout. Insurance may cover a large part of the losses to both the building and equipment in case of a fire but it compensates in no way for the loss of service to the subscriber due to such an interruption. So the buildings are constructed to make them as fire-proof as is possible and are also thoroughly equipped with hand fire extinguishers and water hose lines and the staffs are carefully instructed in how to meet any emergencies that may occur.

Dust is one of the worst enemies in the maintenance of dial equipment. For this reason, all feasible methods are employed in the buildings to eliminate as far as it is possible the sources of dust. All ceilings and walls are painted as the disintegration of concrete and plaster on the inside of a building is one of these sources. Linoleum covering is used for all equipment floors and it is kept clean and polished. Vacuum cleaners are supplied at all offices. At several of the larger centres air compressors for blowing out the apparatus has proved of great assistance in maintenance work. Several schemes of ventilation have been tried out with the object of cleaning the air that is drawn into the building for circulation. Conditioning of the air especially during the seasons of the year when the humidity of the atmosphere is high has been considered. This whole question of ventilation with apparatus for cleaning and conditioning air is quite an open one and under extensive studies at the present time.

The limitations set in this paper will allow of no description of the other parts of our plant such as central office equipment, exchange line and station equipment. Each of these divisions might readily be the subject of a paper as to the part each plays in the rendering of telephone service.

Toll Service

The telephone plant in Montreal has been designed not to meet the requirement for urban use only but for universal service. It would be a far simpler condition and less costly if problems were confined to merely giving city service. The rapid development of world wide service has been accomplished largely due to the fact that the foundation for such service had already been done in advance in the exchange plant which has been built to strict transmission requirements. The year 1932 will stand out as distinctive in two achievements towards world wide service. Early in the year the trans-Canada lines were officially opened and so furnished a network of toll lines wholly within the Dominion from Halifax to Vancouver, while in July the trans-Atlantic service was placed in operation which provided facilities for telephone communication to Great Britain and other parts of the British Empire. Both these services were provided without any change in the local plant in Montreal.

Conclusion

A telephone might be well described as a constant watchman whose duty never ceases. A city without a telephone under present day conditions would be a city of the dead. As night spreads its blanket of darkness upon its sleeping people the telephone brings a feeling of safety. In the business and social activities of a busy day it is almost indispensable, while in times of stress and sudden need it has a value beyond price.

The wonder of the telephone lies not in the instrument in the office or home, but in the system behind it, which links your own telephone with thirty-one million other telephones in all parts of the world.

To those who belong to the great army of specialists in communication, no better ideal can be followed than that of proceeding along the lines of rendering the best possible service at the lowest cost consistent with financial safety.

The Wellington Street Subway, Montreal

L. J. Leroux, A.M.E.I.C.,
Engineer of Bridges and Tunnels, City of Montreal.

Presented before the Montreal Branch of The Engineering Institute of Canada, March 9th, 1933.

SUMMARY.—The author describes the design and construction of a subway some 900 feet long carrying the vehicular and pedestrian traffic of Wellington street, Montreal, under the Lachine canal. The difficult nature of the subsoil, the quantity of water to be dealt with, the necessity of avoiding delay to navigation and the problem of ventilation were points requiring special consideration. The tunnel accommodates two street railway tracks, two 18-foot roadways and a footway.

The scheme to construct a tunnel carrying Wellington street under the Lachine canal, thus avoiding the delays to traffic arising from the operation of the existing swing bridge, has been before the citizens of Montreal for a number of years. Although recognized to be of primary importance for the development of a large portion of the city, delay arose owing to financial difficulties. These were finally solved only two years ago, and the project was thus made possible.

The necessity for the tunnel may be judged from the fact that the interruptions to vehicular and pedestrian traffic due to the frequent opening of the various bridges over the canal during the period of navigation amounted annually to about twenty business days of twelve hours, or nearly 12 per cent of the period during which the canal is open to navigation.

Preliminary plans and specifications for the tunnel were prepared by the Montreal Tramways Commission under the direction of Paul Seurot, M.E.I.C., and the estimated cost was $2,556,000.00, of which both the Dominion government and the Montreal Tramways Company each agreed to contribute one third, the balance being the city's share. The city was also to finance and manage the whole undertaking. The contract was given to the Dufresne Construction Company on a cost plus basis with the estimated cost as a limit. The actual construction work was started early in the spring of 1931 but on account of the numerous surface and underground services which had to be disturbed and also due to long expropriation proceedings it was only possible to work on the north approach during the summer of 1931 and the section south of the Lachine canal was left for the next season. The canal section proper had to be done during the period between the closing and the opening of navigation and this was completed in the winter of 1931-1932, well in advance of the opening of navigation.

Design

Before the work started, a more thorough study of the plans resulted in a certain number of modifications which necessitated the redesigning of the project. A complete new set of plans was drawn by the Department of Bridges and Tunnels of the city under the direction of the writer who was in charge of the construction.

Service Facilities

The tunnel was designed to accommodate two lanes of vehicular traffic and one tramway line in each direction with one sidewalk for pedestrian traffic which is located in the west roadway tube.

These traffic lanes are all independent of one another and separated by longitudinal walls which divide the whole tube into four independent tunnels. The sidewalk is elevated over the roadway and the area underneath provides sufficient space to pass all underground electrical and ventilation ducts.

Calculations

The ground tests and borings made showed that the natural ground water level came to a point which would submerge the lower half of the structure and therefore the tunnel had to be designed to take care of a floating condition, the worst case being when the canal was drained as is the case each spring, for a period of one month previous to the opening of navigation. When this happened it was estimated that the total weight of the structure and the backfill which covered it exceeded the buoyancy by almost one thousand pounds per square foot. Part of this necessary surplus weight was obtained through the use of a thick layer of grading material placed between the bottom structure slab and the finished paving.

The structure was designed, however, as if the total weight, including the backfill, was uniformly distributed on the foundation bed and all the stresses were taken by a structural steel skeleton. This was composed of parallel frames spaced at four-or five-foot centres according to the

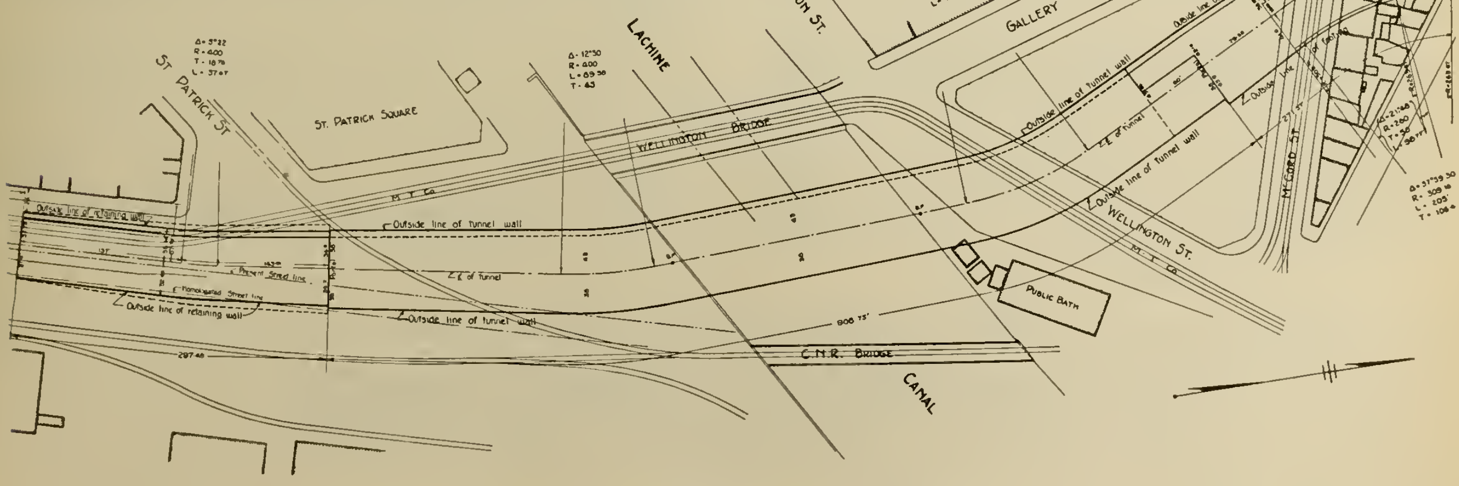


Fig. 1—General Plan of Subway Location.

load to be carried and consisting of columns and beams some of which were 240 pounds per foot. Exterior columns had to be designed for combined direct and bending stresses to take care of the lateral pressure which at a depth of 50 feet will, in places, run as high as 3,000 pounds per square foot.

A special feature of the design was introduced after the discovery was made during the course of the excavation work that the foundation bed was so soft that it would not be safe to build on it. It was therefore decided to carry the structure on reinforced concrete piles driven to rock, each pile with a load capacity of fifty tons. These were distributed under the walls of the tunnel according to the various loads which these walls carried, and the pile cap was designed as a distributing slab two feet thick, in reinforced concrete.

Precautions

Waterproofing.—The whole tunnel tube was surrounded by water, and this made waterproofing a question of primary importance. The tunnel was therefore wrapped with a four-ply membrane of asphalt-saturated cotton fabric, with double reinforcement at all angles, isolated from the structure by two plies of resin paper, and protected in different ways (according to whether it was at the base, on the walls or on the roof). The base membrane was protected by a layer of brick laid in asphalt mastic; the wall membrane by a four-inch brick wall with cement mortar and the roof was covered by ½ inch of asphalt mastic and a six-inch concrete slab. A similar process was used for the ventilation buildings.

Drainage.—As is shown in Fig. 3 the depth of the bottom slab with the screening fill and the paving was sufficient to permit the construction of a system of gullies and drainage pipes which would not be affected by the frost.

The standard city gully grates were used and the gully pits introduced between the structural steel frames were connected to a system of 8-inch W.I. pipes embedded in the bottom slab and leading to the catch basin of the pump room. An interesting feature of this pump room design was introduced through discovery of the treacherous nature of the soil at the foundation level. The catch basin and pump pit occupy an area of about 550 square feet which had to be excavated 12 feet below the tunnel itself. A test pit dug previously had showed that new material was coming from the bottom as quickly as it was being taken from the top. As a result it was hopeless to try open excavation. It was therefore decided to sink a pneumatic caisson to rock 20 feet below the tunnel, and make a concrete base for the pump room; the catch basin and pump pit were constructed in the caisson up to the tunnel floor. The advantage of this process was that this difficult work could be done independently and before any tunnel work proper was done in that section.

The pumping installation is composed of two 8-inch suction by 6-inch discharge sewage pumps of the vertical non-clogging type working under a 53-foot head and each driven by a 40-h.p. 550-volt squirrel cage induction motor. The capacity of each pump is 1000 gallons per minute.

The two pumps are independent, can be operated separately or simultaneously and are controlled automatically by an electric float switch. The installation is also equipped with recording instruments giving the periods of pumping and the current used daily.

The tunnel is easily kept dry and it is only necessary to operate the pumps for eight-minute periods three times a day. F. V. Dowd, A.M.E.I.C., was responsible for the design of this pumping station.

Notes on Ventilation

The exhaust type of ventilation is used, and the fresh air is supplied to the roadways at both ends and also at three points along the tunnel through the Tramway Company's tubes. The used air is exhausted through the medium of ducts and registers by four exhaust fans—two machines having been installed in the south fan room and two others in the north fan room.

The ordinary traffic will probably require only two machines running together (one in each room), but when the traffic is heavy it will be necessary to operate all four machines.

To calculate the required capacity of the fans it was first necessary to determine the number of changes of tunnel air required per hour.

From the data collected at many of the important American tunnels, it was known that thirty changes per hour (or a change every two minutes) was a little more than was actually required under even the most adverse conditions.

As there are two machines in each room it was assumed that each one would take care of one-quarter of the length of the tunnel.

There is about fifty feet at each entrance without artificial ventilation and also a small portion where the fresh air inlets are located; thus there is a length of 180 feet of tunnel (both roadways) to be ventilated by one machine. This represents a total volume of air of:

400 by 180— 72,000 cubic feet (sidewalk side) west roadway
300 by 180— 54,000 cubic feet (other side) east roadway.
Total —126,000 cubic feet

As the air must be changed completely in two minutes, the volume to be handled would be: 63,000 cubic feet per minute.

In order to choose the size of the fans and motors, the total static pressure to be overcome by the fan in the entire system from the registers to the outlet chimney was also required, and calculations made yielded the following results:

Registers	.03 inches of water
Risers	.05 " " "
Ducts	.50 " " "
Elbows	.50 " " "
Plenum chamber at the machine	.25 " " "
Outlet	.05 " " "
Discharge	.45 " " "
	1.83 " " "
Add 10 per cent	.19
As a safety	2.02 inches

To determine the necessary size of ducts, risers, elbows and registers the practical allowable speeds for each of these sections was kept in mind.

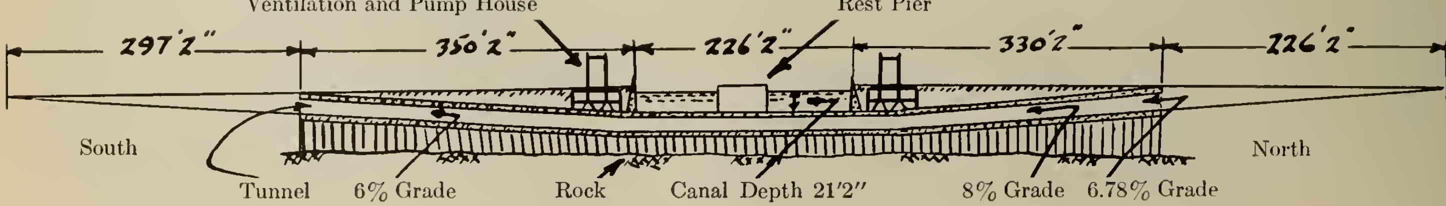


Fig. 2—Longitudinal Section of Subway.

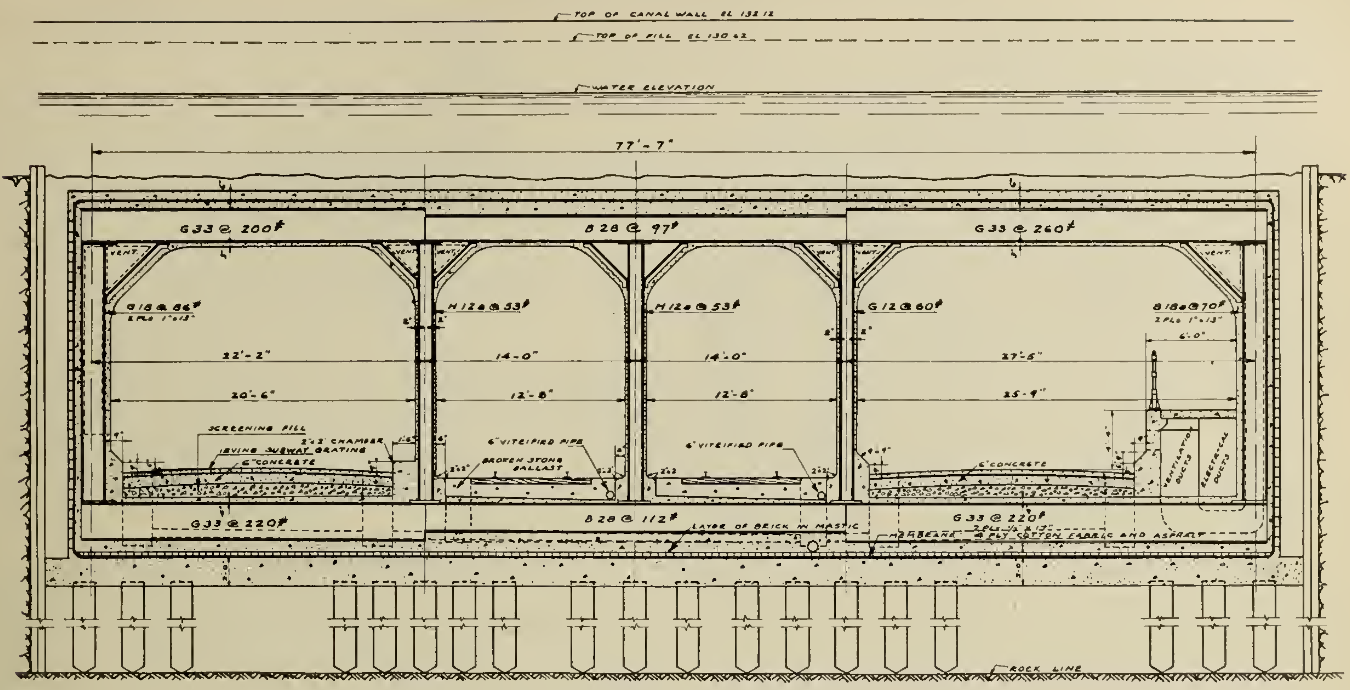


Fig. 3—Cross Section of Subway.

At all registers approximately 400 feet per minute.

In all risers and cross connections 800 to 900 feet per minute.

In all main ducts between 2,000 to 2,200 feet per minute

As an example, consider one-quarter the length of the roadway (sidewalk side); the total volume of air is $\frac{72,000}{2}$ = 36,000 cubic feet of air to be handled in one minute.

All this air must go through two collecting ducts (at least near the fan rooms). One of these ducts is rectangular and has a cross section of 12 square feet, the other is triangular and has a cross section of 5 square feet.

These two ducts will each handle a quantity of air proportional to their sections:

17 square feet	—	36,000 cubic feet per minute
12 " "	—	25,400 " " " "
5 " "	—	10,600 " " " "

In each duct the speed of the air will be:

$$\frac{25,400}{12} - 2,100 \text{ feet per minute.}$$

$$\frac{10,600}{5} - 2,120 \text{ feet per minute.}$$

The number of registers attached to the rectangular duct is eight—so there is a volume of:

$$\frac{25,400}{8} - 3,200 \text{ cubic feet per minute}$$

passing through each register with a section of approximately

7.5 square feet and an inlet speed of

$$\frac{3,200}{7.5} - 425 \text{ feet per minute.}$$

All four fans are Canadian Blower and Forge Silex fans, each one having a capacity of 65,000 cubic feet per minute against a static pressure of 2½ inches of water, when running at 360 r.p.m. with air at 70 degrees F. They have a constantly rising pressure characteristic from free delivery to no delivery, and a self-limiting horse power characteristic which prevents overloading of the motor especially when the air is very cold.

The outlet velocity at the fans is 1,900 feet per minute.

The normal horse power required from the motors is 38 (when air is at 70 degrees F.) but the maximum horse power required under any conditions is 45.

The four motors used are all General Electric 20-pole, 50-h.p., 360-r.p.m., 550-volt, horizontal shaft constant speed squirrel-cage induction motors with anti-friction bearings and directly connected to the fans. With the actual location of the fan rooms, ducts and registers there will be practically no draught in the tunnel as the exhausted air will only travel a few feet to reach the registers.

The main reason for ventilating the roadways was that the presence of carbon monoxide made it imperative that some means be arranged for detecting the presence of that poisonous gas.

For this reason two continuous carbon monoxide recorders have been installed, which register very low concentrations of carbon monoxide on a chart.

The apparatus consists essentially of a cell and a flow meter. The cell itself contains an active chemical and

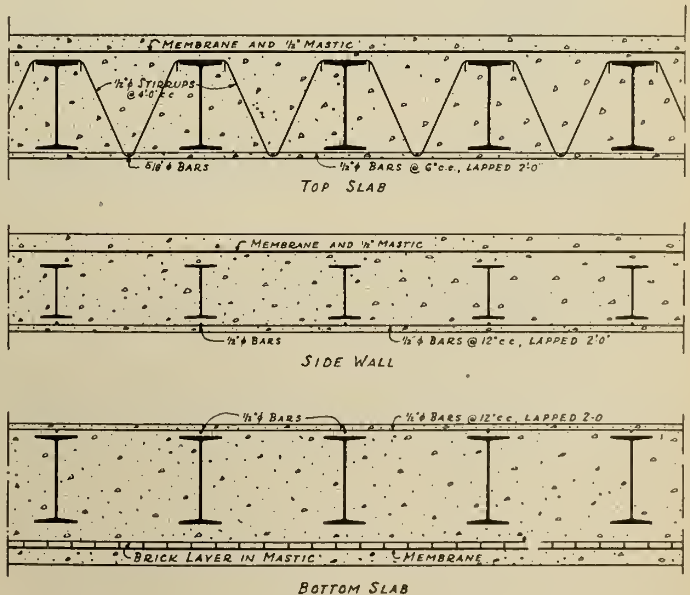


Fig. 4—Typical Slab and Wall Reinforcement.

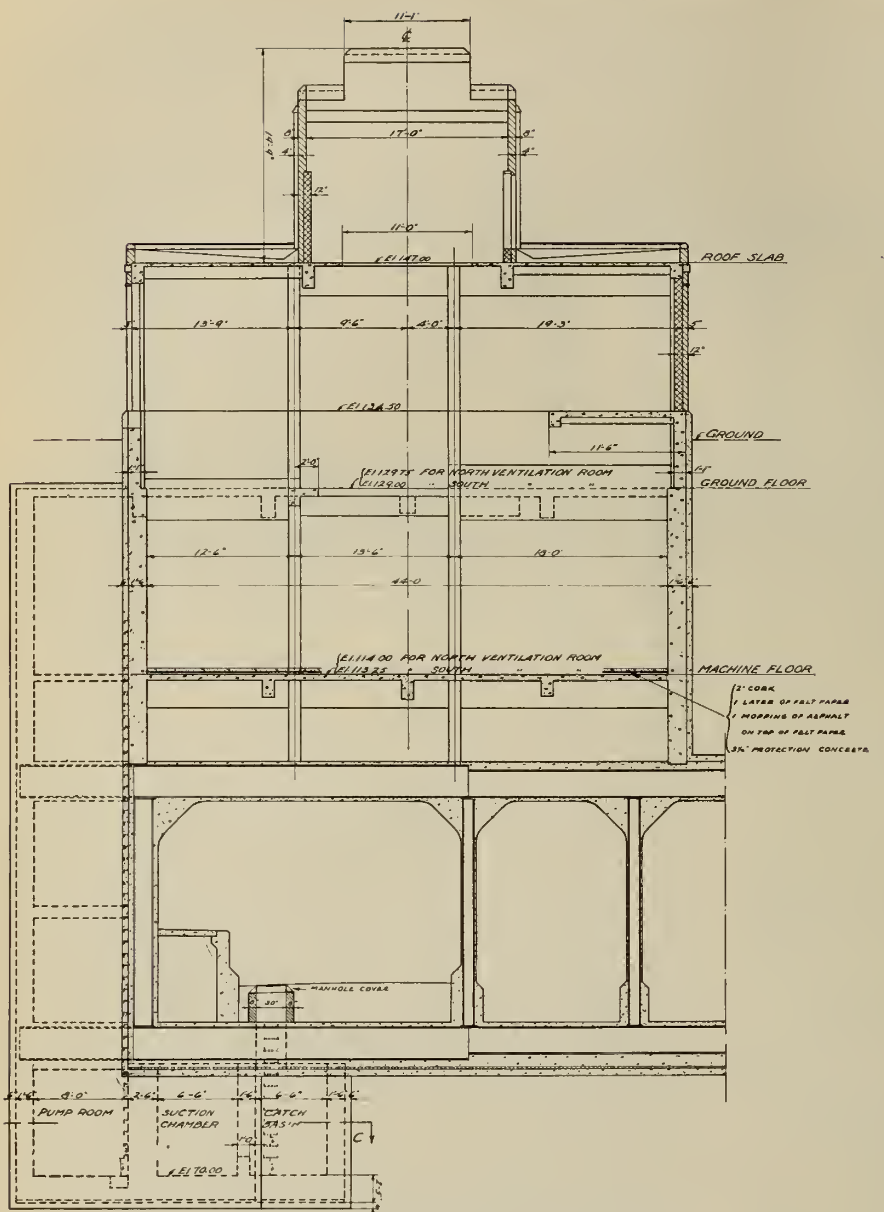


Fig. 5—Cross Section of Ventilation and Pump House.

thermocouples, the chemical, which is called Hopcalite, serves as a catalyst for the oxidation of carbon monoxide, and so generates heat at a rate proportional to the amount of *CO*.

This heat affects the thermocouples which in turn can register on a Leeds and Northrup potentiometer even if a few parts in a million of carbon monoxide are present in the sample air.

The flow-meter permits the passing of the sample air through the Hopcalite at a uniform rate.

It has been found from experience that the concentration of *CO* in vehicular tunnels should not exceed .04 per cent for an hour's exposure.

Of course, a much higher percentage can be tolerated when it is certain that no one will remain for more than a few minutes in the tunnel. However, it may happen that pedestrians will remain in the tunnel for nearly fifteen or twenty minutes, and there is also the possibility of a jam in the traffic with all motors kept running.

The *CO* recorders not only register continuously the actual state of the tunnel air, but will also serve as an alarm signal, and when the quantity of *CO* reaches a dangerous percentage, a relay attached to the recorders will automatically operate traffic lights at the entrance to the tunnel and stop incoming traffic.

These recorders also permit large savings in electrical energy by informing the operator when it is necessary to leave two or four machines in operation.

Telephones and Traffic Signals

In order to keep the tunnel clear of all possible obstructions a telephone system has been installed.

At four points in each roadway a telephone set is installed in the wall, each one communicating with the fan-room operator. The reason for this, is that to facilitate the quick removal of a disabled vehicle, the driver calls the tunnel operator through the nearest wall telephone and the latter communicates with some garage as instructed by the driver.

At each entrance telephone pedestals have been installed, thus permitting intercommunication between the traffic officers on duty and the fan room operator.

The traffic lights will be automatically operated by the *CO* recorders, as already stated, but they can also be operated by hand by the police officer in charge when it is deemed advisable.

Lighting

To most visitors the tunnel lighting will look too bright, but when entered on a very bright day, at a speed of 25 miles per hour, this does not appear to be the case.

The greatest difficulty is the day-time lighting of a tunnel, and it requires much more lighting at that time than it does at night due to the great contrast between outside and inside illumination. In a few seconds the driver's eyes must accommodate themselves to a big change in intensity of light, passing from say 5000 foot candles outside to 5 or 10 foot candles in the middle of the tunnel. This was the reason that the lighting units were spaced closer together near the entrances than was the case further down in the tunnel.

The increased artificial lighting at the entrances together with the natural light coming through the portals enable the eye to accommodate itself gradually to a lower intensity of lighting on getting into the tunnel. This process must be reversed in coming out of the tunnel.

At night nearly half of this lighting could be turned off without inconvenience, as the tunnel will then appear to be much brighter, due to the low intensity outside and also due to the fact that most drivers keep their headlights turned on.

The units used are special dust and moisture proof Holophane light directors with 150-watt lamps and a strong wire guard as a protector. These units are recessed in the ceiling.

In the tramways sections special Benjamin pit units are used.

The approaches have been treated in the same manner as street lighting, the lighting brackets being attached to the Tramway Company's poles.

The electric current is supplied at high voltage from two independent sources, so that if one fails the other will be available for the service. A series of 4.75-kv.a. and two 25

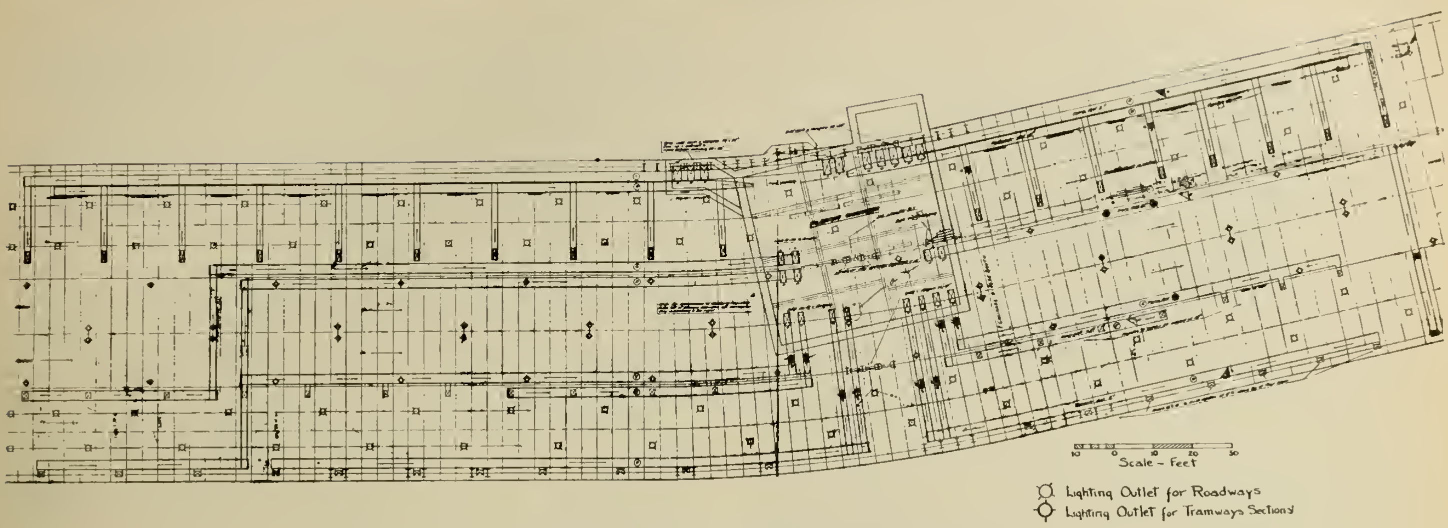


Fig. 6—Ventilation Plan of Portion of South Side.

kv.a. transformers located in the south ventilation room reduces the voltage to that required for the pumps, the fans and the lighting installation respectively. With these transformers are also installed in the south ventilation room the *CO* recorders and the electric control equipment for all the services of the tunnel.

Fibre Ducts

In view of the future development of the underground system of electrical conduits it is the practice to introduce in all the city's permanent construction of bridges and tunnels the electrical conduits which it is estimated will eventually be required. Conforming to the provisions of the Electrical Commission of the city, a series of sixteen fibre conduits, called low tension ducts, were installed for city services and another series of twelve conduits, called high tension ducts, were installed for the requirements of the power transmission lines.

All these ducts were placed under the sidewalk in the west roadway according to the specifications of the Electrical Commission and are now ready for service.

Construction

Before any actual construction work could be done the site had to be cleared of all existing services, such as telegraph, telephone and power lines, railways and tramways, gas mains, water mains and sewers. A new route had to be found for each and they had to be transferred before excavation could begin, and in the case of the tramway lines on the south side of the canal the transfer could not be executed until the necessary expropriations had been completed. The north side of the canal was partly cleared of obstructions in the early spring of 1931 and work started on the north approach.

On account of the thin layer of ground left on top of the tunnel roof in the canal section the only method of excavation possible was by open cut.

The contractor's programme was to take a first cut leaving a natural slope on the edges, the first 30 feet being solid hard ground. This cut was dug down to elevation 93 on the north approach and 98 on the south approach, and the canal section.

Steel sheet piling was then driven to rock from those elevations throughout the total length of the tunnel making a closed cofferdam with three to four feet clearance on each side to allow plenty of room for the erection of the structure.

This sheet piling was to act as a retaining wall against the side banks which were known to have very little consistency at the lower elevations.

At that stage of the work on the north section of the tunnel it was discovered that the foundation bed on which the structure would rest was so soft that it involved great risks of settlement and it was decided that concrete piles

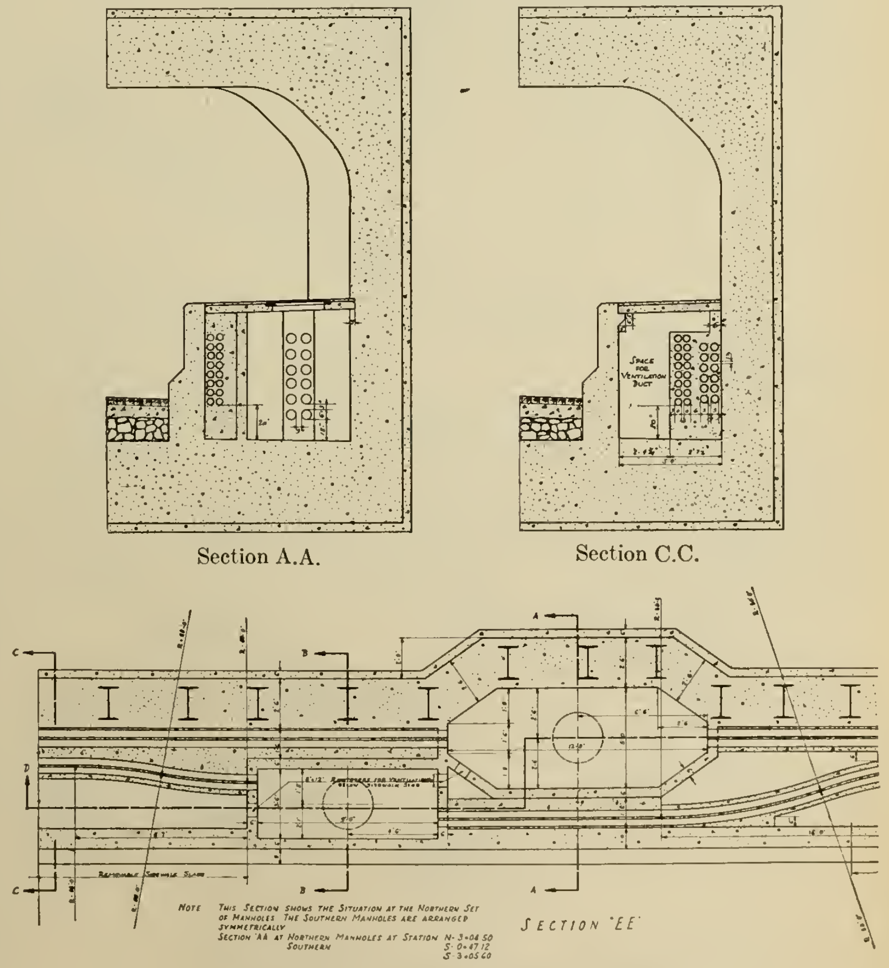


Fig. 7—Sidewalk and Electrical Duct Layout.

should be used. Later developments proved that this precaution was a very wise move.

In view of the fact that the underlying material was solely mud it was decided not to depend on friction piles and piles of uniform cross section driven to rock were preferred. Canadian Vibro piles were used in the north section and driven through about eight feet of overburden with the standard equipment. A 16½-inch steel shell was placed on a cast iron shoe and driven to rock by means of a 4,500-pound steam hammer until the last ten blows with a 3-foot 6-inch stroke hardly drove at all.

The reinforcing was then placed in the shell and 2,000 pound concrete poured in to the required elevation. The shell was then pulled out with the help of the driving hammer reversed. One machine could drive three piles in an hour.

For the canal section which was to be undertaken next and carried out in a rush it was decided to modify the piles and a precast reinforced concrete pile of adequate capacity was designed which was to be driven with the same equipment. These piles were cast at the shop in special steel moulds in a vertical position and vibrated. They were 13 inches in diameter, reinforced with 8¾-inch steel rods and ¼-inch hooping. On the field these piles were dropped in the steel shell on a cushion of fresh poured concrete. Whereas the use of precast piles involved a somewhat higher cost it was considered that this was justified by the satisfaction of knowing that every pile driven was perfect.

The next operation was excavating to grade. The steel sheet piling was first braced, one side against the other, by means of timber trusses braced together in pairs, due to the span being 90 feet long. These trusses were carefully located so that the steel frames of the structure could be erected between them.

The excavation was then carried to grade by hand and the material hoisted in buckets between the bracings. As soon as one section of sub-grade was prepared, generally 20 feet long, the pile cap and first slab was poured and that was the end of the muck trouble.

On this first slab the membrane waterproofing was laid and the brick and mastic protection, which left the field ready for the erection of the steel structure. Following completion of the steel erection the bottom concrete slab almost four feet thick was poured embedding the structure and the drains.

The steel sheet piling was then blocked against the steel frames of the tunnel and the timber trusses were then removed.

The balance of the walls and roof construction was ordinary work.

By-Pass

The Lachine canal water flow is used by numerous firms either for power development or for industrial purposes and is the object of leases between those firms and the Department of Railways and Canals. These interests had to be safeguarded by the contractors and at the same time the canal had to be unwatered to permit the construction of the tunnel to be carried on. This was made possible by the construction of a by-pass 100 feet south of the canal, a sufficient distance away to allow the construction of the tunnel and the reconstruction of both canal walls, all of which had to be completed during the idle season of navigation, namely between December 1st and May 1st.

The power users required a flow of water of nearly 2000 cubic feet per second and the by-pass was designed for a normal capacity of 2100 second feet.

It was 600 feet long with inlet just above the end of the rest pier of the Wellington bridge and outlet in the Wellington basin east of the Canadian National Railways bridge. The useful dimensions of this by-pass were 18 feet 3 inches wide by 15 feet deep. The inlet sill was at elevation 112 and the outlet sill at elevation 110.5 and the water stream had a depth which varied little from 13 feet.

A brief description of this by-pass construction may be interesting. The side of the excavated trench was held by a line of 3-inch plank sheathing with longitudinal wales 6 by 12 on each side. Between these a skeleton of 6 by 12 timber frames was erected, these frames being spaced 6 feet centre to centre. Inside this skeleton the flume proper was built and composed of 3-inch tongue and groove planking, a three-ply asphalt paper membrane and a 1¼-inch wood board covering for protection. On top of this the lower six feet of the flume walls were reinforced with an extra 3-inch planking to prevent deflections which might have injured the membrane.

The inlet and outlet were built of reinforced concrete and provided with stop-log gates to hold the water during the construction of the by-pass in the summer of 1932. The inlet and outlet had to be built when the water was taken out of the canal in the spring.

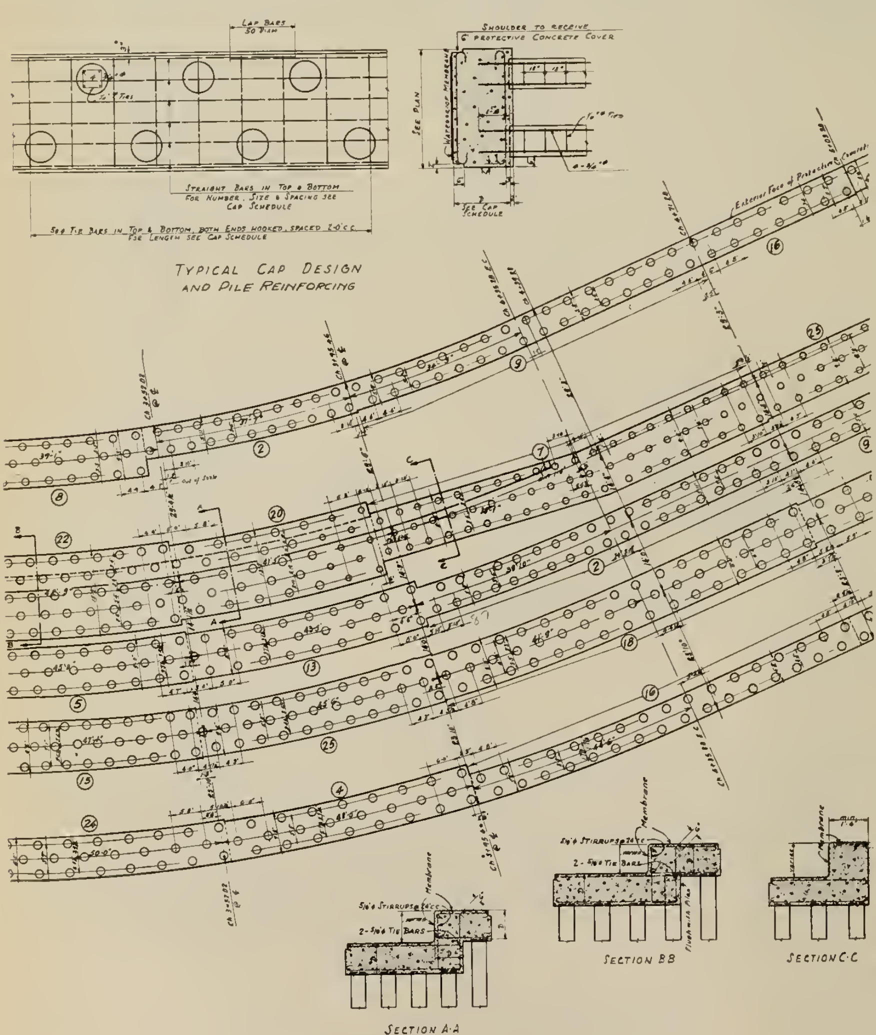


Fig. 8—Typical Concrete Pile Layout.

Cofferdams

The by-pass being completed, a cofferdam was built across the Lachine canal on each side of the tunnel site to permit the unwatering of the field of construction.

These cofferdams were of the ordinary crib type built of 12 by 12 timber in short individual sections and sunk to the bottom by loading them with stone.

The dam was completed with a gravel toe fill in front and on top of those cribs, making a jetty about 18 feet high, 15 feet wide at the top and 30 feet wide at the base.

In the meantime a pumping station was built close to the east cofferdam on the north bank of the canal. This station was equipped with a battery of four pumps, two of which were 12-inch centrifugal pumps each driven by a 125 h.p. electric motor and two 10-inch pumps of the same type driven by 100 h.p. electric motors. These four pumps had a combined capacity of 1,000,000 gallons per hour. It took four days to empty the canal between the two cofferdams with this equipment.

As was naturally expected, some seepage developed through the cofferdams, especially near the inlet of the by-pass where the whirlpool was undermining the dam. Considering that the water was rushing in the by-pass at the speed of 9 feet per second this undermining is easily explained. The remedy was found when a row of steel sheet piling was driven in front of the inlet and continuously along the toe of the cofferdam with 8 to 10 feet penetration in the bed of the canal. Whatever leakage took place then was easily taken care of by a five-inch pump working at intervals.

These two cofferdams, which represent some 9000 cubic yards of material, were entirely removed from the canal well in advance of the opening of navigation in April 1932.

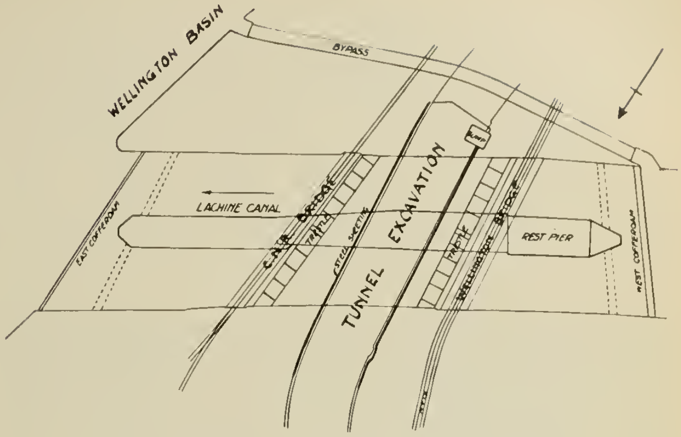


Fig. 9—Location of Cofferdams and By-Pass.

The following quantities will help in forming an idea as to the size of the enterprise.

There were 180,000 cubic yards of excavation and 45,000 cubic yards of concrete in which 315,000 bags of cement were used.

Work in the tunnel tube including the retaining walls required 4500 tons of structural steel and 575 tons of reinforcing steel.

In the foundations 2600 piles were used of which 2000 were precast.

The steel sheet piling amounted to 2500 tons. The form work and timber bracing required 3,500,000 f.b.m. of wood. The form work was designed in removable panels and these panels were used five or six times.

There were 60,000 cubic yards of backfill.

Highways and Byways in Ontario

Hugh A. Lumsden, M.E.I.C.
County Engineer, County of Wentworth, Hamilton, Ont.

Paper presented before the Hamilton Branch of The Engineering Institute of Canada, November 8th, 1932

The King's Highways of Ontario are the main travelled-through roads of the province. They have been taken over entirely by the province and are constructed and maintained entirely by provincial authorities, but the county in which such a road is situated is called upon to pay 20 per cent of all that is spent on the King's Highways within its boundaries.

Furthermore, within a moderate distance of each city the city itself is also called upon to pay 20 per cent of the costs, these sections being known as King's Suburban Highways, so the building and maintenance of these roads is not an unmixed blessing. In the county of Wentworth, the costs to the county alone for their 20 per cent have exceeded a million dollars in the past twelve years. If it had been possible to pay expenses as they were incurred, it would have been easier, but the geographical situation at the head of Lake Ontario necessitated the construction of more mileage of pavement than in any like area elsewhere, consequently debentures had to be issued for the county's share of all construction work and it will be many years before the payments on these are completed.

The Department of Highways constitutes one of the largest and most important of those that make up the administration of this province. It is directly under a Minister of Highways and under him comes the Deputy Minister and the chief engineer. The organization may be illustrated by Fig. 1.

It will thus be seen that the activities of the department's officers are not confined to King's Highways alone, but that they have a great interest in county suburban and township roads. These they inspect and advise on through their Municipal Roads Branch. So that, in brief, everything which pertains to the roads of the province (exclusive of colonization roads) is directly or indirectly advised upon and the expense is contributed towards (in varying amounts) by the Department of Public Highways.

It may be of interest here to consider the present state of the King's Highways. Out of the 52,280 miles of roadways of all classifications which make up the roads in the organized counties of Ontario, 2,998 miles of these are King's Highways or a little over 5½ per cent. At the end of last year 2,262 miles of these had been paved.

Next in importance are the county roads and the suburban roads. These constitute the main through local roads, amounting to 7,890 miles. They are, as it were, a secondary main system, second only in importance to the King's Highways. These roads are usually township roads which have been assumed as county roads under the Highway Act by a By-Law passed by the county council. Such roads then come under the jurisdiction of the county council.

The county appoints a county road committee which directs the work to be done over the county roads.

The administration and management of the county road system is vested in the county road superintendent, acting under the direction of the road committee, Sub-Section (a) Item (4) Section 12, of the Highway Act reads:

(*a*) "Every engineer hereafter appointed by the Council of a county shall be a graduate in civil engineering of a university of recognized standing or a member of The Engineering Institute of Canada or an Ontario Land Surveyor.

This is mentioned as it is wished to illustrate that the counties are carrying out the work over their roads subject to the direction of qualified engineers.

The county roads usually comprise from 10 to 20 per cent of the total roads within the county and there are

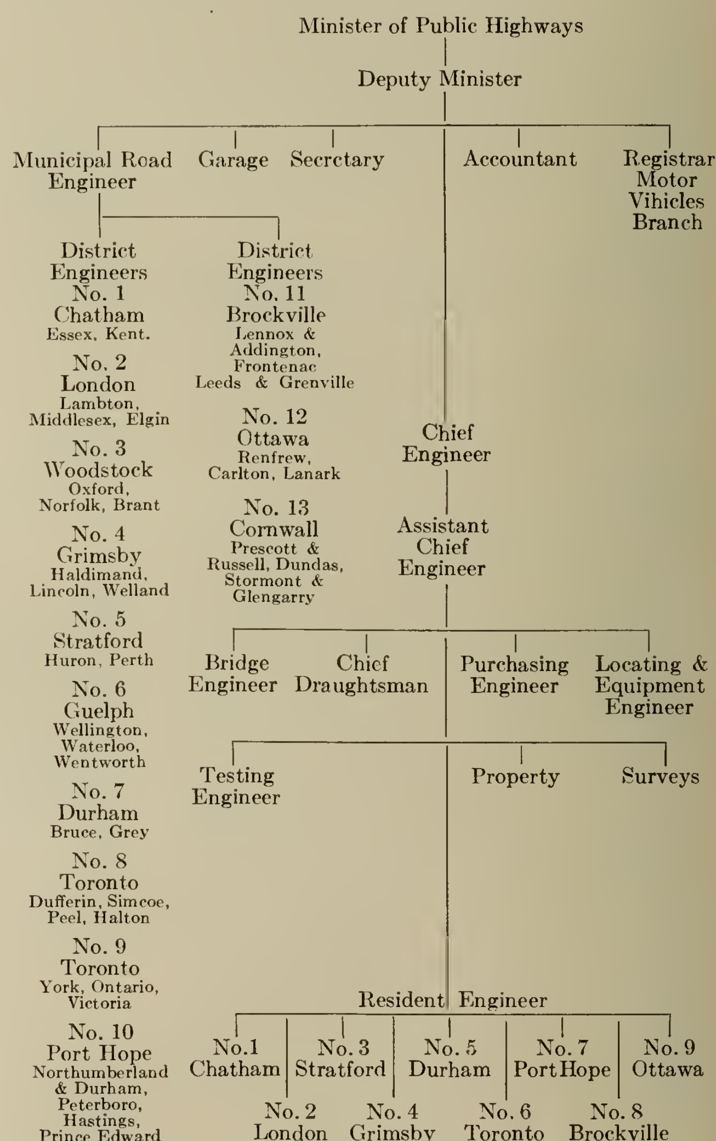


Fig. 1—Department of Public Highways, Ontario.

7,941 miles of such roads in the organized counties. Each county has somewhat different practice in its method of carrying out work. Some do all work by day-labour;

others do everything by contract. Again, some employ both methods. For the maintenance it is customary to employ patrol men over short sections of road.

An outline of the procedure is that an estimate is prepared early in the year and submitted first to the road committee and later to the county council. This usually details the amount required for maintenance and construction during the year and states the location and extent of the proposed new work. Once passed by the council, the work is carried out during the season, and at the end of the year a detailed report is submitted to the council. On all the money spent on these county roads, the province repays fifty per cent. During the year a government engineer inspects the work from time to time.

Suburban roads have been mentioned and these are not to be confused with King's Suburban Roads which are merely the King's Highways, towards which the city contributes 20 per cent of the cost. Suburban roads are county roads in the immediate vicinity of a city or separated town which have been designated as suburban roads and the operation of which has been assumed by a suburban commission. This commission consists of three members in the case of towns or cities less than 50,000 and five members for cities of 50,000 or over. Either one or two of the members are appointed each by the county and city and in case the two or four do not agree on the third or fifth member, he is appointed by the government.

Whatever amount the county votes for the work of these commissions must then be met by the city up to half a mill of its assessment and the province then pays its 50 per cent of the total spent as in the case of county roads.

It is very common practice for the county engineer to be also engineer for the commission and for the county equipment to be purchased and used jointly.

It will thus be seen that for the expenditure of 25 per cent of the cost the county is having roads built within its borders. The city is having roads built leading in to the city and in many cases roads which become city streets as the city expands. There are in all 716 miles of county road under the control of suburban commissions, such as have been described.

Lastly there are the township roads, and these constitute the huge bulk of the roads of the province. In fact there are approximately 41,392 miles of this class of road, only 210 miles of which have been paved. This comparatively small amount of paving is not to be wondered at, for after all it is traffic and the type of traffic that makes paving necessary, and whereas these township roads make up the huge bulk of the mileage, they do not carry much traffic as compared with either King's Highways or county roads.

Township roads remain under the control of the township council and provided statute labour has been abolished, all work done upon them becomes eligible for a grant of forty per cent of the cost from the province,—provided, of course, such work is done under a duly appointed township road superintendent and is inspected and approved by the department engineer.

The various classes of roads within the organized counties of Ontario have now been dealt with but it should also be mentioned that the provincial government has appointed a "Highway Committee" consisting of three men who may be called upon to advise and report on matters relative to any phase of highway work. This board serves without remuneration and its advice has proved of great value to the province.

Turning now to the actual road construction; the preliminaries necessary before a road is constructed or paved are far more complicated than one would imagine, as so many features must be taken into consideration before a plan of construction is commenced.

(*a*) Present traffic. (*b*) Potential traffic. (*c*) Types of traffic, truck or pleasure vehicles, etc. (*d*) To what extent will construction relieve other roads? (*e*) Is the traffic seasonal or all the year round? (*f*) Will distance be shortened? (*g*) Will grades or curves be reduced?

In all this study nothing plays a greater part than the study of traffic. Let us glance at the census on several King's Highways: For example, on Labour Day, 1914, there passed Port Credit on the Toronto-Hamilton Highway 520 vehicles of all kinds, of which 255 were horse-drawn, and there were no vehicles from outside Ontario. Twelve years later, in 1926, there passed the same spot on Labour Day, 19,484 vehicles, 24 only being horse-drawn, 6,279 being foreign cars and 298 busses. Other counts of interest might be mentioned, for instance the Freelton-Guelph Highway shows an average of 1,212 vehicles per day, and a maximum of 2,200. The Galt Highway at the top of the Dundas Mountain which in 1914 showed a maximum of 441 vehicles per day, showed a maximum of 2,687 in 1926 and 3,152 in 1932. The Brantford-Galt Highway Number 24, at its junction with road 8 at Preston shows a daily average of 1,377 and a maximum of 1,847. The foregoing is just to illustrate the huge volume of traffic which is now passing over some Ontario roads.

Fig. 2—A Tar Penetration Road, Constructed 1932.

County roads also carry a heavy volume of traffic, particularly those under the suburban road commissions. In the county of Wentworth there are five main roads carrying over a thousand vehicles a day, the highest giving an average traffic of 3,107 and the lowest 105. On the average township road, however, it would be exceptional to find traffic exceeding 100 vehicles per day.

What then are the limits within which paving would be considered necessary? This is a big question and generally each individual road must be considered on its merits. The considerations previously outlined must all be taken into account as well as the drainage, character of the soil, proximity of local material etc. However, in order to form some idea, the limits would be somewhat as follows:

Traffic 0—300 Stone or gravel base, can be maintained as such, probably a dust layer applied in places.

300— 500 Stone or gravel base, surface treating with tar and chips desirable.

500—1000 Stone or gravel base, traffic becoming too heavy to maintain economically and paving should at least be considered.

Traffic —1000 and up.

The cost of maintenance becomes very heavy and a pavement of one type or another will save money over the years.

Now to consider the types of pavements. Those most in use today are concrete, bituminous roads of various sorts, and bituminous concrete roads.

Concrete Roads. The cement companies have a slogan "Concrete for Permanence" and a well constructed concrete road will undoubtedly give most excellent service. The census on the Toronto-Hamilton highway has been mentioned. This road is the oldest concrete road of any great length in the province, built at a time when it was little realized what a complete change the motorization of vehicles would bring about. In 1915 when the first of this road was laid, it was thicker in the centre than on the sides and was conforming with common practice over most of the states where it had been used at all for roadway purposes. At that time 18 feet was considered adequate width.

Today the standard design as adopted by the Department of Highways is 20 feet in width and wider around the curves. The thickness of the slab is 7 inches in the centre and for 7 feet from it,—then deepening for 7 to 10 inches in the last three feet. The camber is 2 inches across the 20 feet. The mix now used is 1.2.3. A centre joint 6½ inches in depth of corrugated metal is laid longitudinally at the centre and ½ inch expansion of joints of asphaltic material are put on transversely every 70 feet. Depending on the subsoil, reinforcing wire mesh should be put in over soft ground. This will vary in amount, but runs about 6 pounds to the square yard. It has also been found that ¾-inch steel rods placed 6 inches in from the edge of the concrete are very effective, preventing corner breaks and greatly strengthening the pavement as a whole.

That the materials must be suitable, the mixing adequate, not less than a minute being spent in mixing, that the floating and finishing must be well done, are but a few important features of the work, but it is not proposed to go into details here as to the specifications of concrete roads for they are a study themselves.

The shoulder along side should be not less than five feet in width and from there on the grade leading into the ditch should be sufficiently flat that if a car runs into it, no accident will result.

It has been gratifying to note during the past season the amount of grading being carried out along King's Highways designed to eliminate the deep ditches.

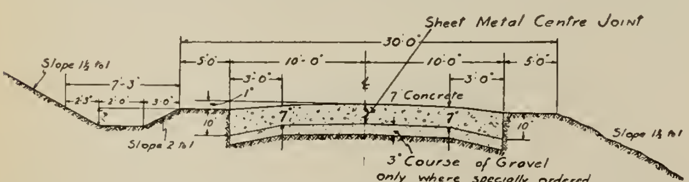


Fig. 3—Cross Section, Concrete Pavement, Ontario Provincial Highway Construction.

As regards the cost of concrete roads the location of the work and accessibility of materials governs the price to a large extent. At present day prices a concrete road can be laid for from $1.50 to $2.00 per square yard.

Bituminous Roads: These are many and varied but the base of all is either asphalt or tar and the principle of all is somewhat the same. Following the required grading and the laying of a satisfactory stone base (the base is often the old macadam road) a top of varying thickness is laid and rolled. This top may consist of asphalt or tar mixed with stone or gravel (usually stone), either in a mechanical mixing plant and the material hauled to the work or else mixed in place on the road. Following the placing of the material, adequate rolling is most necessary. Sometimes these roads are of one course, often of two courses. To enumerate a few of the leading types of roads:

Penetration Roads. These consist of the 2-inch stone spread over the road to a depth of three to four inches, rolled

Fig. 4—A Retread Road Constructed 1932.

over once and then penetrated by spraying in under pressure about 1½ gallons of tar asphalt to the square yard. A smaller stone is then spread over about one inch in thickness and again sprayed with about ½ gallon to the square yard. Following this, a coating of ⅜-inch chips and thorough rolling. Within six months after rolling, a regular surface treatment using about ⅓ of a gallon should be given such a road. Such a type of road will cost between 70 cents and $1.20 per square yard or $8,000 to $12,000 per mile. This is an example of a mixed in place road. So also is what is sometimes called the "poor man's pavement" or "retread." This consists of first putting on a prime coat of a light oil or dust layer, then the stone is spread over the road and sprayed with about one gallon of material. The whole mass is then bladed from side to side until the stone is thoroughly coated. It is then brought to an even grade and rolled. A surface treatment with chips is then applied and the whole thoroughly rolled. The cost would be 50 to 60 cents per square yard for this type of road or about $6,000 per mile is a fair cost. The necessity of a thoroughly good base before using this type must be kept in mind.

Among the most used of the many types of pavement, mechanically mixed and hauled to the work, mixed *Macadam* or *Black Base* should be mentioned. This is and has been used to such a great extent that its composition might be given.

The stone consists of coarse and fine aggregate, uniformly mixed with asphalt cement. The approximate amounts and sizes of materials making up the aggregate are as follows:

Stone, passing a 2-inch and retained on a 1-inch screen, 10-35 per cent.

Stone, passing a 1-inch and retained on a ¼-inch screen, 30-50 per cent.

Stone, passing a ¼-inch screen, 15-30 per cent.

Bitumen asphalt cement soluble in carbon disulphide, 4-6 per cent. In many cases up to 10 per cent sand is put in.

The mineral aggregates are first put through a revolving drier and heated to a temperature of from 225 to 350 degrees F., the temperature being determined by a pyrometer installed at the discharge end of the drier.

The coarse and fine aggregates are then measured either by weight or volume as is the asphalt cement by scales attached to the asphalt bucket.

The mixture is then made in a batch-mixer, the weighed coarse and fine aggregate being first mixed, after which the asphalt cement is added, the mixing being continued for at least 45 seconds after all is in the mixer.

The various other materials are brought about by various differences in the size of stone used, the temperature of the mix, the cut back in the bituminous material, the amount of fines used, etc. Thus there are many paving mixtures, most of them excellent.

Then there are the emulsions, which are asphalt made to mix with water. These, as with the foregoing, are used satisfactorily for surface treating and penetration work.

So much for various types of road but before closing, consider briefly the tendency in road construction today.

As regards grading, it is being more and more recognized that the elimination of ditches is one of the prime necessities. Secondly, it is becoming generally recognized that the pedestrian must be given a chance. In our anxiety to provide roads for vehicles, the foot passenger has been crowded out of the picture. As a consequence, he either blunders along a wet ditch or timidly tries to walk the pavement. At nights his difficulty is far greater and he is in constant danger of his life. The motorist also is in continual fear of hitting someone when by reason of the glare of oncoming traffic he is able to see but a few feet in front of him, and so an improvement in legislation such that will bring about a more comprehensive policy of pathway construction alongside highways is to be hoped for.

The huge payment called for from the counties as a result of provincial highway construction has resulted in a tendency on the part of the counties to cease expenditure. It is hoped that a change in the percentages which municipalities are called upon to pay will soon be forthcoming, for the traffic on the road is many times greater while the rural population has tended to decrease rather than increase, so obviously the counties should be called upon to pay a much smaller percentage. Other minor features of the highway work should not be neglected, such as beautification, the planting and maintenance of trees, the care of boulevards, signing of roads. These catch the eye of those travelling over smoothly laid pavements and should not be neglected.

In closing, the author commented that all that has been learned concerning road improvement only serves to demonstrate what a large amount still remains to be discovered. No engineering field throws out a greater challenge to the engineers of to-day and to-morrow than the study of the betterment of roads whether it be the improvement of bituminous or concrete surfaces or the elimination of the "wash-board" in gravel and stone roads.

Notes on Wood Poles and Their Preservative Treatment

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Paper presented before the Junior Section of the Montreal Branch of The Engineering Institute of Canada, November 2nd, 1933.

Wooden poles have long been used for the erection of pole lines, and, although steel and concrete are to-day in extensive use the wooden pole will always be used for small extensions and short lines, since it is relatively cheap, light, easy to transport and erect.

Unfortunately all types of timber are not suitable for poles, due to their weight, strength or rate of decay.

Eastern, or Northern White, Cedar has been used more in the past than any other type of wood, and this extensive use has depleted our forests to such an extent that other types of wood must be found to take its place. The wood is light, shows a very low rate of decay, but is the weakest of all the woods usually used for poles.

Western, or Red, Cedar belongs to the same family as eastern cedar, but is stronger, heavier, and its rate of decay is greater. The poles are supplied in very long lengths and are symmetrical. The taper is small, and it has been known that, with untreated poles, the tops have been placed in the ground instead of the butts. Their great length and symmetry gives these poles great importance.

Red, or Northern Pine has approximately the same strength as western cedar, but its rate of decay in the untreated state is much greater.

Yellow, or Southern Pine is stronger than western cedar, being the strongest of the pole timbers, but its rate of decay, in the untreated state, is great.

Other types of pole timber are chestnut, redwood, cypress, lodgepole pine, and juniper or southern white cedar. They are used to some extent but are usually confined to the locality in which they are found.

From an inspection of the above, it can readily be seen that the creosoted pine pole is much the best for pole line construction. The western cedar pole, if treated, will also give a very satisfactory pole.

It is important to consider the cause and prevention of decay in pole timbers, since by the proper corrective measures very strong and long lived poles can be obtained.

Pole Defects and Decay

All timber is liable to be found defective when delivered, or it may develop defects after its delivery or erection. There are three main subdivisions of defects:—

(1) *Fungi.* This decay usually starts at the exterior of the pole and may be classified under three headings:—
   - (*a*) *Butt rot* is caused by fungi entering the living tree through the roots, or an abrasion near the roots. It is comparatively slow in development and usually ceases when the tree is cut down.
   - (*b*) *Heart rot* is caused by fungi entering the pole through abrasions, dead branch stumps, etc.
   - (*c*) *Sap rot* is caused by fungi attacking the outer layers of the wood, causing disintegration and discolouration.

(2) *Insect damage.* Above the ground line insects enter the pole by defects, knot holes, etc. leaving only a small hole, so that their presence is not always detected. They, like the fungi, live on the food in the wood cells and penetrate to a considerable depth. Woodpeckers, seeking to live on these insects, create considerable damage by removing large portions of the pole.

(3) *Season checks.* These are caused by many agencies, such as shrinking while the pole is being seasoned, thus

leaving splits, by which insects and fungi enter the pole. These checks can be partly overcome by proper seasoning and storing.

Decay of Timber

In its natural state, wood contains food for the lower species of plant life organisms, called fungi, and for the wood-boring insects. The decay is caused by these fungi and wood-borers feeding upon the contents of the wood-cells, thus breaking them down, and destroying the timber. In breaking down these cells, the wood is left in a powdered state, which is highly inflammable. It is easy to visualize how the wood-borers destroy the timber, but an outline of how fungi do this may prove interesting.

Fungi are propagated by spores, which are the seeds of the fungi, which lodge in the defects of the timber. These spores take root, and send their roots, called mycelia, into the wood, which break down the cells, and feed upon the contents. The fungi, like all other plant life, require food, moisture, a favourable temperature and air for their development. This can be proved as follows:—

(1) No living thing can exist without food.
(2) Furniture in a dry house is free from fungi.
(3) Poles in the frozen north do not develop fungi.
(4) Poles submerged in water are not attacked by fungi.

In a telephone pole for example, these four requisites are present. The food is furnished by the wood cells of the pole. The butt of the pole, being below the surface of the ground, retards the evaporation, and thus there is moisture. The temperature, except in winter, is not very low below the ground, and unless the pole is set in a swampy location, the amount of moisture is not sufficient to completely fill the wood cells, so some air is to be found. Above the ground line the combination of moisture, temperature and air is not favourable, so that the greatest rate of decay is just at, or just below the ground line. If any of the above requisites are prevented the fungi can be killed off, but if the food is destroyed the wood-borers can also be warded off, and thus the decay overcome.

This poisoning of the contents of the wood cells, called preserving, consists of the application of poisonous compounds, which, fortunately, does not harm the wood.

The requirements of a good preservative are that it must be toxic (poisonous), stable, permanent and must penetrate the wood readily.

There are two general types of preservative, both of which have certain antiseptic and poisonous properties.

(1) *Salts* Poisonous metallic salts, such as,

(*a*) zinc chloride	(*d*) iron sulphate
(*b*) mercuric chloride	(*e*) sodium fluoride
(*c*) copper sulphate	(*f*) arsenic compounds

The above are the most extensively used salts, particularly zinc chloride. They are cheap and very poisonous, but, being soluble in water, they are not very stable or permanent. They are used extensively for timber in general but very seldom for poles.

(2) *Creosote* This was discovered by John Bethell of England in 1838 who foresaw the advantages of a high grade preservative. It is an antiseptic and poisonous oil, and is obtained from the distillation of tars. There are three general types.
  (*a*) *Coal tar creosote*, a by-product of gas works.
  (*b*) *Water-gas tar creosote*, a by-product of the manufacture of water-gas.
  (*c*) *Wood tar creosote*, obtained by the destructive distillation of wood.

Coal tar creosote has been found to be the best preservative. In addition to preventing decay, it makes a pole resistant to fire, by:—

(1) Preventing the formation of decayed wood, which is highly inflammable.
(2) Depositing a coating of carbon on a burning pole which keeps the flame from the wood.

This added protection is important where lines are built through forests.

In applying creosote as a preservative for pole timbers, there are three general types of treatment, which are, in their order of effectiveness:

(1) Closed tank or pressure treatment.
(2) Open tank treatment.
(3) Brush or spray treatment.

Closed Tank Treatment. The poles which have been framed and cut to the users' specifications, are placed in a cylinder which is sealed and is air tight. Steam is admitted, which is used to expand the cell walls, and allow absorption of the creosote. The steam is released, and a vacuum created to withdraw all the moisture. Creosote, at a temperature of about 200 degrees F. is allowed to flow into and fill the cylinder. The creosote is kept hot by steam coils in the cylinder and pressure is exerted on the creosote which drives it into the pole. After a pre-determined time, the pressure is slowly released, and the creosote allowed to flow out of the cylinder. At this stage the treatment can resolve itself into the full or empty cell process.

(*a*) *Full Cell Process.* This is the Bethell process in which about 12 pounds of creosote are retained in the pole per cubic foot.

(*b*) *Empty Cell Process.* This is the Rueping process, in which about 8 pounds of creosote are retained in the pole per cubic foot. After the creosote is allowed to flow out of the cylinder, a vacuum is created which withdraws some of the creosote from the pole; they are then removed and stacked to dry.

Open Tank Treatment. In this case the poles are placed in a bath of creosote and left to absorb the creosote. Since the poles cannot be steamed to expand the wood cells, hot creosote is used, ranging from 180 degrees F. to 230 degrees F., which temperature is maintained by steam pipes in the bath. The poles are removed after a sufficient length of time, and stacked to dry. Some suppliers apply zinc chloride before treatment by creosote.

Brush Treatment. Hot creosote is spread on the pole by means of a brush or spray, two or three coats being applied. Sometimes zinc chloride is applied before the creosote, and some firms char the pole before applying preservative. Poles can be treated while in service by spraying, or by charring the pole, then applying the treatment.

Poles can also be painted, but the treatment is ineffective, since very little penetration, if any, is obtained, and wood checks and abrasions are still open which allow fungi and wood-borers to enter the wood.

The closed tank treatment covers the whole pole, while the other two treatments apply to the butts only.

Bleeding is objectionable in the full-cell processed pole. This has been overcome, partly by giving the pole a coat of wax after treatment, by some pole suppliers.

The effectiveness of treatment is measured by the amount of penetration, and the type of preservative, thus it will be seen that the closed tank full cell treatment is the best, the closed tank empty cell treatment second best, then the open tank treatment, and lastly the brush treatment. The brush treatment lengthens the life by three to six years, the open tank by ten to fifteen years, but there is not sufficient data yet on the closed tank treatment to state what lengthening may be expected. There are some poles in England to-day that are still in service after sixty years of life.

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Mechanization and Agriculture

The Canadian farmer, whether growing grain or engaged in mixed farming, carries on his business to-day under conditions differing greatly from those existing a generation ago. The mechanization of the age, the development of our transportation systems, and the changes which have taken place in our social organization and outlook have altered his way of living and confronted him with new problems in purchasing and marketing.

Within the memory of many now living the average family-size farm was practically self-contained, in the sense that it provided for its owner or tenant almost everything that he and his family needed. Wood for fuel; wool for clothing; meat; milk; eggs; grain; vegetables, and other foodstuffs, all these were furnished by the farm as a result of the family's industry. The farmer, of course, expected, and in most cases obtained, a fair living for himself and his family, but usually did not receive any considerable income in cash.

Since those days there has been a general rise in the standard of living and not least in that of the average farmer. People are no longer satisfied with homemade equipment and have acquired more expensive tastes. In the country they now purchase their clothing and shoes, cut less wood, and buy coal; they need gasoline for the family car as well as for the tractor, and incur cash expenditure in many directions undreamed of in the old days. As a result the farmer needs a substantial cash income for which he is dependent on the power of the public to pay for his produce. Thus, he has a direct personal interest in the welfare of the non-agricultural portion of the population, who in turn benefit by the farmers' ability to buy manufactured goods, supplies, and equipment. Actually, the farmer cannot stand aloof from the mechanization of the age, which gives him wider opportunities and a closer relation to the manufacturing industries of the country whose workers purchase so large a proportion of the products of his fields.

This situation applies to the wheat farmers of the west, as well as to those occupied in fruit growing and mixed farming in the east. It must be remembered that a generation ago the agricultural settlement of the Canadian west had hardly begun. Our great transportation systems had not been developed, and the amount of grain exported from Canada was very small. The settlers on the agricultural lands of the west naturally engaged in raising grain, and indeed much of the area available for settlement in the prairie provinces is not suitable for mixed farming. The western farmer therefore, from the outset has had to purchase almost all the supplies he needed. His farm with its great fields of grain yields other crops in smaller proportion, and in some cases he may even have to purchase food stuffs, eggs, meat or milk for his own consumption.

Unfortunately, at the present moment, while the farmer is receiving very low prices for what he sells, he has to pay what seem to him disproportionately high prices for everything he has to buy, particularly commodities which his farm under present day conditions cannot provide or cannot produce economically.

It is noteworthy that this condition has arisen during the years when the Canadian manufacturing industries have seen their most rapid development. During the same period remarkable advances have been made in the improvement of farm appliances and in the mechanization of farm work. Had it not been for the latter event, there is no doubt that the farmer's position would have been much more difficult than it is to-day. In addition to a host of labour-saving appliances for his home and his farm, he now has at his command many conveniences such as telephones, radio, electric light, good roads and automobiles, which have tended to lessen the disadvantages of country life, and have added greatly to its amenities, though some of them have not added directly to his revenue.

Improvements which economize labour, however, have a direct monetary return, and it may be of interest to note their effects.

The development of the gasoline tractor and the combine have led to some radical changes in farming methods, especially in the west, where such improvements are of particular advantage as enabling the available labour to work a larger acreage. This has as its natural result a tendency towards the operation of much larger farms, with an accompanying change in the organization which works them. Some idea of the possible saving in labour can be formed from the statement that one man driving a tractor operating a five-bottom 14-inch plough can turn over more land in an hour than the same man with a walking plough can cover in a day. As regards the increase in size of grain farms it is stated that between 1924 and 1928 the average size of a group of successful farms in Montana increased from 598 acres to 1265. Grain farming is, of course, pre-eminently adapted to machine methods of production with their resulting larger output per worker. As a result of this ability to save labour, the crop-acres per worker in Canada increased 109 per cent during the period 1881 to 1891, and the average value of the farm produce per farm worker was $509.00 in 1901, while in 1921 it was $1,340.00.

In the east, and in respect to mixed farming generally, the modifications in farm life have been equally striking, and have also made possible a considerable increase in the output per worker. Improved methods and equipment have been introduced which save labour (mechanical milkers, gas engines, electric power), or improve the product (cream separators, refrigerators, separating machines), or eliminate waste (silage cutters, hay-making machinery), and all these can be adopted on a family-sized farm without serious alteration in the existing farm organization. The tendency towards larger farms so noticeable in the grain areas of the West has, however, not shown itself to the same extent in the case of mixed farming.

Some people have the mistaken idea that the contributions of the Eastern provinces, where mixed farming predominates, to the agricultural wealth of Canada are almost negligible as compared with those of the grain growing provinces. This is not really the case. For example, the figures of the Dominion Bureau of Statistics indicate that the gross value of field crops, farm animals, dairy products, fruit and vegetables, poultry and eggs, etc., produced in Quebec and Ontario in 1928 (a good year for grain) was $810,000,000 as compared with a total value of $843,000,000 for the same products in Manitoba, Saskatchewan and Alberta.

Much can be done for the farmer, even if he operates on a comparatively small scale, by giving him cheap power. As illustrating the attention which has been paid to rural power supply by the Hydro-Electric Power Commission with a view of assisting the development of agricultural areas in Ontario, Dr. F. A. Gaby, M.E.I.C.,* has stated that from 1925 to 1930 the number of rural power districts in operation increased from 52 to 131, the number of individual consumers from 4,200 to 30,000 and the power taken in those districts from 2,000 h.p. to 17,000 h.p. This figure, of course, includes power used for household appliances in the farmer's home as well as that used for industrial purposes on the farm.

It seems evident that a stage in farm mechanization has now been reached which has demonstrated the economy and practicability of the newer methods. If farm organization is properly adapted to the improved equipment available, and if proper use is made of such equipment, there will be a reduction in operating costs, an increase in the production per worker, and a further improvement in the standard of living of the community and in the convenience and pleasantness of agricultural life.

To ensure this result, however, the farmer will have to look at his problems more and more from the engineers' point of view. He must have technical knowledge of the capacity and performance of the equipment he thinks of employing and must balance the probable benefit against the expenditure required, remembering that improved methods, whose adoption may be justified when operating on a sufficiently large scale, may not be warranted when applied in a smaller establishment.

The White Point Beach Meeting—1933

On the Atlantic coast of Nova Scotia, rather more than a hundred miles southwest of Halifax and not far from Liverpool, is White Point Beach, the place selected for the 1933 Maritime gathering which has just concluded. This meeting, at which about one hundred and twenty members, ladies and guests were present, is noteworthy as being the first Professional Meeting of The Institute to be held with the active co-operation and support of one of the Provincial Associations of Professional Engineers. It was in fact a joint undertaking. Some of the sessions were those of a Maritime General Professional Meeting of The Institute; a portion of the time was devoted to a General Meeting of the Association of Professional Engineers of Nova Scotia. The great majority of engineers attending were members of both organizations, so that this arrangement presented no difficulty. It certainly gave an effective demonstration of the way in which the educative and technical work of The Institute can be carried on in conjunction with the official duties of a Professional Association.

Representatives of all the four Maritime Branches of The Institute were present, as well as members of the Association of Professional Engineers of New Brunswick, but the onerous work of preparation for the meeting was actually performed by a joint committee composed of members of the Halifax Branch of The Institute and members of the Association of Professional Engineers of Nova Scotia.

Colonel C. H. L. Jones, M.E.I.C.

The committee's good judgment in selecting White Point Beach as the location for the meeting was fully justified. The Lodge, with good facilities for holding both business and professional sessions, afforded ample opportunity for social functions and for recreation when the serious work of the meeting was over. Access by motor is easy, and Liverpool is only six miles away. The principal power developments of the Nova Scotia Power Commission are on the Mersey river, and at Liverpool is situated the modern newsprint mill of the Mersey Paper Company, which presents many features of interest even to those who are familiar with the technical problems of paper mill engineering and transportation. It is not too much to say that the success of the gathering would have been far less complete without the guidance and generous support of the officers of these two organizations.

The officials of the Commission, notably H. S. Johnston, M.E.I.C., chief engineer, and Howard Fellows, A.M.E.I.C. assistant chief engineer, made elaborate arrangements for the entertainment and information of the delegates, and for the inspection of the three power developments on the Mersey river. In fact, through the kindness of the Commissioners, a guide book was provided giving full explanations as to the construction and operation of this important undertaking.

The generous hospitality of the Mersey Paper Company was an outstanding feature of the meeting. Colonel C. H. L. Jones, M.E.I.C., President of the company, under whose command some of the members present had served overseas, acted as chairman of the committee in charge of arrangements, threw open all departments of the mill for visit by the members, and together with Mrs. Jones overwhelmed the members and ladies by many acts of personal kindness in which he was ably seconded by H. Mowbray Jones, A.M.E.I.C.

In a meeting of this kind the task of the Ladies Committee is not an easy one, as their arrangements must not clash with those of the sterner sex, and must be comple-

*"Economic Aspects of Electrical Supply in the House and on the Farm" (Paper presented at the Second World Power Conference, Berlin) The Engineering Journal, July 1930, page 463.

mentary to the men's programme. That committee, composed of Halifax and Liverpool ladies, worked out a plan which proved particularly enjoyable, thanks to the kindness of Mrs. C. H. L. Jones and Mrs. J. Ross Byrne.

The official proceedings of the Meeting began after luncheon on Thursday, July 13th, when an assembly of the members of the Halifax Branch of The Institute and the Association of Professional Engineers of Nova Scotia was held under the joint chairmanship of the President of the Association, Professor W. P. Copp, M.E.I.C., and the chairman of the Branch, H. S. Johnston, M.E.I.C. The delegates were welcomed in a felicitous speech by His Worship the Mayor of Liverpool, H. D. Madden, Esq. After the transaction of the necessary formal business an adjournment was taken, the members and guests proceeding to the plant of the Mersey Paper Company at Liverpool, where they found a corps of courteous and well informed guides, one of whom was detailed for each party of four or six. As a result everyone had the opportunity to secure information of special value and interest in his particular line of work, a result which can only be attained when careful attention is given to the organization of such a visit, as in the present instance. At the conclusion of their journey through the plant the parties were hospitably received by the officers of the company's steamer "Markland", a ship which has admirable facilities both for the economical carriage of large quantities of newsprint in rolls and the refreshment of visitors who have just absorbed a mass of interesting technical data.

Visit of Party to No. 3 Development, Mersey Power System, Friday, July 14th, 1933.

In the evening the first professional session was held and two papers were presented and discussed. Mr. Fellows chose for his subject the supervisory control system which has been adopted to control the three power developments on the Mersey system of the Nova Scotia Power Commission enabling the two upper stations, which are fully automatic and unattended, to be operated from the switching and control station at No. 3 development. The discussion was of a very technical nature, and the electrical experts evidently enjoyed themselves.

The paper of H. Mowbray Jones, A.M.E.I.C., treated of the system at the Mersey Mill under which a portion of the electric power required by the plant is developed by a 5,000-kw. turbo-generator taking steam at 375 pounds pressure, the turbine exhaust being at a pressure which renders it available for process steam. The paper dealt to some extent with power costs, a most commendable feature which added greatly to its value. Both papers gave rise to active discussion, limited only by the time available. As it was the dancers had to curb their impatience for a time, while the technicians thrashed out their arguments.

On Friday, the 14th, cars were in readiness at 9 a.m. to convey the party to the Nova Scotia Power Commission's developments on the Mersey river. The numbered paragraphs of the handbook specially prepared by the Commissioners, giving leading data regarding the undertaking, corresponded with similarly numbered signs placed at all the points of interest so that he who motored might also read. Personal explanations were kindly given by the officers of the Commission wherever two or three enquirers were gathered together; in fact, nothing was left undone to make the tour informative, and at the point last visited, extremely refreshing.

The party returned to White Point Beach Lodge, where they were most hospitably entertained at lunch by Col. C. H. L. Jones, and did great execution on a multitude of Nova Scotia lobsters.

A general meeting of the Association of Professional Engineers of Nova Scotia followed, at which the President, Professor W. P. Copp, M.E.I.C., was in the chair. He referred briefly to the cordial relations existing between the Professional Associations and The Institute in the Maritime Provinces, and pointed out that the functions of these bodies, while quite distinct in purpose, are equally necessary to the wellbeing of the profession. After the transaction of certain Association business, the formal meeting was adjourned and members present remained for the second professional session, under the chairmanship of C. H. Wright, M.E.I.C. The chairman announced that the completion of the paper presented by Mr. R. W. McColough had been impossible owing to the author's illness, but that Mr. K. MacKenzie of Mr. McColough's department would present one on Concrete Road Surfaces This paper dealt largely with the technique and precautions necessary to obtain satisfactory results in service, and gave rise to prolonged discussion, centring largely on the Nova Scotia road problem, and the extent to which expenditure on permanent pavement, replacing gravel or other low cost surfaces, would be justifiable in that province.

H. S. Johnston, M.E.I.C., Chairman, Halifax Branch.

K. H. Marsh, M.E.I.C., chief engineer of the Dominion Steel and Coal Corporation, Sydney, followed with a paper on the Use of High-Ash Pulverized Coal in Steam Boilers, and gave an illuminating description of the development of the art of using coal of this kind for the service named, referring specially to the pioneer installations in Canada which anticipated many of the most recent methods of design. The discussion, which was unfortunately curtailed due to the limited time available, indicated the special difficulties which had been successfully surmounted at the Seaboard plant at Glace Bay.

The evening was devoted to two important functions, —dining and dancing. The chairman at the banquet was

Professor W. P. Copp, M.E.I.C., President, Association of Professional Engineers of N.S.

Colonel Jones, whose first duty was to announce the receipt of telegrams of regret from President Lefebvre, stating that an unexpected emergency had prevented him from attending—and from Past-President Camsell who had been unable to leave Sydney in time to take part in the meeting. Colonel Jones, in his usual happy vein, filled Dr. Lefebvre's place as principal speaker, and addresses were also delivered by President Copp of the Professional Association, and Chairman Johnston, of the Halifax Branch of The Engineering Institute of Canada, in response to the toasts of the Association and The Institute respectively. The evening was well advanced when dancing commenced, but the company made up for their late beginning by an extension of time at the finish.

The programme prepared for the entertainment of the ladies was as well planned and successful as that for the men, which is saying a good deal. Two of the items most appreciated were the theatre party at the Astor Theatre, Liverpool, and the visit to Mersey Lodge, a delightful camp in the woods fronting the Mersey river, where the ladies were entertained to luncheon by the Mersey Paper Company. Mrs. C. H. L. Jones and Mrs. J. Ross Byrne were the hostesses, and in the afternoon the ladies had the choice of several alternatives—many took advantage of an ideal sailing day and accepted the invitation of Colonel Jones for a cruise on his schooner yacht.

The officers of the Professional Association and of the Halifax Branch have undoubtedly earned the many congratulations which they have received on the success of this meeting. The attendance was unexpectedly large, everyone was enthusiastic, weather conditions were ideal, and the place selected was an inspiration. It would be difficult to recall any Institute meeting from which members departed more reluctantly or which has been more effective in promoting social and professional intercourse between Institute and Association members.

OBITUARIES

Arthur Emile Doucet, M.E.I.C.

Regret is expressed in recording the death at Quebec, Que. on July 16th, 1933, of Captain Arthur Emile Doucet, M.E.I.C.

Captain Doucet was born at Montreal on June 9th, 1860, and graduated from the Royal Military College, Kingston, Ont. in 1880.

Following graduation, Captain Doucet was employed on the construction of the Algoma branch of the Canadian Pacific Railway along the north shores of Lake Huron, and for the next twenty years he was connected with railway construction throughout eastern Canada. When the North-west Rebellion broke out in 1885, he joined the Infantry School Corps and served as aide-de-camp to the late Lieut.-General Sir F. D. Middleton. Later he was engaged on the construction of the Lachine bridge at Montreal, the Cape Breton Railway and the Newfoundland railway. For a time he was divisional engineer for the Canadian Pacific Railway Company at St. Johns, Que., and again worked on the Algoma branch, and was also with the Canadian Pacific in British Columbia.

Captain Doucet went to Quebec in 1900 as chief engineer with the old Quebec and Lake St. John railway, later becoming connected with the building of the Great Northern Trans-Canada and the Transcontinental railways. His most recent work was in connection with the building of the shipping terminal at Wolfe's Cove, Quebec, when he acted as chief construction engineer for the Quebec Harbour Commission.

Captain Doucet became a Member of The Institute (then the Canadian Society of Civil Engineers) on June 9th, 1887, and was a member of Council in 1905, 1908 to 1914, and 1916, 1917 and 1918. In 1910 he was chairman of the Quebec Branch.

Charles Augustine Mullen, M.E.I.C.

Members of The Institute will learn with regret of the death in Montreal on July 13th, 1933, of Charles Augustine Mullen, M.E.I.C.

Mr. Mullen was born at Chapel Point, Charles county, Maryland, on December 29th, 1883.

In 1905, Mr. Mullen became connected with the Barber Asphalt Paving Company in New York, N.Y. and remained with that firm until 1907, being in charge of various paving repairs, as assistant to the superintendent of the company. In 1907 he was sent to Pittsburgh as superintendent in full charge of the company's operations in that city. From 1908 to 1910 Mr. Mullen was in business as an independent paving contractor in New York City, and in 1910-1911 was located at Milwaukee as superintendent of steel construction and repair for the city. In 1912 and 1913 he was commissioner of public works at Schenectady, N.Y. In 1914 Mr. Mullen returned to New York where he was again in business as a contractor, remaining there until 1916, when he became director of the paving department and chief consulting paving engineer for the Milton Hersey Company Limited, at Montreal. In 1927 he was appointed vice-president and managing director of the newly-formed company known as Milton Hersey Ontario Limited, which office he held in addition to his former work and his practice as an independent consulting paving engineer.

William Augustus Bucke, M.E.I.C.

The death of William Augustus Bucke, M.E.I.C., was announced recently as having occurred at Toronto, Ontario, on June 23rd, 1933.

Mr. Bucke was born at Sarnia, Ont., on April 12th, 1873, and following his graduation from the University of

Toronto in 1895, with the degree of B.A.Sc., he entered the service of the Royal Electric Company, Montreal, being on the engineering staff in charge of the testing department and later erecting engineer until 1900. When this company was absorbed by the Canadian General Electric Company Ltd., in 1901, Mr. Bucke was transferred to the staff of the latter organization in the Toronto district office. Six years later, he was appointed manager of the Toronto district office, and upon the formation of the apparatus sales

William Augustus Bucke, M.E.I.C.

department in 1919, Mr. Bucke was appointed manager, which position he held until his death.

Mr. Bucke was a member of the Senate, University of Toronto, of the Toronto Electric Club, the Empire Club, Canadian Club, National Club, the American Institute of Electrical Engineers, and was a past-president of the Toronto Engineers Club.

Mr. Bucke joined The Institute (then the Canadian Society of Civil Engineers) on February 7th, 1907, as an Associate Member, and became a full Member on May 22nd, 1922. He took a keen interest in the affairs of The Institute and was a member of Council in 1914, 1915 and 1916.

It is felt that Mr. Bucke's death has meant a great loss, not only to the company with which he was connected and the electrical engineering profession in Canada, but to his large circle of personal friends.

Angus Lynn Sutherland, A.M.E.I.C.

The membership of The Institute will learn with regret of the death at Toronto, Ont., on June 22nd, 1933, of Angus Lynn Sutherland, A.M.E.I.C.

Mr. Sutherland was born at Chippewa Falls, Wisconsin, U.S.A. on August 21st, 1885, and coming to Canada at an early age was educated in this country, graduating from the University of Toronto with the degree of B.A.Sc. in 1911.

Following graduation, Mr. Sutherland was until 1913 engaged on electrical tests with the Canadian General Electric Company Ltd., later being assistant to the transformer engineer on transformer design and assistant to the data engineer, compiling general engineering data. In 1915-1916 he was in the production department, following up the manufacture of induction motors and repair parts. From March to December 1916, Mr. Sutherland was in charge of production of rifle parts with the Ross Rifle Company, Quebec, and following that was until May, 1918, engaged on engineering and draughting on air compressors and air tools with the Canadian Ingersoll-Rand Company Ltd. He was later, for about nine months, in charge of draughting and detailing marine engines with the same company.

In 1918 Mr. Sutherland returned to the Canadian General Electric Company Ltd., and was located for a time at Peterborough. For the past twelve years he has been distribution transformer engineer at Toronto, Ont.

Mr. Sutherland joined The Institute as an Associate Member on November 25th, 1919.

David Gemmell Wallace, A.M.E.I.C.

Deep regret is expressed in recording the untimely death by accident at Montreal, on July 4th, 1933, of David Gemmell Wallace, A.M.E.I.C.

Mr. Wallace was born at Newmilns, Ayrshire, Scotland on November 17th, 1901, and graduated from Glasgow University with the degree of B.Sc. in mechanical engineering in November 1926.

From 1920 to 1922, and during the summers of 1923 and 1924, Mr. Wallace was an apprentice fitter with Glenfield and Kennedy, hydraulic engineers, Kilmarnock, Scotland, and during the summer of 1925 and from March 1926 to February 1928 he was with the same company in the capacity of draughtsman and designer. Following this, Mr. Wallace was until May 1929 designing engineer with Synthetic Ammonia and Nitrates Limited, Stockton-on-Tees, England.

Coming to Canada in 1929, Mr. Wallace joined the staff of the Dominion Bridge Company Ltd., Lachine, Que., as designing engineer, engaged on estimating and designing sluice head and regulating gates and operating machinery for same for hydro-electric power developments. In 1933 he became connected with the Shell Oil Company of Canada Ltd., Montreal East refinery.

Mr. Wallace was elected a graduate of the Institution of Mechanical Engineers in 1927.

He became an Associate Member of The Institute on September 22nd, 1930.

PERSONALS

J. Lyle McDougall, Jr.E.I.C., is now on the staff of the Sherbrooke Machinery Company Limited, at Sherbrooke, Que. Mr. McDougall was for some time with Price Brothers and Company at Kenogami, Que., and later with the Plessisville Foundry Company, Plessisville, Que.

H. J. Buncke, M.E.I.C., has been appointed chief engineer of the Oxford Paper Company at Rumford, Maine, U.S.A. Mr. Buncke graduated from Columbia University in 1915 with the degree of C.E., and, in 1916, having taken a special course in pulp and paper manufacture at the University of Maine, obtained the degree of M.S. from that institution. In 1916, Mr. Buncke joined the staff of the Abitibi Power and Paper Company as draughtsman and general assistant to the master mechanic, and in 1917, was appointed superintendent of the groundwood mill. In 1918 he served as first lieutenant in the United States Engineers. Returning to the Abitibi Power and Paper Company in 1919, Mr. Buncke became assistant to the manager, and in 1921 he was promoted to the position of plant engineer. From 1923 until 1928 he was chief engineer of the Iroquois Falls division of the company, and in 1928 was appointed chief engineer for the entire group of the company's mills, which position he has held until recently.

R. S. Trowsdale, A.M.E.I.C., has been appointed manager of the Calgary district for the Canadian General Electric Company Limited. A native of Prince Edward Island, Mr. Trowsdale received his early education in Charlottetown, and served his apprenticeship with the

Robb Engineering Company at Amherst, N.S., being assistant to the chief engineer in charge of the test department in 1906 and 1907. From 1907 to 1909, Mr. Trowsdale was in charge of power plant construction for the same company in Nova Scotia, and from 1909 to 1912 filled the same office in Alberta and British Columbia. In 1912 he became connected with the Canadian Allis Chalmers Company as district engineer for Alberta, occupying that position until 1917, when he was appointed district sales engineer for the Canadian General Electiic Company Limited and associated companies in the Calgary district, which position he has held up to the present time. Mr. Trowsdale takes an active interest in the affairs of The Institute, and is a past chairman of the Calgary Branch.

J. J. Macdonald, M.E.I.C., chief engineer of the Halifax Harbour Commission, has resigned to assume charge of the design and construction of a large industrial development in London, the firm of Sir Alexander Gibb and Partners being the consulting engineers for the project in question. Mr. Macdonald is a graduate of McGill University of the year 1911, when he received his degree of B.Sc. Following graduation he took a post graduate course at McGill in the advanced theory of structures. Later Mr. Macdonald entered the employ of Messrs. Waddell and Harrington, consulting bridge engineers, Kansas City, Mo., and specialized in structural design and construction. He was next appointed office engineer on the staff of The Halifax Ocean Terminals project and then served as resident engineer on the construction of sections of the above work. Early in 1919 Mr. Macdonald joined a firm of engineers and contractors with a view to introducing Canadian or American methods of design and construction in connection with reconstruction work in Great Britain and France, and in 1923 he became construction engineer with J. G. White and Company Ltd., of London, England. In 1925 Mr. Macdonald was engaged on the foundation work for the new bridge across the Tyne river at Newcastle, under Sir Douglas Fox and Partners for Dorman Long and Company, Ltd., who secured the contract for the work. In 1926 he returned to Canada as chief engineer for the Foundation Company of Canada, Ltd., with headquarters in Montreal, and in 1930 was appointed chief engineer of the Halifax Harbour Commission.

RECENT ADDITIONS TO THE LIBRARY

Proceedings, Transactions, Etc.

Institution of Mechanical Engineers: Proceedings 1932.
Northeast Coast Institution of Engineers and Shipbuilders: List of Members, 1933.
Corporation of Professional Engineers of the Province of Quebec: Official List of Members, 1933.
Institution of Mechanical Engineers: List of Members, 1933.

Reports, Etc.

Department of Mines, Canada:
Geological Survey Memoir 170—Studies of Geophysical Methods, 1930.
Mines Branch: Investigations in Ceramics and Road Materials, 1930-1931.
Department of Labour, Canada:
Labour Legislation in Canada.
Department of Interior, Canada:
Publications of the Dominion Observatory, Ottawa, Vol. X.
Bibliography of Seismology, No. 17, Jan., Feb., March, 1933.
Department of Trade and Commerce, Canada:
Bureau of Statistics: Condensed Preliminary Report on the Trade of Canada, 1933.
The Asphalt Institute:
Specifications for Liquid Asphaltic Road Materials.
Institution of Civil Engineers:
Report of the Committee on Engineering Quantities.
American Society of Mechanical Engineers:
Committee on Water Hammer; Symposium on Water Hammer.
Air Ministry, Aeronautical Research Committee, Great Britain:
Reports and Memoranda:
No. 1510: Turbulence in the Wake of a Body.
No. 1525: Abstract; Detonation, Spark-Plug Position and Engine Speed.
No. 1508: Critical Reversed Speed for an Elastic Wing.
No. 1524: Abstract—Oxidation of Fuel Vapours in Air.
No. 1506: Theory of Loss of Lateral Control due to Wing Twisting.
No. 1523: Abstract-Intercrystalline Corrosion of Duralumin.
No. 1504: Tests on a Bristol Bulldog fitted with a Thin Townend Ring.
No. 1518: Present Position of Investigation of Airscrew Flutter.
No. 1503: Surging in Centrifugal Superchargers.
No. 1516: Some Possible Advantages of a Variable Pitch Airscrew.
No. 1502: Aircraft Turning Performance.
No. 1515: Spinning of a Bristol Fighter.
No. 1486: Oil Cooling for Aircraft.
No. 1511: Effect of Turbulence on Drag of Airship Models.

Technical Books, Etc., Received

Album Souvenir, *Université de Montréal.*
Trevethick Centenary Commemoration—*Memorial Lecture delivered before the Institution of Civil Engineers,* April 24th, 1933.
Vocational Guidance in Engineering Lines, (*American Association of Engineers*).

BULLETINS

Silent Pinions—Catalogue No. 111, on Silent Pinions of Rawhide or Phenolic Compound, containing 12 pages has been received from the Hamilton Gear and Machine Company, Toronto. This contains some useful information on rawhide or phenolic compound pinions, and outlines the advantages of using silent pinions. The best materials to use under various conditions are given, together with comparisons of the strength of metallic pinions, also points to observe in the installation, lubrication, speed, etc. of these pinions. Horse power ratings per inch of space are given for pinions of from 12 to 60 teeth, from 1 to 18 diametral pitch, for pitch line velocities from 100 to 3000 feet per minute.

Test set, portable—The Roller-Smith Company, New York, have issued a 2-page circular giving details of their new split core transformer and ammeter with which it is possible to obtain alternating current ampere readings as low as ½ ampere and as high as 200 amperes.

Oil Pumps—A 2-page pamphlet listing motor-driven oil pumps and also Kwart Kwick barrel pumps has been received from the Viking Pump Company of Canada, Ltd., Walkerville, Ont.

Lost Russian Turbine

The strange story of a turbine, which was lost for seventeen years in Russia, is confirmed in a bulletin issued by the General Electric Company, Schenectady, New York. It appears that in 1916, this company built a 360-kw. set for the Imperial Russian government which was duly shipped to Riga, where it was landed. On the approach of the German army, however, it was evacuated to the neighbourhood of Moscow, and before it could be installed the revolution occurred and it entirely disappeared. Recently it appeared again near Moscow, but no less than fifty miles from a railway; how it reached that position and what had been its history in the meantime is a mystery. When it was unpacked it was found to be in exceptionally good order. The casing had never been opened and the temporary cover plates over the inlet and exhaust were still in position. When the casing over the coupling was removed the latter was found to be in perfect condition and was still protected by the original coating of oil. Certain parts were missing, but the Soviet government are proposing to replace these and to put the machine into service.—*Engineering.*

Distribution of Pulverized Fuel in Bulk

The announcement is made by H. Tollemache and Co., Ltd., of Canada House, London, that, in order to meet a steadily increasing demand for pulverised coal, they have decided to produce pulverised fuel for marketing purposes, and that a first plant, which is now being erected at a colliery in Yorkshire, will, it is anticipated, be in production in a few weeks time. This is the first practical step yet made to bring this country into line with Germany and America, where, for some years past, pulverised fuel has been available for purchase by consumers. Special arrangements are being made for delivery in small quantities, but for regular consumption the fuel will be distributed in specially designed tank wagons, from which it will be discharged by pipe line into the consumer's bunker, with all the simplicity, convenience, and cleanliness of fuel oil. The special form of wagon used on the Continent for the transport of pulverised fuel is a three-wheeled truck carrying three cylindrical tanks with wedge-shaped bottoms and conical tops. These tanks are loaded through a manhole at the top and when closed are perfectly air-tight. They are discharged by air at a pressure of 30 pounds per square inch through a pipe line or flexible hose directly into the consumers' bunkers. A 10-ton container can be easily discharged in thirty minutes. Under these conditions of handling there is no danger, and it is understood that during ten years of operation in Germany and other countries there has never been an explosion.

BRANCH NEWS

Border Cities Branch

T. H. Jenkins, A.M.E.I.C., Secretary-Treasurer.

Visit to Radio Station CKOK

The regular monthly meeting of the Border Cities Branch was held in the Prince Edward Hotel, Windsor, on February 10th. After the dinner the meeting adjourned to the studios of radio station CKOK, Windsor, where Mr. Carter, chief engineer of CKOK, and Mr. Hill control engineer, described the construction, operation, and management of a modern radio broadcasting station, illustrating their remarks by reference to the equipment in actual operation. The acoustic treatment of the studios, the element of time in broadcasting, were discussed and a complete radio broadcast was outlined from the initial negotiations of the programme to its final production.

The members then motored to the transmitting station of the company where the design, construction, and operation of the transmitter was detailed and the equipment in actual operation was examined at close range.

Technocracy

The regular monthly meeting was held in the Prince Edward Hotel, Windsor, on March 7th. The speaker on this occasion was a member of the Branch, C. M. Goodrich, M.E.I.C., chief engineer of The Canadian Bridge Co., his subject being "Technocracy."

Mr. Goodrich explained that the world "Technocracy" was originally coined by the economist Dr. Thorstein Veblen in 1918 to explain his idea of "government by the technically trained." The current scheme was due to Mr. Howard Scott, self-styled Director of the Energy Survey of North America, sponsored by the Columbia University of New York. The present world economic crisis provided a ready-made setting for the introduction of this system of political economy.

That this introduction was premature; that it was announced as a news sensation, Mr. Goodrich proved by a critical analysis of some of the articles recently appearing in major publications. The principles of "Technocracy" have not been thoroughly and logically founded, and the whole exposition is vague and inaccurate. There is an absurd use of scientific terms and measures.

Conditions in the Far East

The regular monthly meeting and dinner was held in the Prince Edward Hotel, Windsor, on April 21st. The chairman, R. C. Leslie, A.M.E.I.C., introduced the speaker Colonel John W. Warden, D.S.O., O.B.E., who addressed the members on the subject "Conditions in the Far East."

Colonel Warden discussed his experiences as an officer in the British Army during the Great War and as an officer in the Intelligence Service at the close of the War. He stressed particularly the need for engineering services to develop the eastern countries. The Near East and the Orient are rich countries but totally undeveloped in the modern sense. Irrigation, better means of communication, and scientific farming were needed and would provide a wonderful field for engineering. The Near East and the Orient are still to-day much the same countries that they were in Biblical Days.

The speaker produced maps and documents to illustrate his lecture and gave many interesting historical and archeological accounts of much that he had seen in his travels.

Hamilton Branch

Alex. Love, A.M.E.I.C., Secretary-Treasurer.
V. S. Thompson, A.M.E.I.C., Branch News Editor.

A joint meeting of the 1932-33 and the 1933-34 executives of the Branch was held at the home of H. B. Stuart, A.M.E.I.C., on the evening of June 21st. E. P. Muntz, M.E.I.C.—the retiring chairman—unfortunately was unable to attend, so Mr. Stuart occupied the chair during both parts of the proceedings, as vice-chairman of the 1932-33 executive, and chairman of the 1933-34 executive.

After the reading of minutes and financial report the new executive entered officially on its duties.

The following committees were appointed:—

Meetings and Papers..........T. S. Glover, A.M.E.I.C., chairman.
W. J. W. Reid, A.M.E.I.C.
E. C. Hay, S.E.I.C.
Membership..................J. Stodart, M.E.I.C., chairman.
W. J. W. Reid, A.M.E.I.C.
W. Hollingworth, M.E.I.C.
H. W. Blackett, Jr.E.I.C.
Entertainment................E. G. MacKay, A.M.E.I.C.,chairman.
W. Hollingworth, M.E.I.C.
J. R. Dunbar, A.M.E.I.C.
C. Anderson, A.M.E.I.C.
Publicity......................V. S. Thompson, A.M.E.I.C.
J. A. M. Galilee, Affil.E.I.C.
G. Moes, A.M.E.I.C.
A. Dove, S.E.I.C.
Unemployment................E. G. MacKay, A.M.E.I.C., chairman with power to add.

Mr. V. S. Thompson was appointed Branch News Editor and Assistant Secretary.

In accordance with a resolution passed at our recent annual meeting the members will shortly be called on to vote on changes in our Branch By-laws making our Branch year correspond with The Institute year. In the event of this being approved, the new executive will vacate office December 31st, 1933.

Tentative plans have been made to visit two places of interest during the summer months—places which should appeal, as they are in keeping with summer temperatures namely, "The Brewery" and the "City of Hamilton Filtration Plant" now in operation. Members will be notified when the visits will take place and it is expected they will draw a large and interested party.

It is expected that, during the winter months, we shall have joint meetings with the following organizations:—Babcock-Wilcox and Goldie-McCulloch Engineering Society, Galt; Toronto Section A.I.E.E.; Ontario Section A.S.M.E.; Hamilton Chapter, Ontario Association of Architects, and Hamilton Section Canadian Chemical Association.

The executive approved the proposal of Council—that Branches should contribute to the cost of the Plenary Meeting of Council in the fall, on a pro rata basis—and authorized the payment of our share.

It is expected that at the next meeting in September the various committees will have some interesting reports to make, particularly with regard to our winter activities.

London Branch

W. R. Smith, A.M.E.I.C., Secretary-Treasurer.
Jno. R. Rostron, A.M.E.I.C., Branch News Editor.

By the kind invitation of W. R. Smith, A.M.E.I.C., the Branch Secretary, the summer outing was held on the grounds of his country residence in Delaware township on June 24th, 1933.

Mr. Smith takes a personal interest in reforestation and an inspection was made of several groves of young trees which he had planted—mostly Scotch Pine. Some of these, planted about thirteen years ago, had reached a height of from 20 to 25 feet.

The day was very warm and advantage was taken of the spring-fed swimming pool by several of the members.

Games of horse-shoe pitching were enjoyed and rifle and pistol shooting at targets situated across a ravine proved a popular pastime.

A competition was instituted, in which all the company took part, the proceeds from which were to go to the Delaware Church Restoration Fund.

The prizes were a couple of live geese and three live ducks. The engineers who excelled in marksmanship were W. C. Miller, M.E.I.C., of St. Thomas and J. A. Vance, A.M.E.I.C., of Woodstock while three guests made the highest scores, Capt. J. M. Dickinson and J. C. Young of London and A. R. Mendizabal of Sarnia.

A very enjoyable time, topped off by an "al fresco" supper, was spent by all.

About 25 members and guests were present.

Montreal Branch

C. K. McLeod, A.M.E.I.C., Secretary-Treasurer.

Inspection Trip

On July 15th, members of the Montreal Branch of The Institute visited the Caughnawaga bridge, the Dominion Bridge Company's shops, and the Beauharnois power house and control dam.

The party left Headquarters at 9.30 o'clock a.m. in motor cars and proceeded to the bridge, where the trestle caissons and piers were inspected by over 200 members. The work is being done by A. Janin and Company and the Foundation Company of Canada, and Messrs. A. Janin, president of the A. Janin Co., and J. A. Beauchemin, A.M.E.I.C., resident engineer met the party at the bridge. Nine of the fourteen scheduled piers are underway. Eleven of these piers are being built under compressed air by means of pneumatic caissons, and of these six have been completed and the seventh is well in hand. The length of the bridge overall is 4,471 feet 5 inches, the north viaduct, 300 feet 11½ inches; the south viaduct, 1,250 feet, and the width of the roadway 27 feet.

Following this the party proceeded to the main office of the Dominion Bridge Company at Lachine, where they were conducted through the machine assembly shop, the machine shop, shipping yard; No. 4 shop and canal yard, where the falsework, steel and caissons being fabricated for the Caughnawaga bridge, and bedded parts, sluice gates, gantry and bridges being fabricated for the Coteau control dam were inspected.

At this point, the members were the guests of the Dominion Bridge Company at a very excellent lunch served in the company's cafeteria in the basement of the main office building. About one hundred and twenty members accepted the company's hospitality.

After lunch, the party drove to the Beauharnois power house and the control dam site at Coteau, where they were greeted by F. H. Cothran, M.E.I.C., vice-president of Beauharnois Construction Co., and M. V. Sauer, M.E.I.C., chief engineer. An inspection was made of the power house which at the present time is equipped to produce 200,000 h.p. of its ultimate 700,000 h.p. capacity.

The party then proceeded to the Coteau control dam, now under construction near Valleyfield, by means of which the water level in Lake St. Francis will be regulated in order to insure an adequate supply for the Beauharnois canal.

On the return journey, the members travelled along the Beauharnois canal, crossing over bridges at two points, which gave them a good idea of the extent of this project.

Quebec Branch

Jules Joyal, A.M.E.I.C., Secretary-Treasurer.

ANNUAL MEETING

The annual meeting of the Quebec Branch of The Engineering Institute of Canada was held at Montcalm Palace on the evening of May 22nd, 1933.

The minutes of the preceding annual meeting were first read and adopted; then the report of the Executive and financial statement for the year ending on the above-mentioned date were read by the Secretary-Treasurer.

The report showed a decrease in membership of 13 from the previous year.

During the 1932-33 season, seven meetings of the Branch and ten meetings of the Executive were held.

Alex. Larivière, M.E.I.C., chairman of the Branch Unemployment Committee also gave a brief report of the activities of his committee.

Marc Boyer, S.E.I.C., and A. Paradis Affil. E.I.C., (scrutineers) reported the result of the ballot and the Branch Executive Committee is now formed as follows:

Hon. chairman	A. R. Decary, M.E.I.C.
Chairman	Hector Cimon, M.E.I.C.
Vice-chairman	Alex. Larivière, M.E.I.C.
Secretary-Treasurer	Jules Joyal, A.M.E.I.C., Quebec Public Service Commission, Court House, Quebec City.
Executive	L. C. Dupuis, A.M.E.I.C.
	L. Beaudry, A.M.E.I.C.
	R. B. McDunnough, A.M.E.I.C.
	T. J. F. King, A.M.E.I.C.
	J. G. O'Donnell, A.M.E.I.C.
	P. Methé, A.M.E.I.C.
(Ex-Officio)	A. B. Normandin, A.M.E.I.C.

Mr. Cimon, re-elected chairman, voiced his thanks to the meeting for his re-election and also thanked the members of the Executive Committee for their cooperation in the past.

Mirrors in Electromagnetic Oscillograph

Mirrors only 1/64-inch wide, 1/32-inch long and 5/1000-inch thick are used regularly in the general engineering laboratory of the General Electric Company. A single one weighs only about three one-millionths of an ounce.

Used in an electromagnetic oscillograph, each mirror is suspended between magnets by two wires, sometimes only three ten-thousandths of an inch in diameter; the human hair is usually more than ten times that thickness. The mirror moves with each variation of voltage applied to the wires, and traces these variations by means of a beam of light, necessarily tiny, on a sensitive photographic film.

The mirrors are made in the laboratory by silvering a microscope cover glass, diamond ruling it, and breaking it into 2048 pieces per square inch.

Invitation from S.A.E.

The President, H. C. Dickinson, and the officers and members of the Society of Automotive Engineers have extended to the members of The Engineering Institute of Canada, a cordial invitation to attend and participate in the S.A.E. International Automotive Engineering Congress at the Palmer House in Chicago, Ill., August 28th to September 4th, 1933.

THE McCHARLES PRIZE 1933

The Committee of Award for the McCharles Prize for scientific discovery and invention in the treatment of Canadian ores, etc., invites the nomination by responsible persons of eligible candidates for this prize under the terms laid down by the Board of Governors of the University of Toronto. Any such nomination should be forwarded before 1st of November, 1933 to Dean C. H. Mitchell. Chairman of Committee of Award, McCharles Prize, University of Toronto, Toronto. Information regarding these terms will be supplied upon request from responsible persons who may contemplate making a nomination.

Engineers' Week—Chicago

It is difficult to describe adequately the scope of the technical activities at Chicago during Engineers' Week—June 26th-30th. However, a list of some of the societies which met and a synopsis of a few of the papers presented will perhaps give the reader an idea of the tremendous field covered.

The American Society of Mechanical Engineers and the American Society of Civil Engineers presented the largest number of papers, but other societies, including—the American Institute of Electrical Engineers, American Society of Testing Materials and the Society for the Promotion of Engineering Education gave papers of practical importance. Further, numerous associations and committees of national importance took advantage of the presence of the larger societies to hold their meetings and also to conduct a number of joint technical sessions.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS' PAPERS

"A Century of Progress in Fuel Technology" by O. P. Hood who stated that a hundred years ago it was estimated that of the total fuel consumption, 80 per cent was wood, 3 per cent charcoal, 2 per cent bituminous coal and 14 per cent anthracite. There was no coke industry, the distillation of oil from coal had not yet begun and the use of natural gas was infrequent.

"Characteristics of the Twin-Set Hell Gate Boilers" by W. E. Coldwell gave the results of tests efficiency and starting up performance of a 1,000,000-pound per hour sectional header, end to end boiler.

"Standby and Reserve Operation of a Pulverized Fuel Plant" by E. H. Tenny who described the procedure of analysing problems of this nature in the Cohokia station, St. Louis, and the methods of operating the plant during sudden load increases. The ability of the boiler room to meet system fault conditions, it was stated, depended on several factors, some mechanical and some human. In discussing the paper it was agreed by large central station operators that 2 or 3 minutes was about the time limit during which stored energy could carry the sudden increase in load caused by a system fault after that time firing equipment must be up to the new load.

"Practical Plasticity Problems" by George M. Eaton recommended fundamental requirements for creep tests for tubes in service as follows: (*a*) Test piece must include the entire 360 degrees of a service tube. (*b*) Type of stress imposed by test must correspond with service stress. (*c*) Tests must be conducted on sections of tubes removed from service after various lengths of time as well as in the "as shipped" conditions. (*d*) Independent determination of creep resistance must be made on material located in three different portions of the cross section of the tube. (*e*) Tests must be of short duration.

"Recent Progress in X-Ray Inspection of Welds" by H. R. Isenberger described modern X-Ray equipment and practice—by the substitution of photographic paper for film and by other recent improvements, photographs of welds in pressure vessels etc., can now be made at less cost. He further described an oil immersed unit suitable for a boiler shop. This was designed for continuous operation at 300,000 volts and occupies 12 feet of floor space.

JOINT PAPERS A.S.C.E. AND A.S.M.E.

Water Hammer Symposium—A committee, S. Logan Kerr chairman, was appointed to review existing information on water hammer with a view to summarizing the theory, comparing the various methods employed and computing the pressure variations, considering actual water-hammer problems and determining what theories have been confirmed by actual experimentation. As a result of this study arrangements were made to have a number of American engineers present treatises on the various phases of water hammer which were classified as follows:—

(1) Conduits of uniform thickness and diameter, simple conduits;
(2) Conduits of variable thickness and diameter, complex conduits;
(3) Conduits have branch pipes, compound conduits;
(4) Water hammer in pump-discharge conduits;
(5) Surge tanks.

In addition seven papers were presented dealing with different aspects such as—"High-Head Penstock Design" by A. W. K. Billings, "Effects of Surge-Tanks and Surge Tank Risers on Water-Hammer Computations" by Eugene E. Halmos, "Surge Control in Centrifugal Pump Discharge Lines" by Ray S. Quick.

"Oil Firing in Pulverized Coal Furnaces" by James F. Muir discussed the methods developed in a number of plants to cope with the problems that have occurred in the many plants that have changed from coal to oil firing in recent years.

The author observed that it is easy to fire oil in pulverized coal burning furnaces equipped with horizontal cylindrical type coal burners, but that intertube and fan tail burner installations present engineering and economic problems if costly changes in water walls and coal burning equipment are to be avoided. On the whole it is his belief that pulverized coal fired furnaces of water wall or refractory construction are adaptable for oil firing with minor changes.

Other papers were also presented on the "Correlation of Grindability with Actual Pulverizer Performance" by Martin Frisch and G. G. Holder.

"Wind Pressure on Buildings" by O. Flochsbort presented a theory that takes aerodynamic and aerologic factors into consideration and expressed the view that wind design methods at present ignore many facts well known to aeronautical engineers and particularly the presence of high negative pressures on any objects placed in the wind stream. These views were supported by a number of discussors, one of whom reported tests of split H-beam wind connections using four, eight, and sixteen rivets. The sixteen rivet connections wasted the value of many rivets and though the four and eight rivet connections were better the inner lines of rivets carried the greater part of the load. Many other papers of interest were also presented on a variety of subjects.

Impressions of Soviet Russia

An abstract of a paper by Mr. John Banks presented on January 13th, 1933, before the Border Cities Branch of The Institute has been received. This reviews the life and conditions in the U.S.S.R. as the author observed them during a year's residence at Kharkov, Stalingrad and Nishni-Novgorod, as superintendent for the Palmer-Bee Company of Detroit, Mich., and may be of interest.

The Five Year Plan was characterized as Russia's attempt at economic determinism. An ambitious $25,000,000,000 project to industrialize a country that has never been industrial, the Plan has resulted in an amount of work accomplished that is little short of marvellous. While the Plan would never approach within 60 per cent of the original objective, in a cultural way it had influenced for the better the living conditions of the people at large. The extension of the Plan contemplates vast municipal projects in sanitation and the improvement of living conditions generally.

The political philosophy of Russia is still largely Marxian. It is generally assumed that the mass-mind is self-determining, but the Communist Party, which embraces only a small percentage of the population, through propaganda, regulates, directs and formulates this mass-mind.

Many details of the Labour Union organization, worker's rights, and scales of pay were explained and it was estimated that there is too much organization within the ranks of Labour to secure the best results in production. At times these unions work against one another and defeat their own objects. The workers dictate their own methods and conditions of working, and this coupled with the fact that no authority is vested in the leaders makes for great confusion and lost endeavour in carrying out the work.

There is a dearth of skilled labour which results in poor workmanship and spoiled material. Production is hampered by red-tape and undertrained technicians in whom too much responsibility is placed. The Plan has been hindered by poor transportation systems. The railways have not been improved since Tsarist days and are in a bad state of repair and poorly equipped. Accidents are frequent and involve enormous delays.

The present administration has made an about-face from the limited competition policy of the Lenin government. This is evidenced in the new collective farms scheme and the political measures taken to ensure its success by the forced liquidation of the kulacks, or independent farmers. The success of these independent farmers as well as the success of independent merchants and manufacturers has aggravated the constant fear of a return to capitalism so that unusually strenuous legal measures have been taken to offset this menace.

The standard of living is low, food is scarce, and the masses suffer from malnutrition. The death rate is unusually high and medical attention is very poor. The bright spot in the Soviet administration to-day is the attention paid to the advancement of education. Every advantage is offered to those who seek education. The rising generation is offered all the education which the individual is capable of attaining, and opportunity is given to those who merit it by their academic accomplishments.

In conclusion the speaker reviewed the natural resources of Russia with the steps taken by the government to ensure their conservation. Despite her great resources and attempt at industrialization it was the author's opinion that it would be many years before Russia would be able to supply her own needs and many more years before she would become a real factor in world trade.

"Beamcasting" with Ultra-Short Waves

An ultra-short wave generator, producing 9 centimeter waves, and frequencies of 3,300,000,000 cycles, or six and six-tenths billion reversals in direction of the current each second, was recently demonstrated at "A Century of Progress," in Chicago at the Westinghouse exhibit. Approximately one watt of power is transmitted and it is interesting that ultra-short waves of this sort, do not follow the curvature of the earth like those from a broadcasting station, nor are they reflected back and forth around the world like ordinary short waves, but instead go shooting off into space.

Because these ultra short radio waves are unaffected by weather conditions, the so called "beamcaster" can be used in place of light signals and for similar purposes.

In "beamcasting," the sender focuses the invisible radio waves upon a silvered, parabolic mirror which concentrates the rays into a long narrow beam diverging only a few degrees and having almost parallel rays. In the receiver a similar parabolic mirror gathers in the beam waves and focuses them upon a tiny aerial less than two inches long.

At the demonstration the distance was several hundred feet, however, the apparatus has been successfully tested between points more than a mile apart, and there is every indication that it can be successfully used between points located 20 miles and more apart.

That the radio waves have the straight line characteristics of light rays was also shown in the demonstration and radio waves from the sender were reflected off a flat sheet of material to the beamcaster's receiver.

The rays can be deflected by any flat material placed directly in the path of the beam. Metals reflect the radio beam almost completely while non-metallic substances absorb part of the energy. Part of the demonstration was devoted to showing the degree of absorption of various materials such as asbestos board, wood and cardboard.

The transmitter has also been developed so that the radio waves are polarized horizontally. A screen, consisting of wires, about three to the inch and running parallel to the direction of polarization, when placed in front of the beam, does not allow the waves to pass through it, but reflects them in a manner similar to a solid sheet of metal. However, when the wires are placed at right angles to the direction of polarization, the rays pass through unhindered.

The McCharles Prize 1933

Announcement is made that an Award of the McCharles Prize, instituted by the University of Toronto, will shortly be made. This is a distinguished prize for engineers, inventors and scientific research workers. It carries not only a very high honour but a cash value of One Thousand Dollars. The first award was made in 1910, a second during the war, one in 1924 and the present one will constitute the fourth.

This prize was established in connection with the bequest of the late Æneas McCharles of the value of $10,000 and is awarded on the following terms and conditions contained in the bequest and authorized by the Governors of the University of Toronto, namely, that the interest therefrom shall be given from time to time, but not necessarily every year, like the Nobel Prizes in a small way:—

(1) To any Canadian from one end of the country to the other, and whether student or not, who invents or discovers any new and improved process for the treatment of Canadian ores or minerals of any kind, after such process has been proved to be of special merit on a practical scale; (2) Or for any important discovery, invention or device by any Canadian that will lessen the dangers, and loss of life in connection with the use of electricity in supplying power and light; (3) Or for any marked public distinction achieved by any Canadian in scientific research in any useful practical line.

The term "Canadian" for the purpose of the award means any person Canadian born who has not renounced British allegiance, and for the purpose of the award in the first of the three cases provided for by the bequest, domicile in Canada is an essential condition.

Every candidate for the prize is required to be proposed as such in writing by some duly qualified person. A direct application for a prize will not be considered.

No prize will be awarded for any discovery or invention unless it shall have been proved to the satisfaction of the awarding body to possess the special practical merit indicated by the terms and spirit of the bequest.

The order of priority in which the three cases stand in the wording of the bequest will be observed in making the award; that is, "the award shall go *caeteris paribus* to the inventor of methods of smelting Canadian ores; and, failing such inventions, to the inventor of methods for lessening the dangers attendant upon the use of electricity; and only in the third event, if no inventors of sufficient merit in the field of metallurgy and electricity present themselves, to the inventor distinguished in the general field of useful scientific research."

The Committee of Award, appointed by the Governors of the University of Toronto is, under the bequest, composed of an expert in each subject of Mineralogy, Electricity and Physics and four others; this Committee for the present award comprises the Deans of the Engineering Faculties at Toronto and Queen's Universities, the President of the Canadian Institute of Mining and Metallurgy, and four Professors of the University of Toronto.

It is desirable that wide publicity be given throughout Canada to this prize and the Committee of Award announces that it will receive nominations for candidates up to the 1st of November next. Nominations may be made direct to Dean C. H. Mitchell, Chairman of the Committee, at the University of Toronto.

The Hackbridge Transformer Company of Canada, Limited, Montreal, announces its retirement from active operations as a company in Canada, and the appointment of BEPCO (Canada) Limited of Montreal and Toronto as sole agents and distributors of "Hackbridge" power and distribution transformers in Canada as and from August 1st, 1933.

BEPCO (Canada) Limited will also undertake the maintenance and servicing of all Hackbridge transformers installed in Canada and all clients of the Hackbridge Company are requested to communicate with BEPCO's servicing organizations at Montreal and Toronto should any emergency arise.

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

Situation Vacant

COMBUSTION ENGINEER. Experienced in fuel oil burning in industrial plants, capable of making investigations, surveys and reports on boiler plants. Must also have thorough knowledge of industrial fuel oil installation work, be capable of training and handling men and taking full charge of installation of industrial burners. Must have good appearance, be fluent in French and English. University graduate preferred. Reply by letter in own handwriting, giving full particulars as to experience, references and age to Box No. 929-W.

Capital Wanted

Small investment required by engineer to manufacture and market newly perfected radio interference eliminating device. A number now in successful operation. Apply to Box No. 991-W.

Situations Wanted

ELECTRICAL AND RADIO ENGINEER, B.Sc., '28. Experience in the design and testing of broadcast radio receivers, including latest superheterodyne practice, and capable of constructing apparatus for testing same. Also familiar with telephone and telephone repeater engineering. Thorough experience in design, and construction and inspection of municipal power conduits. Apply to Box No. 12-W.

MECHANICAL ENGINEER, Canadian, with technical training and executive experience in both Canadian and American industries, particularly plant layout, equipment, planning and production control methods, is open for employment with company desirous of improving manufacturing methods, lowering costs and preparing for business expansion. Apply to Box No. 35-W.

MECHANICAL ENGINEER, A.M.E.I.C. Married. Experience in machine shops, erection and maintenance of industrial plant mechanical and structural design. Reads German, French, Dutch and Spanish. Seeks any suitable position. Apply to Box No. 84-W.

YOUNG ENGINEER, B.A., B.Sc., A.M.E.I.C., R.P.E., Ont. Competent draughtsman and surveyor. Eight years experience including design, superintendence and layout of pulp and paper mills, hydro-electric projects and general construction. Limited experience in mechanical design and industrial plant maintenance. Apply to Box No. 150-W.

PURCHASING ENGINEER, graduate mechanical engineer, Canadian, married, 34 years of age, with 13 years' experience in the industrial field, including design, construction and operation, 8 years of which had to do with the development of specifications and ordering of equipment and materials for plant extensions and maintenance; one year engaged on sale of surplus construction equipment. Full details upon request. Apply to Box No. 161-W.

STRUCTURAL ENGINEER, B.A.Sc., '15, A.M.E.I.C., R.P.E., (Ont.) Married. Experience in structural steel and concrete includes ten years design, five years sales, two years shop practice and erection, and one year advertising. Available at two weeks notice. Apply to Box No. 193-W.

CIVIL ENGINEER, age 44, open for employment anywhere, experience covers about 20 years' active work, including 7 years on municipal engineering, 2 years as Town Manager, 3 years on railway construction, 3 years on the staff of a provincial highway department, 2 years as contractor's superintendent on pavement construction. Apply to Box No. 216-W.

REINFORCED CONCRETE ENGINEER, B.Sc., P.E.Q., eight years experience in construction design of industrial buildings, office buildings, apartment houses, etc. Age 30. Married. Apply to Box No. 257-W.

MECHANICAL ENGINEER, B.Sc., McGill '19, A.M.E.I.C. Married. Twelve years experience including oil refinery power plant, structural and reinforced concrete design, factory maintenance, steam generation and distribution problems, heating and ventilating. Available at once. Location immaterial. Apply to Box No. 265-W.

ELECTRICAL ENGINEER, B.Sc., '28, Canadian. Age 25. Experience includes two summers with power company; thirteen months test course with C.G.E. Co.; telephone engineering, and the past thirty months with a large power company in operation and maintenance engineering. Location immaterial and available immediately. Apply to Box No. 266-W.

PLANE-TABLE TOPOGRAPHER, B.Sc., in C.E. Thoroughly experienced in modern field mapping methods including ground control for aerial surveys. Fast and efficient in surveys for construction, hydro-electric and geological investigations. Apply to Box No. 431-W.

Situations Wanted

ELECTRICAL ENGINEER, B.Sc., A.M.E.I.C., AM.A.I.E.E., age 30, single. Eight years experience H.E. and steam power plants, substations, etc., shop layouts, steel and concrete design. Location immaterial. Available immediately. Apply to Box No. 435-W.

CIVIL ENGINEER, B.A.Sc., A.M.E.I.C., Jr.A.S.C.E., age 28, married. Experience: construction, design, cost estimating on hydro-electric and storage work, also railway. Desires work in engineering, industrial or commercial fields. Available at once. Apply to Box No. 447-W.

CIVIL ENGINEER, B.Sc., A.M.E.I.C., with six years experience in paper mill and hydro-electric work, desires position in western Canada. Capable of handling reinforced concrete and steel design, paper mill equipment and piping layout, estimates, field surveys, or acting as resident engineer on construction. Now on west coast and available at once. Apply to Box No. 482-W.

MECHANICAL ENGINEER, B.Sc. Age 28, married. Four and a half years on industrial plant maintenance and construction, including shop production work and pulp and paper mill control. Also two and a half years on structural steel and reinforced concrete design. Located in Toronto. Available at once. Apply to Box No 521-W.

CIVIL ENGINEER, Canadian, married, twenty-five years' technical and executive experience, specialized knowledge of industrial housing problems and the administration of industrial towns, also town planning and municipal engineering, desires new connection. Available on reasonable notice. Personal interview sought. Apply to Box No. 544-W.

Unemployment Data

It was decided at a recent meeting of The Institute Unemployment Committee under the chairmanship of D. C. Tennant, M.E.I.C., that it would be advisable to present a complete up-to-date report of the unemployment situation to the Plenary Meeting of Council in September.

Chairmen of Branch Unemployment Committees will, therefore, receive a request for all available data from the Secretary within the next few days, and in order to assist them in gathering the complete information which will be required, it will be appreciated if members will aid the committee by furnishing (unsolicited) to their Branch Unemployment Committees, any useful information regarding unemployment conditions in their Branch.

ELECTRICAL AND MECHANICAL ENGINEER, B.Sc., A.M.E.I.C. Experience includes C.G.E. Students Test Course and six years in engrg. dept. of same company on design of electrical equipment. Four summers as instrumentman on surveying and highway construction. Recently completed course in mechanical engineering. Available at once. Location preferred Ontario, Quebec, or Maritimes. Apply to Box No. 564-W.

MECHANICAL ENGINEER, A.M.E.I.C., with twenty years experience on mechanical and structural design, desires connection. Available at once. Apply to Box No. 571-W

MECHANICAL ENGINEER, B.A.Sc., '30, desires position to gain experience, and which offers opportunity for advancement. Experience in pulp and paper mill and one year in mechanical department of large electrical company. Location immaterial. Available immediately. Apply to Box No. 577-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.

MECHANICAL ENGINEER, Canadian, technically trained; eighteen years experience as foreman, superintendent and engineer in manufacturing, repair work of all kinds, maintenance and special machinery building. Location immaterial. Available at once. Apply to Box No. 601-W.

Situations Wanted

CHEMICAL ENGINEER, S.E.I.C., B.Sc., University of Alberta, '30. Age 31. Single. Six seasons' practical laboratory experience, three as chief chemist and three as assistant chemist in cement plant; one year's p.g. work in physical chemistry; three years' experience teaching. Desires position in any industry with chemical control. Available immediately. Apply to Box No. 609-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.

CIVIL ENGINEER, A.M.E.I.C., R.P.E., Ontario; three years construction engineer on industrial plants; fourteen years in charge of construction of hydraulic power developments, tower lines, sub-stations, etc.; four years as executive in charge of construction and development of harbours, including railways, docks, warehouses, hydraulic dredging, land reclamation, etc. Apply to Box No. 647-W.

MECHANICAL ENGINEER, A.M.E.I.C., Canadian, technically trained; six years drawing office. Office experience, including general design and plant layout. Also two years general shop work, including machine, pattern and foundry experience, desires position with industrial firm in capacity of production engineer or estimator. Available on short notice. Apply to Box No 676-W.

ELECTRICAL ENGINEER, B.Sc., '29, Jr.E.I.C. Age 26. Undergraduate experience in surveying and concrete foundations; also four months with Canadian General Electric Co. Thirty-three months in engineering office of a large electrical manufacturing company since graduation. Good experience in layouts, switching diagrams, specifications and pricing. Best of references. Available immediately. Apply to Box No. 693-W

MECHANICAL ENGINEER, Jr.E.I.C., grad. Tech. Coll., age 29. Seven years experience pulp and paper mill design and maintenance. Hydro developments. Recently designing engineer road making machinery, hoists, crushers, gravel plants, graders, foundry and machine shop supervision. Paper machine design, building construction. Technical advertising. Location immaterial. Apply to Box No. 699-W.

MECHANICAL ENGINEER, B.Sc., '27, Jr.E.I.C. Four years maintenance of high speed Diesel engines units, 200 to 1,300 h.p. Also maintenance of D.C. and A.C. electrical systems and machinery. Draughting experience. Westinghouse apprenticeship course. Practical mechanical and electrical engineer with a special study of high speed Diesel engine design, application and operation. Location in western or eastern Canada immaterial. Apply to Box No 703-W.

COMBUSTION ENGINEER, R.P.E., Manitoba. A.M.E.I.C. Wide experience with all classes of fuels. Expert designer and draughtsman on modern steam power plants. Experienced in publicity work. Well known throughout the west. Location. Winnipeg or the west. Available at once. Apply to Box No. 713-W.

YOUNG ENGINEER, B.A.Sc., (Univ. Toronto '27), Jr.E.I.C. Four years practical experience, buildings, bridges, roadways, as inspector and instrumentman. Available at once. Present location, Montreal. Apply to Box No. 714-W.

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

MECHANICAL ENGINEER, age 41, married. Eleven years designing experience with project of outstanding magnitude. Machinery layouts, checking, estimating and inspecting. Twelve years previous engineering, including draughting, machine shop and two years chemical laboratory. Highest references. Apply to Box No. 723-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.

DESIGNING ENGINEER, M.Sc. (McGill Univ.), D.L.S., A.M.E.I.C., P.E.Q. Experience in design and construction of water power plants, transmission lines, field investigations of storage, hydraulic calculations and reports. Also paper mill construction, railways, highways, and in design and construction of bridges and buildings. Available at once. Apply to Box No. 729-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

CIVIL ENGINEER, M.Sc., 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.

ELECTRICAL AND RADIO ENGINEER, B.Sc. '31, S.E.I.C. Age 25. Nine months experience on installation of power and lighting equipment. Eight months on extensive survey layouts. Two summers installing telephone equipment. Specialized in radio servicing and merchandising. Available at once. Location immaterial. Apply to Box No 740-W

CIVIL ENGINEER, graduate '29. Married. One year building construction, one year hydro-electric construction in South America, fourteen months resident engineer on road construction. Working knowledge of Spanish. Apply to Box No. 744-W.

Situations Wanted

SALES ENGINEER, B.Sc., McGill, 1923, A.M.E.I.C. Age 33. Married. Extensive experience in building construction. Thoroughly familiar with steel building products; last five years in charge of structural and reinforcing steel sales for company in New York state. Available at once. Located in Canada. Apply to Box No. 749-W.

DESIGNING ENGINEER, graduate Univ. Toronto '26. Thoroughly experienced in the design of a broad range of structures, desires responsible position. Apply to Box No. 761-W.

MECHANICAL ENGINEER, graduate, '23, A.M.E.I.C., P.E.Q., age 32, married. (English and French.) Two years shop, foundry and draughting experience; one year mechanical supt. on construction; six years designing draughtsman in consulting engineers' offices (mechanical equipment of buildings, heating, sanitation, ventilation, power plant equipment, etc.). Present location Montreal. Available immediately. Montreal or Toronto preferred. Apply to Box No. 766-W.

CIVIL ENGINEER, S.E.I.C., B.Sc. Queen's Univ '29. Age 25. Married. Three years experience as construction supt. and estimator for contracting firm. Experience includes general building, bridges, sewer work, concrete, boiler settings, sand blasting of bridges and spray painting. Available at once. Apply to Box No. 767-W.

ELECTRICAL ENGINEER, B.Sc. (McGill Univ. '29), S.E.I.C. Married. Experience in pulp and paper mill mechanical maintenance, estimates and costs and machine shop practice. Desires position with industrial or manufacturing concern. Location immaterial. Available on short notice. References. Apply to Box No. 770-W.

ELECTRICAL ENGINEER, Queen's Univ. '24, Jr.E.I.C., age 32, married. Experience includes, student Test Course, Can. Gen. Elec. Co., four years dial system telephone engineering with large manufacturing company. Available at once. Apply to Box No. 772-W.

CIVIL ENGINEER, B.Sc., '25, Jr.E.I.C., P.E.Q., married. Desires position, preferably with construction firm. Experience includes railway, monument and mill building construction. Available immediately. Apply to Box No. 780-W.

DRAUGHTSMAN, experience in civil engineering, forestry engineering, land surveying and house construction. Good references. Apply to Box No. 781-W.

ELECTRICAL AND SALES ENGINEER, S.E.I.C., grad. '28. Experience includes one year test course, one year switchboard design and two years switchboard and switching equipment sales with large electrical manufacturing company. Three summers Pilot Officer with R.C.A.F. Available at once. Apply to Box No. 788-W.

SALES REPRESENTATIVE. Electrical engineer with ten years experience in power field interested in representing established firm for electrical or mechanical product in Montreal territory. Excellent connections Apply to Box No. 795-W.

CIVIL ENGINEER, S.E.I.C., graduate '30, age 23, single. Experience includes mining surveys, assistant on highway location and construction, and assistant on large construction work. Steel and concrete layout and design. Apply to Box No. 809-W.

CIVIL ENGINEER, college graduate, age 27, single. Experience includes surveying, draughting concrete construction and design, street paving both asphalt and concrete. Available at once; will consider anything and go anywhere. Apply to Box No. 816-W.

CIVIL ENGINEER, B.E. (Sask. Univ. '32), S.E.I.C. Single. Experience in city street improvements; sewer and water extensions. Good draughtsman. References. Available at once. Location immaterial. Apply to Box No. 818-W.

CIVIL ENGINEER, S.E.I.C., B.Sc. (Queen's '32), age 21. Three summers surveying in northern Quebec. Interested in hydraulics and reinforced concrete. Available at once. Location immaterial. Apply to Box No. 822-W.

CIVIL ENGINEER, B.Sc., A.M.E.I.C., with fifteen years experience mostly in pulp and paper mill work, reinforced concrete and structural steel design, field surveys, layout of mechanical equipment, piping. Available at once. Apply to Box No. 825-W.

ELECTRICAL ENGINEER. S.E.I.C., grad. '29, age 24, married; experience includes one year Students Test Course, sixteen months in distribution transformer design and eight months as assistant foreman in charge of industrial control and switchgear tests. Location immaterial. Available at once. Apply to Box No. 828-W.

SALES ENGINEER, M.E.I.C., graduate civil engineer with twenty years experience in the structural, sales, and municipal engineering fields, and as manager of engineering sales office. Available at once. Apply to Box No. 830-W.

CIVIL ENGINEER, B.A.Sc., O.L.S., O.L.S., A.M.E.I.C., age 46, married. Twelve years experience in charge of legal field surveys. Owns own surveying equipment. Eight years on technical, administrative, and editorial office work. Experienced in writing. Desires position on survey work, assisting in or in charge of preparation of house organ, on staff of technical or semi-technical magazine, or on publicity, editorial or administrative office work. Available at once. Will consider any salary, and any location. Apply to Box No. 831-W.

AERONAUTICAL ENGINEER, B.Sc. (McGill), M.Sc. (Mass, Inst. Tech.). Canadian. Age 26, recent graduate. Capable of aeroplane design and stress analysis. Apply to Box No. 838-W.

Situations Wanted

CIVIL ENGINEER, M.Sc., R.P.E. (Sask). Age 27. Experience in location and drainage surveys, highways and paving, bridge design and construction city and municipal developments, power and telephone construction work. Available on short notice. Apply to Box No. 839-W.

CIVIL ENGINEER, S.E.I.C., B.Sc. '32 (Univ. of N.B.). Age 25, married. Two years experience in power line construction and maintenance; one year of highway construction; one summer surveying for power plant site, location and spur railway line construction. Available at once. Location immaterial. Apply to Box No. 840-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.

CIVIL ENGINEER, B.Sc. (Alta. '31), S.E.I.C., age 24. Experience, three summers on railroad maintenance, and seven months on highway location as instrumentman. Willing to do anything, anywhere, but would prefer connection with designing or construction firm on structural works. Available immediately. Apply to Box No. 846-W.

MECHANICAL ENGINEER, Jr.E.I.C., technical graduate, bilingual, age 30. Two years as designing heating draughtsman with one of the largest firms of its kind on this continent handling heating materials; three years designing draughtsman in consulting engineers' office, mechanical equipment of buildings, heating, ventilation, sanitation, power plant equipment, writing of specifications, etc. Present location Montreal. Available at once. Apply to Box No. 850-W.

BRIDGE AND STRUCTURAL ENGINEER, A.M.E.I.C., McGill. Twenty-five years' experience on bridge and structural staffs. Until recently employed. Familiar with all late designs, construction, and practices in all Canadian fabricating plants. Desirous of employment in any responsible position, sales, fabrication or construction. Apply to Box No. 851-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.

MECHANICAL ENGINEER, B.Sc. '32, S.E.I.C. Good draughtsman. Undergraduate experience:—One year moulding shop practice; two years pipe fitting and sheet metal work; one year draughting and tracing on paper mill layout; six months machine shop practice; and eight months fuel investigation and power heating plant testing. Desires position offering experience in steam power plants or heating and ventilating design. Will go anywhere. Apply to Box No. 858-W.

MECHANICAL ENGINEER, age 31, graduate Sheffield (England) 1921; apprenticeship with firm manufacturing steam turbine generators and auxiliaries and subsequent experience in design, erection, operation and inspection of same. Marine experience B.O.T. certificate thoroughly conversant with Canadian plants and equipment. Available on short notice. Any location. Box No. 860-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.

ENGINEER, McGill Sci. '21-'25, S.E.I.C., aerial mapping, stereoscopic contour work; lumber classification; highway, railway and transmission line locations; estimates; water storage investigations, etc. Five years ground surveys; three years aerial mapping. Bilingual. Available on short notice. Apply to Box No. 872-W.

CONSTRUCTION ENGINEER (Toronto Univ. of '07). Experience includes hydro-electric, municipal and railroad work. Available immediately. Location immaterial. Apply to Box No. 886-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.Sc., Montreal 1930, age 26, single, French and English, desires position technical or non-technical in engineering, industrial or commercial fields, sales or promotion work. Experience includes three years in municipal engineering on paving, sewage, waterworks, filter plant equipment, layout of buildings, etc. Available immediately. Apply to Box No. 891-W.

ELECTRICAL ENGINEER, grad. Univ. of N.B. '31. Experienced in surveying and draughting, requires position. Available at once Will go anywhere. Apply to Box No. 893-W.

CIVIL ENGINEER, B.A.Sc., Jr.E.I.C., age 29, single. Experience includes two years in pulp mill as draughtsman and designer on additions, maintenance and plant layout. Three and a half years in the Toronto Buildings Department checking steel, reinforced concrete, and architectural plans. Available at once. Location immaterial. At present in Toronto. Apply to Box No. 899-W.

ENGINEER, Jr.E.I.C., specializing in reconnaissance and preliminary surveys in connection with hydro-electric and storage projects. Expert on location and construction of transmission lines, railways and highways. Capable of taking charge. Location immaterial. Apply to Box No. 901-W.

Situations Wanted

MECHANICAL ENGINEER, Canadian, age 25, B.Sc. (Queen's '32). Since graduation on supervision of large building construction. Undergraduate experience in electrical, plumbing and heating, and locomotive trades. Available at once. Apply to Box No. 903-W.

DESIGNING ENGINEER, A.M.E.I.C. Permanent and executive position preferred but not essential. Fifteen years experience in designing power plants, engine and fan rooms, kitchens and laundries. Thoroughly familiar with plumbing and ventilating work, pneumatic tubes, and refrigeration, also heating, electrical work, and specifications. Apply to Box No. 913-W.

INDUSTRIAL ENGINEER, B.Sc. in M.E., age 25, married, is open for a position of a permanent nature with an industrial concern. Experience includes three years in various divisions of a paper mill and two years in an electrical company. Apply to Box No. 917-W

ENGINEER, B.Sc., A.M.E.I.C., R.P.E. (N.B.), age 35, married. Seven years' mining experience as sampler, assayer, surveyor, field work, and foreman in charge of underground development; two years as assistant engineer on highway construction and maintenance. Available on short notice. Apply to Box No. 932-W.

CIVIL ENGINEER, B.Sc., '25, McGill Univ., Jr.E.I.C., P.E.Q., age 32, married. Experience as rodman and instrumentman on track maintenance. Seven and one-half years with Canadian paper company, as assistant office engineer handling all classes of engineering problems in connection with woods operations, i.e., road buildings, piers, booms, timber bridges, depots, dams, etc. Apply to Box No 933-W.

ELECTRICAL ENGINEER, Dipl. of Eng., B.Sc. (Dalhousie Univ.), S.B. and S.M. in E.E. (Mass. Inst. of Tech.), Canadian. Married. Seven and a half years' experience in design, construction and operation of hydro, steam and industrial plants. For past sixteen months field office electrical engineer on 510,000 h.p. hydro-electric project. Available at once. Apply to Box No. 936-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.

ELECTRICAL ENGINEER, twenty years experience, desires position, either temporary or permanent. Experienced in design, construction, and operation of power and industrial plants, and supt. of construction. Apply to Box No. 974-W

INDUSTRIAL ENGINEER, B.Sc., in C.E. (McGill Univ. '30), graduate student in industrial engineering '33 session, age 27, single, available for a position of temporary or permanent nature with industrial concern. Has theoretical knowledge of latest methods of market analysis, production control, management and cost accounting. Also experience in the design and construction of industrial buildings. Location immaterial. Apply to Box No. 981-W.

CIVIL ENGINEER, B.Sc. (Univ. of Sask. '33), S.E.I.C., age 28, single. Experience in testing hydro-electric equipment, draughting, surveying, city street, improvements, technical photography. Available at once. Location immaterial. Apply to Box No. 986-W.

MECHANICAL ENGINEER, S.E.I.C., B.Sc., Queen's University '33. Age 24, desires position on power plant and power distribution problems, factory maintenance, heating and ventilation or refrigeration design. Willing to work for living expenses in order to gain experience. Apply to Box No. 999-W.

ELECTRICAL ENGINEER, S.E.I.C., B.Sc., (N.S. Tech. Coll., '33), desires work. Experience in transmission line construction. Location or class of work immaterial. Apply to Box No. 1010-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.

CIVIL ENGINEER, B.Sc. (Queen's 14), A.M.E.I.C., Dominion Land Surveyor, 5 months' special course at the University of London, England, in municipal hygiene and reinforced concrete construction. Experience covers legal and topographic surveys, plane tabling and stadia surveying, railway and highway construction, drainage and excavation work. Available at once. Apply Box No. 1035-W.

MECHANICAL ENGINEER, S.E.I.C., B.Sc. (Queen's Univ. '33). Will work for living expenses anywhere to gain experience. Maintenance, operation, sales, or design of machinery preferred. Apply to Box No. 1042-W.

For Sale

THEODOLITE—A Cooke-Troughton theodolite, 4 in. hor. circ. to 10 secs. direct by microms. 4 in. vert. circ. to 30 secs. by verniers. 12 in. telescope, 2 in. objective. Wt. under 151 lbs. short standards, does not transit, telescope rocks 40 degs. Slightly damaged but accuracy not greatly affected.

DRAUGHTING TABLE—Keuffel & Esser, Hudson draughting table 36″ by 60″, tilting top, with two drawers. Practically new.

BAROMETER—Harrison Aneroid mining barometer. 2,000′ descent, 5,000′ ascent.

PLAN FILE—Pigeon hole steel plan file 2′ by 5′ by 6½′ (12 pigeon holes).

The above are all located in Montreal, and information may be secured regarding any article, from the Secretary: The Engineering Institute of Canada, 2050 Mansfield Street, Montreal, Que.

Purchasers' Classified Directory

A Selected List of Equipment, Apparatus and Supplies

For Alphabetical List of Advertisers see page 14.

A

Acids:
Canadian Industries Limited.
Aerial Survey:
Canadian Airways Ltd.
Ammeters and Voltmeters:
Bepco Canada Ltd.
Crompton Parkinson (Canada) Ltd.
Angles, Steel:
Bethlehem Steel Export Corp.
U.S. Steel Products Co.
Ash Handling Equipment:
Babcock-Wilcox & Goldie McCulloch Ltd.
Combustion Engineering Corp. Ltd.
E. Long Ltd.

B

Ball Mills:
Dominion Engineering Works Limited.
Ball Mill Liners:
Sorel Steel Foundries Ltd
Balls, Steel and Bronze:
Can. S.K.F. Co. Ltd.
Barking Drums:
Canadian Ingersoll-Rand Company, Limited.
Bars, Steel and Iron:
Bethlehem Steel Export Corp.
U.S. Steel Products Co.
Bearings, Ball and Roller:
Can. S.K.F. Co. Ltd.
Billets, Blooms, Slabs:
Bethlehem Steel Export Corp.
U.S. Steel Products Co.
Bins:
Canada Cement Co. Ltd.
Blasting Materials:
Canadian Industries Limited.
Blowers, Centrifugal:
Can. Ingersoll-Rand Co. Ltd.
Blue Print Machinery:
Montreal Blue Print Co.
Boilers:
Babcock-Wilcox & Goldie-McCulloch Ltd.
Combustion Engineering Corp. Ltd.
Foster Wheeler Limited.
Wm. Hamilton Ltd.
E. Leonard & Sons Ltd.
Vulcan Iron Wks. Ltd.
Boilers, Electric:
Can. General Electric Co. Ltd.
Dominion Engineering Works Limited.
Northern Electric Co. Ltd.
Boilers, Portable:
E. Leonard & Sons Ltd.
Boxes, Cable Junction:
Northern Electric Co. Ltd.
Braces, Cross Arm, Steel, Plain or Galvanized:
Northern Electric Co. Ltd.
Brackets, Ball Bearing:
Can. S.K.F. Co. Ltd.
Brakes, Air:
Can. General Elec. Co. Ltd.
Brakes, Magnetic Clutch:
Northern Electric Co. Ltd.
Bridge-Meggers:
Northern Electric Co. Ltd.
Bridges:
Canada Cement Co. Ltd.
Dominion Bridge Co. Ltd.
Bucket Elevators:
Jeffrey Mfg. Co. Ltd.
Plessisville Foundry.
Buildings, Steel:
Dominion Bridge Co. Ltd.

C

Cables, Copper and Galvanized:
Northern Electric Co. Ltd.
Cables, Electric, Bare and Insulated:
Can. Westinghouse Co. Ltd.
Can. General Electric Co. Ltd.
Northern Electric Co. Ltd.
U.S. Steel Products Co.
Caissons, Barges:
Dominion Bridge Co. Ltd.
Cameras:
Associated Screen News Ltd.
Capacitors:
Bepco Canada Ltd.
Can. Westinghouse Co. Ltd.
Lancashire Dynamo & Crypto Co. of Can. Ltd.
Cars, Dump:
E. Long Ltd.
Castings, Brass:
The Superheater Co. Ltd.
Castings, Iron:
Babcock-Wilcox & Goldie-McCulloch Ltd.
Dominion Engineering Works.
Wm. Hamilton Ltd.
E. Leonard & Sons Ltd.
E. Long Ltd.
The Superheater Co. Ltd.
Vulcan Iron Wks. Ltd.
Castings, Steel:
Sorel Steel Foundries Ltd.
Vulcan Iron Wks. Ltd.
Catenary Materials:
Can. Ohio Brass Co. Ltd.
Cement Manufacturers:
Canada Cement Co. Ltd.
Chains, Silent and Roller:
The Hamilton Gear & Machine Co. Ltd.
Jeffrey Mfg. Co Ltd.
Chains, Steel:
Sorel Steel Foundries Ltd.
Channels:
Bethlehem Steel Export Corp.
Hamilton Bridge Co. Ltd.
U.S. Steel Products Co.
Chemicals:
Canadian Industries Limited.
Chemists:
Milton Hersey Co. Ltd.
Chippers, Pneumatic:
Canadian Ingersoll-Rand Company, Limited.
Choke Coils:
Ferranti Electric Co.
Circuit Breakers:
Can. General Elec. Co. Ltd.
Can. Westinghouse Co. Ltd.
Northern Electric Co. Ltd.
Clarifiers, Filter:
Bepco Canada Ltd.
Crompton Parkinson (Canada) Ltd.
Clutches, Ball Bearing Friction:
Can. S.K.F. Co. Ltd.
Clutches, Magnetic
Northern Electric Co. Ltd.
Coal Handling Equipment:
Babcock-Wilcox & Goldie-McCulloch Ltd.
Combustion Engineering Corp. Ltd.
E. Long Ltd.
Combustion Control Equipment:
Bailey Meter Co. Ltd.
Compressors, Air and Gas:
Babcock-Wilcox & Goldie-McCulloch Ltd.
Canadian Ingersoll-Rand Company, Limited.
Foster Wheeler Co.
Concrete:
Canada Cement Co. Ltd.
Condensers, Steam:
Babcock-Wilcox & Goldie-McCulloch Ltd.
Canadian Ingersoll-Rand Company, Limited.
Foster Wheeler Limited.
Condensers, Synchronous and Static:
Bepco Canada Ltd.
Can. General Elec. Co. Ltd.
Can. Westinghouse Co. Ltd.
Crompton Parkinson (Canada) Ltd.
Harland Eng. Co. of Can. Ltd.
Lancashire Dynamo & Crypto Co. of Can. Ltd.
Northern Electric Co. Ltd.
Bruce Peebles (Canada) Ltd.
Conduit:
Can. General Elec. Co. Ltd.
Can. Westinghouse Co. Ltd.
Northern Electric Co Ltd.
Conduit, Underground Fibre, and Underfloor Duct:
Northern Electric Co. Ltd.
Conduit Fittings:
Northern Electric Co. Ltd.
Conduits, Wood Pressure Creosoted:
Canadian Wood Pipe & Tanks Ltd.
Controllers, Electric:
Can. General Elec. Co. Ltd.
Can. Westinghouse Co. Ltd.
Northern Electric Co. Ltd.
Couplings:
Dart Union Co. Ltd.
Dresser Mfg Co. Ltd.
Couplings, Flexible:
Dominion Engineering Works Limited.
Dresser Mfg. Co. Ltd.
The Hamilton Gear & Machine Co. Ltd.
Cranes, Hand and Power:
Dominion Bridge Co.
Cranes, Locomotive:
Dominion Hoist & Shovel Co. Ltd.
Cranes, Shovel, Gasoline Crawler, Pillar:
Dominion Hoist & Shovel Co. Ltd.
Crowbars:
B. J. Coghlin Co. Ltd.
Crushers, Coal and Stone:
Canadian Ingersoll-Rand Company, Limited.
Jeffrey Mfg. Co. Ltd.

D

Dimmers:
Northern Electric Co. Ltd.
Disposal Plants, Sewage:
W. J. Westaway Co. Ltd.
Ditchers:
Dominion Hoist & Shovel Co. Ltd
Drills, Pneumatic:
Canadian Ingersoll-Rand Company, Limited.
Dynamite:
Canadian Industries Limited.

E

Economizers, Fuel:
Babcock-Wilcox & Goldie-McCulloch Ltd.
Combustion Engineering Corp. Ltd.
Foster Wheeler Limited.
Ejectors:
Darling Bros. Ltd.
Elbows:
Dart Union Co. Ltd.
Electric Blasting Caps:
Canadian Industries Limited.
Electric Railway Car Couplers:
Can. Ohio Brass Co. Ltd.
Electric Trucks:
The Can. Fairbanks-Morse Co. Ltd.
Electrical Supplies:
Can. General Elec. Co. Ltd.
Can. Ohio Brass Co Ltd.
Can. Westinghouse Co. Ltd.
Northern Electric Co. Ltd.
Electrification Materials, Steam Road:
Can. Ohio Brass Co. Ltd.
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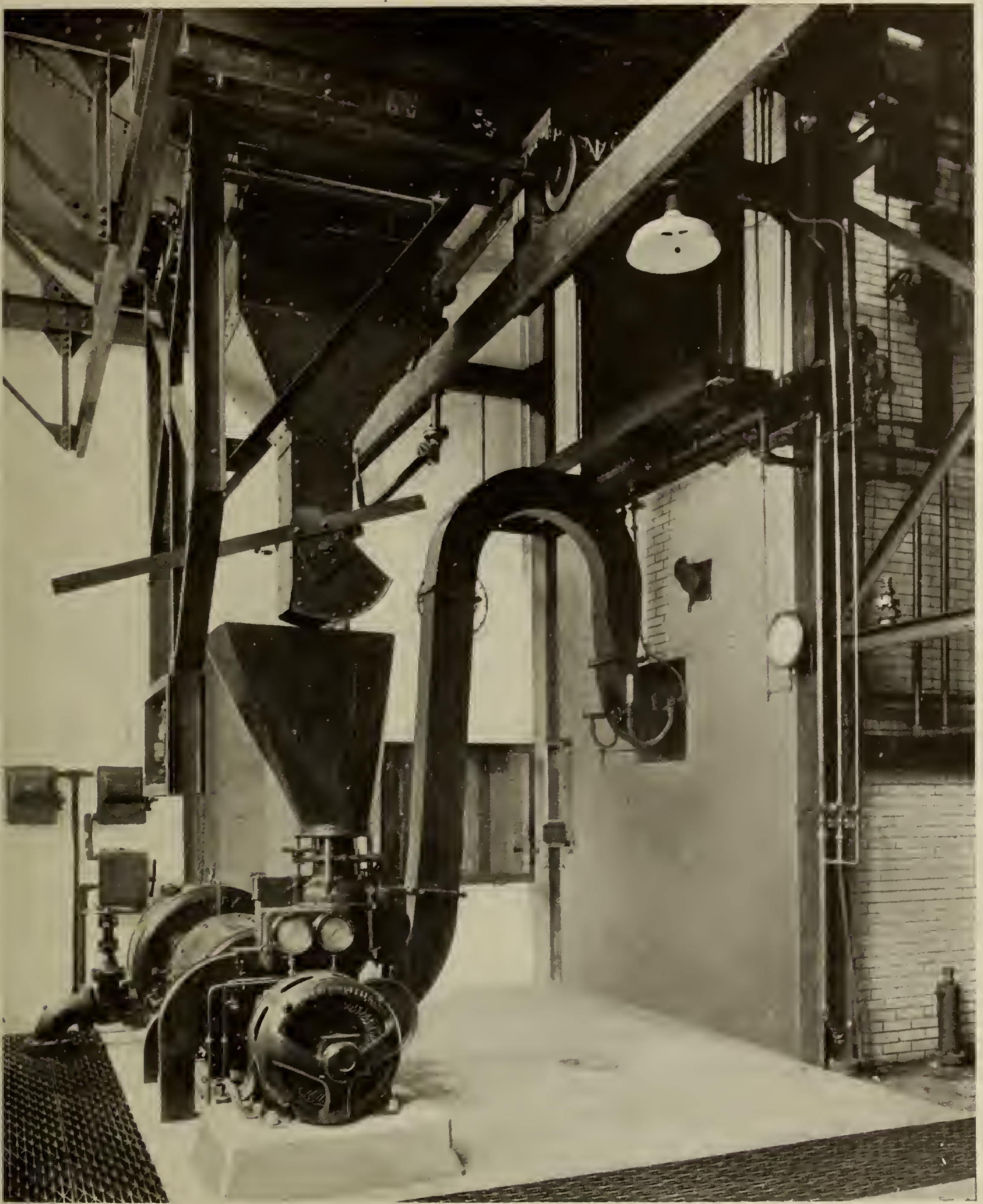

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106-A
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PHOTO AT RIGHT—
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Burrard Bridge from the Northeast.

The Burrard Bridge, Vancouver

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Paper presented before the Vancouver Branch of The Engineering Institute of Canada, October 25th, 1932.

SUMMARY.—The Burrard bridge, completed in 1932, has a total length of 2,800 feet, and conveys highway traffic across the entrance to False Creek in the vicinity of Burrard street, Vancouver. The author sketches the development of the project, including the selection of the site and the provisions for a future lower deck to carry a double railway track to replace that at present crossing the Kitsilano bridge. The paper gives a detailed description of the structure which consists of five steel spans with a length of 1,151 feet, connected with the abutments by reinforced concrete viaducts. The design and construction of the steel and reinforced concrete parts of the structure are discussed, and data are given as to the time taken to construct the various portions, with notes as to the cost and the methods adopted by the various contractors in handling the work.

A by-law for the construction of the Burrard bridge was submitted to the ratepayers in Vancouver, B.C., in January, 1911, but failed to receive the necessary majority, and the residents of the large area south of English bay have waited over twenty years for adequate transportation facilities. A traffic count on the adjoining bridge at Granville street, which was built in 1909, made by the Town Planning Commission on January 27th, 1927, between 4.30 and 6.30 p.m., showed 3,222 vehicles besides seven street car lines and interurban trains using that structure, which has a total capacity of four lanes of traffic. The congestion caused delays and accidents, and the traffic was at times completely blocked by the opening of the swing span for navigation. These interruptions cannot be avoided at rush hours because at the swing span of the Kitsilano railway bridge, situated 900 feet north-west, there is only sufficient depth of water for navigation at high tide.

On the recommendation of Charles Brakenridge, M.E.I.C., city engineer, in September, 1928, the city council appointed the author consulting engineer to prepare alternative preliminary plans and estimates for a proposed double deck railway and highway bridge, and also for a single deck highway bridge across the entrance to False creek in the vicinity of Burrard street. The report with plans and estimates was submitted on November 15th, 1928. The proposed alignment of the double deck structure was from the intersection of Burrard and Pacific streets to Cedar street and First avenue with a connection to Cornwall street. It crossed the Kitsilano railway bridge and provided for the removal of this structure, which was strongly advocated by navigation interests, and is an essential step in the development of False creek. The single deck design proposed a through arch span entirely bridging the channel about 850 feet north-west of the Kitsilano railway bridge swing span, and left this structure to provide for railway and tram service to be reconstructed by the owners.

The city was unable to obtain from the Dominion government any financial assistance towards the removal of the Kitsilano railway bridge and the improvement of navigation in False Creek, therefore, the city council authorized proceeding with the detail design of the single deck arch structure, but the by-law submitted to the ratepayers in May, 1929, failed to secure the necessary majority. A by-law was again submitted in December, 1929, for the upper highway deck of a double deck bridge, making provision for a low level double track deck to provide for railway and tram traffic. The Canadian Pacific Railway Company promised $250,000 towards the cost of the lower deck on condition that the Dominion government contribute a like amount towards the removal of the Kitsilano railway bridge, owned by the railway. This by-law received the necessary majority and the author was authorized to proceed with the detailed design on December 16th, 1929.

Location

Burrard bridge crosses the entrance to False creek, Vancouver's secondary harbour. The location plan, Fig. 2, shows its relation to some of the major streets, also a suggested distributor street from the city end of the bridge to the Georgia viaduct, and a connection between Cedar and Arbutus streets, which avoids the crossing of the double track interurban railway.

The location of the bridge was only decided upon after very careful consideration of all possible sites, and the community's appreciation is due to the Canadian Pacific Railway Company and the British Columbia Electric Railway Company, the crossing of whose land, tracks and shops permitted the construction of the bridge on the best alignment.

The desire to secure a beautiful structure was one of the governing considerations in the design, particularly since the bridge occupies a very prominent situation, being visible for miles at sea and from many points in the city.

The need of providing for navigation and a low level double track railway deck governed certain features of the design. Fig. 1, a view from the north-east, shows the arrangement of the principal portion of the structure with rising grades joined by vertical curves. Massive piers, extending to the deck at the junction of the steel spans and the concrete approach viaducts, and with pylons connected by cross galleries above the deck at the ends of the channel span, together with the concrete handrail and deep fascia girders, were used to produce the effect illustrated. The ends of the bridge are marked by ornamental concrete pylons, with bronze braziers having twelve panels of cathedral glass and illuminated by 2,500-candlepower lamps. The top of the brazier is 39 feet above the roadway and 66 feet above the bottom of the steps.

It has been the author's good fortune to have the assistance of Messrs. Sharp and Thompson as collaborating architects and they are responsible for many of the features which have helped to produce a bridge of aesthetic merit.

General Description

The bridge, which has a length between abutments of 2,817 feet 6 inches, provides a roadway paved with 2-inch granular surface type Warrenite-Bitulithic pavement 60 feet wide, between curbs 12½ inches high, for six lanes of traffic, and two sidewalks having a clear width of 8 feet 6 inches. Rising grades of 3 per cent from each approach are connected over the channel piers and span by vertical curves.

The principal portion of the structure consists of five steel spans with a length between centres of end piers of 1,151 feet. The centre, or channel, crossing is a through truss span with a length of 315 feet 6 inches centre to centre of main piers, with 90 feet clearance above high water for navigation, and the adjoining deck truss spans are 216 feet 8 inches and 176 feet between centres of bearings, the longer length being required to provide clearance for the future double track railway, which will curve to the east after passing through the north main pier.

Reinforced concrete viaducts connect the steel portion of the structure and the abutments: that on the north shore has a length of 353 feet and consists of five spans, the longest being 75 feet clear, over Beach avenue; that on the south shore has a length of 1,294 feet and consists of twenty-one spans varying in length from 17 feet 6 inches to 84 feet clear, as required to accommodate the car shops and fourteen tracks of the B.C. Electric Railway Company, and make provision for the future double track railway, which will curve to the east and west from under the viaduct. Bents with rectangular columns connected by deep beams with curved haunches support the deck.

Retaining walls confine the fills at the approaches: those at the south end have a length of 152 feet and those at the north a length of about 260 feet curving to the east and west. The height of the north abutment is 34 feet and of the south abutment 23 feet; the counterfort type was adopted for these as well as for the adjoining retaining walls except where the height of the latter was less than 20 feet when cantilever walls were used. Stairways are provided at the north abutment and at the ends of the retaining walls at the south approach.

Borings and Bearing Tests

As a basis for the foundation design, ten test holes were drilled on the line of the bridge, eight of these being located at the main piers. The depths varied from 23 feet 6 inches, 20 feet of which was in rock, to 89 feet with no rock encountered for the most southerly hole. The rock was sandstone or sandy shale from which 80 to 98 per cent core was obtained. Where rock was not close to the surface good hardpan was found at a reasonable depth.

Bearing tests were made during April and May, 1930, at six points by means of a testing machine, which consisted of a bearing plate, loading post with adjusting screw, balance beam with 200-gallon water tank at the outer end, saddle beam with anchorages and the recording device. Loads were applied in one thousand pound units up to twenty thousand pounds and the settlement measured. The tests indicated that no appreciable settlement was to be anticipated for any of the viaduct bents or the piers founded on hardpan, and this has been corroborated during construction.

Design Loading and Unit Stresses

The bridge was designed for a live load of two 20-ton trucks, or alternatively a 30-ton trailer, with the balance of the roadway loaded with a uniform load of 120 pounds per square foot, which uniform load was reduced to 80 pounds per square foot when the loaded length of the bridge exceeded 200 feet. The live load for the sidewalks was assumed as a concentrated load of 5,000 pounds or a uniform load of 100 pounds per square foot, reduced to 60 pounds per square foot for a length of 160 feet or more. Provision was made in the design for impact, wind loads, traction and temperature.

Class "F" concrete, which was specified to contain 650 pounds of cement per cubic yard and 4½ gallons of water per bag of cement, was specified for columns, girders, cross beams, sidewalk brackets, and the roadway and sidewalk slabs of the steel spans as well as the concrete viaducts. It was designed for the following unit stresses in pounds per square inch:

Direct compression	625
Combined axial load and flexure:	
(a) Dead and live load	750
(b) Wind temperature and traction with dead and live loads	940
Extreme fibre stress in flexure	940
Shearing stresses:	
(a) Longitudinal bars without special anchorage and no web reinforcement	50
(b) Longitudinal bars with special anchorage and with stirrups and bent up bars	200
Bond for plain bars	100
Tension in billet steel structural grade reinforcement bars	16,000

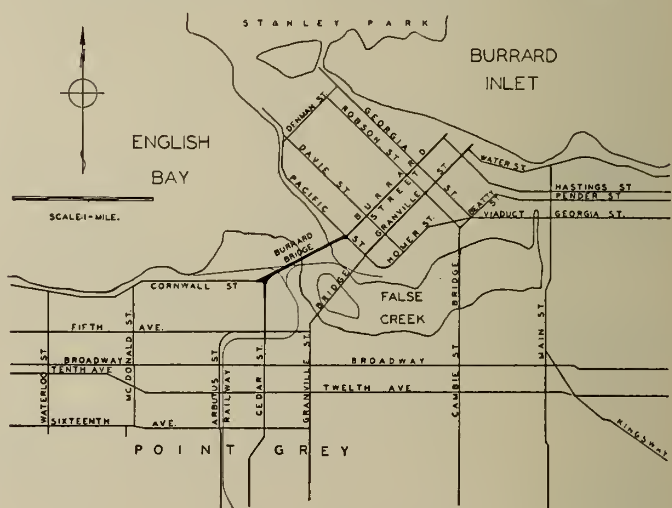

Fig. 2—Location Plan.

Abutments, piers and footings were designed for lower unit stresses corresponding to the different classes of concrete specified. Ten different classes of concrete were used for the work, with varying size and quantity of aggregate, weight of cement and water ratio, and a two-minute mixing time was specified for all concrete. For the handrails and pylons an addition of 2½ pounds of "Diatite" per bag of cement was specified.

Structural carbon steel was specified for the steel portions of the structure, and the design was based on 16,000 pounds per square inch on the net section for tension and corresponding values for other stresses.

Design of Concrete Viaducts, Roadway and Sidewalk Slabs

The viaducts consist of roadway and sidewalk slabs supported by cross beams, longitudinal girders and fascia

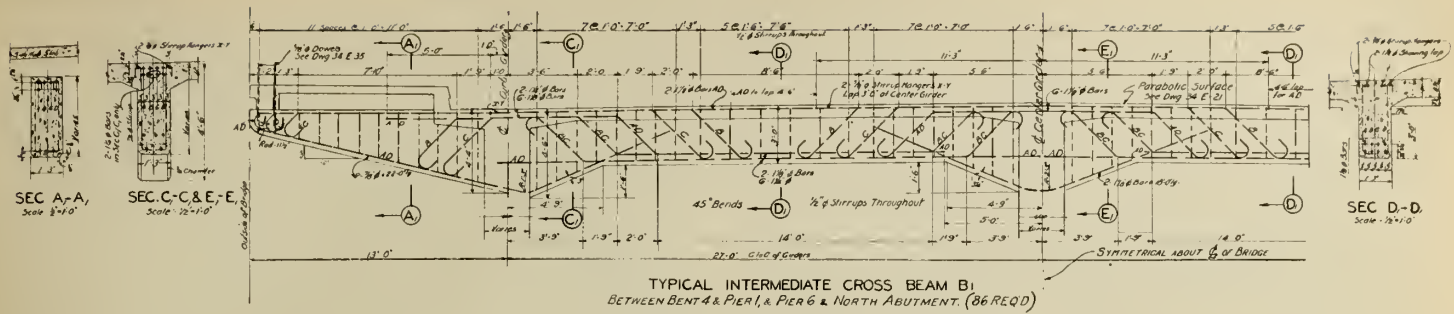

Fig. 3—Concrete Viaduct—Typical Cross Beam.

beams at the ends of cantilever brackets. Three lines of longitudinal girders, continuous over two or more spans, are spaced 27 feet centre to centre, which gives practically equal deflection for the three girders under full dead load. The deck is supported by reinforced concrete bents with stepped footings.

A careful analysis was made of the stresses in the roadway slab due to the concentrated loads. The maximum clear span is 13 feet 10 inches and the slab thickness 8½ inches with haunches 3½ inches deep and 7½ inches long at the cross beams, and 2 feet long at the longitudinal girders. The reinforcement consists of ⅝-inch round bars spaced 3½-inch centres at the bottom of the slab, and 10½-inch centres at the top. Every third bottom bar is bent up and extended into the adjoining panels. Transverse reinforcement consists of eleven ½-inch round bars per panel with increased reinforcement over the longitudinal girders to provide for negative moment. One inch cover is provided for all slab reinforcement.

The sidewalk slabs are designed for a concentrated load of five thousand pounds. The clear span between the curb and fascia beam is 8 feet and the slab has a total thickness of 5¼ inches, which includes ¾ inch wearing surface, and is reinforced with ½-inch round bars spaced 5-inch centres.

Design of Cross Beams and Brackets

The cross beams with the cantilever brackets were designed as continuous over three elastic supports. The intermediate cross beams (Fig. 3) have a width of 1 foot 3 inches and a total depth of 3 feet with haunches extending 4 feet 9 inches from the centre line of the girders and a depth at the girder of 1 foot 6 inches, except for four spans adjoining the south abutment where the clearance over the B.C. Electric Railway Company's tracks permitted a haunch only 4 inches deep.

The reinforcement for the principal cross beams, of which eighty-six were required, consists of two 1⅛-inch and six 1¼-inch round bars for the bottom flange at the centre of the span, and also for the top flange at the curb girders and extending into the cantilever brackets, and for the top flange over the centre girder six 1⅛-inch round bars. Both the top and bottom bars were bent where necessary to provide for shear reinforcement and ½-inch diameter stirrups were used throughout.

Where necessary to give lateral support to the girders, deep arched cross beams are provided over the column bents, two being required at the expansion joints, and double cantilever brackets are used at all bents where aesthetic considerations justify their use as supports for the large handrail posts provided at the lamp standards.

Design of Longitudinal Girders

The appearance of the viaducts was a major consideration in the design, therefore longitudinal girders with curved haunches (see Fig. 4) having a depth of nearly three-quarters the depth of the girder, and extending to the quarter point, were adopted throughout except for one point in the shops of the B.C. Electric Railway Company where the clearance required the use of shorter haunches. The girders are continuous over two, three, or four spans and the deep curved haunch gave the most economic section for continuity over the supports.

The calculations of all moments and shears in the girders by formulae based on the elastic theory were checked by the method of distribution of end moments proposed by Professor Hardy Cross*. The maximum negative moment of 7,490,000 foot pounds and the maximum shear of 408,700 pounds was found for the centre girder over bent 20 (the north bent of the south viaduct at the junction of two 74-foot 6-inch continuous spans) and required tension reinforcement of twenty-eight 1½-inch round bars. The maximum positive moment of 4,640,000 foot pounds, requiring tension reinforcement of twenty-seven 1½-inch round bars, was found for the centre line end girders of the three continuous spans, bents 13 to 16, having end spans 71 feet 9 inches and centre span 84 feet clear. The depth varies from 3 feet 9 inches to 7 feet 3 inches for the centre girders; the curb girders are 3 inches less corresponding to the 4-inch camber of the roadway, and the width of the girders and haunches vary from 23 to 29 inches. (See Fig. 5.)

Fig. 4—Completed Railway Fill and Bents of South Viaduct.

Bending moment and shear diagrams were drawn for each set of girders. The bending of the longitudinal steel was determined from the bending moment diagrams, and the required shear reinforcement determined from the shear diagrams. Additional bent bars were usually required at the supports where the girders are continuous and ⅝-inch vertical stirrups were used throughout. Additional stirrups were used to tie in all compression steel in the haunches and to take the components of bent reinforcement.

Where the girders are continuous over the columns they are rigidly attached thereto by vertical steel extending

*See Proceedings of the American Concrete Institute, Volume XXV. (1929), page 669, and Proceedings of the American Society of Civil Engineers, May, 1930.

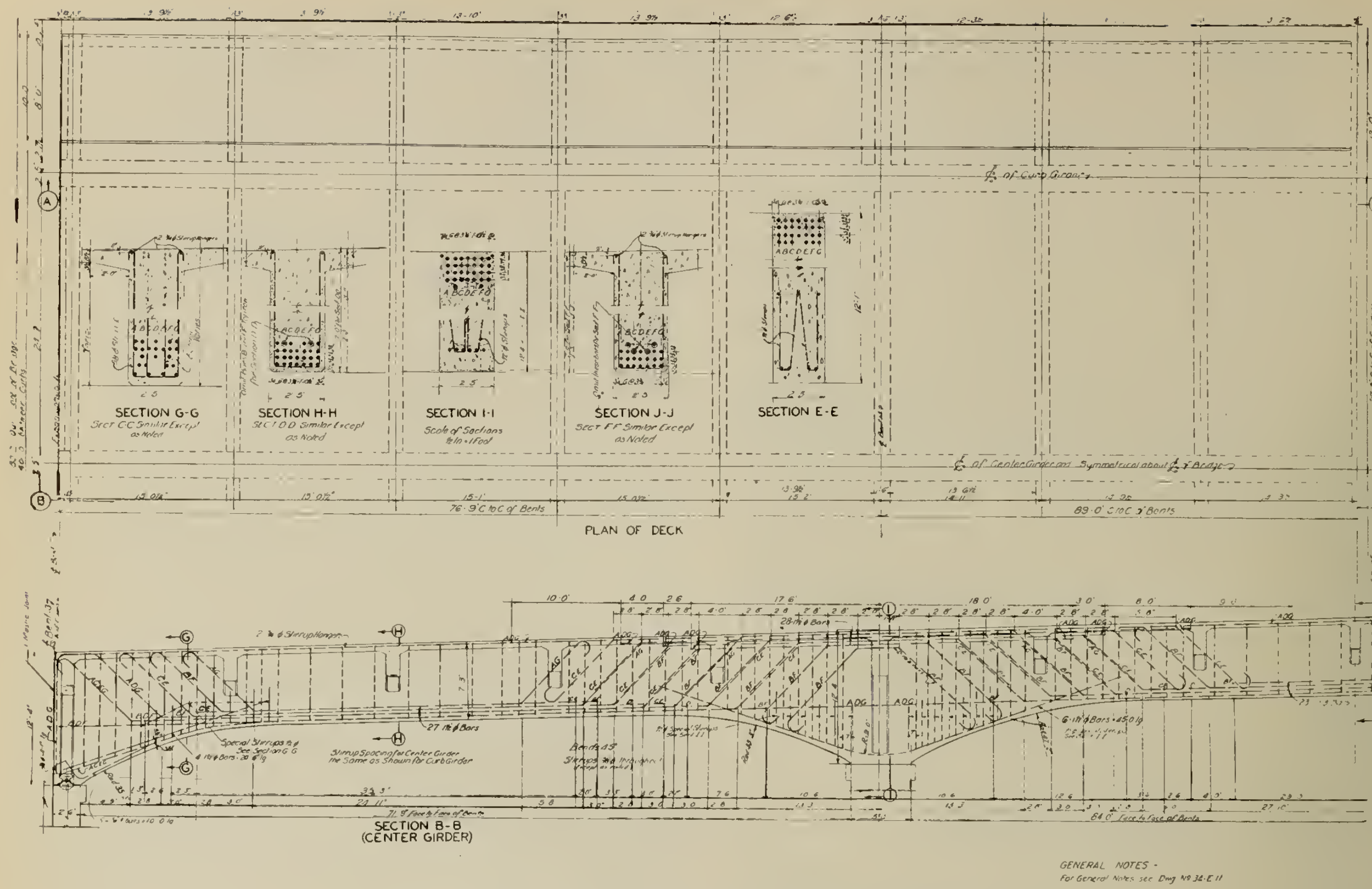

Fig. 5—Concrete Viaduct—Typical Centre Girder and Deck.

from the columns, and at the free ends the girders are supported by pin or rocker bearings, the latter being in reservoirs packed with Valvoline "Hi-melt" grease.

The expansion joints for the roadway of the viaducts and also for the fixed ends of the deck truss spans at piers 3 and 4 consist of two angles, one 7 inches by 3 inches by ½ inch, the other 7 inches by 2 inches by ½ inch, the 3-inch leg sliding on the 2-inch leg. Each angle is supported by a continuous angle, one leg of which is riveted to the 7-inch leg and the other bearing on the concrete deck, to which it is anchored.

Design of Bents

Three-column bents with the columns under the longitudinal girders support the deck, except where the clearance required for the future or present railway tracks, or the shops of the B.C. Electric Railway Company necessitated the use of a two-column bent or the columns being placed off centre. Transverse girders with curved haunches give lateral support to the columns, except for the five skew bents adjoining the south abutment, where the columns are short, and rectangular cross beams the full depth of the girders give lateral support. Bent 4 is in the interior of the railway shops and in order to provide the desired clearance, it was necessary to substitute heavy steel columns encased in concrete with the east column offset 11 feet 9 inches from the curb girder, which required a heavy cross beam to carry the girder reactions. The columns, except for bents 4 and 14, vary from 2 feet 6 inches by 3 feet to 3 feet by 5 feet for curb columns and from 2 feet 6 inches by 3 feet 6 inches to 4 feet by 5 feet for centre columns, the 5-foot dimension being parallel to the centre line of the bridge.

Railway clearance permitted the use of only two columns for bent 14. These are 4 feet by 5 feet 6 inches and are spaced 44-foot centres. This required a heavy transverse girder 3 feet wide and 10 feet 4 inches deep, reinforced with thirty-two 1½-inch round bars to carry the reactions of the longitudinal girders to the columns. About one foot above the ground line the section of all columns is increased 6 inches on all sides providing pedestals which transfer their loads to stepped footings.

The columns were designed for the direct load, bending due to unbalanced loading of girders, temperature and traction, and for lateral bending caused by temperature, wind and eccentricity where the columns are not directly under the girders. The column footings were all founded on hardpan. The footings were proportioned for a maximum pressure under axial load of four tons per square foot and the pressure under extreme conditions of bending was slightly over six tons.

Design of Piers

In piers 1, 2, 3 and 4 provision has been made for the future lower deck double track railway. The width of the opening is 34 feet at pier 1, 29 feet at pier 2, and 32 feet 6 inches at piers 3 and 4. The clear height is 22 feet 6 inches at all piers.

Pier 1, at the junction of the south viaduct and the steel spans, is of reinforced concrete 22 feet wide, 92 feet long by 111 feet high with vertical sides and consists of four shafts, for the support of the adjoining spans, and wells with walls 12 to 18 inches thick connected above the railway clearance by deep transverse girders, and connected below the railway deck by an abutment wall which confines the 30-foot railway fill and will support the ends of the future railway plate girder spans. The end wells are 15 feet by 20 feet clear and that at the west end contains a stairway of one hundred and twenty-one steps in twelve flights from the deck to a path along the side of the railway fill. The well at the east end is available for an elevator if required. A cross gallery under the deck eliminates the need of pedestrians crossing the 60-foot roadway. A space is also provided for electric conduits and water pipes, for which provision is made across the steel portion of the structure. Pier 1 has its foundation at elevation 72.0 on 236 fir piles driven to refusal in hard clay and gravel and cut off at about elevation 74.0.

Pier 6, at the junction of the north viaduct and the steel spans, is reinforced concrete 18 feet wide by 81 feet long by 85 feet high with vertical sides and consists of five shafts for the support of the adjoining spans, and wells with walls 12 to 14 inches thick. A gallery is provided below the deck for electric conduits and water pipes and openings below the ground line for connections with the city services. This pier has its foundation at elevation 98.0 on hardpan.

Piers 2 and 5 each support the fixed end of a 176-foot and the expansion end of a 216-foot 8-inch deck truss span by rectangular shafts 8 feet by 12 feet under the coping and having a batter of ½ in 12. The shafts are 43-foot centres and are connected at the top by reinforced beams with curved haunches and about 32 feet below the truss seats by reinforced cross walls, which in the case of pier 2 will form the support for the future railway deck plate girders. Pier 2 has its foundation at elevation 63.7 and pier 5 at elevation 80.75, both on hardpan.

Piers 3 and 4, on either side of the navigable channel, comprise one of the unusual features of the bridge. They are built on massive lines with pylons extending above the roadway to a height of 146 feet above high water, and are connected by cross galleries above the roadway. (Fig. 7.)

The piers have a length of 96 feet and a width of 33 feet, with a 3-foot 6-inch projection for the end supports of the future railway swing span. Above the heavy coping, located at the bridge seat of the future railway deck, the reinforced concrete pier has a slight batter and consists of two towers connected above the railway clearance by 24-inch cross walls. Deep wells extend from chambers below the upper deck to the pier footing, which is 42 feet 2 inches wide by 102 feet long. The bearings of the channel span extend below the inner corners of the pylons and separate bearings are provided for the ends of the sidewalk beams. The walls of the pylons are 24 inches thick to the level of the floor of the cross galleries and 8 inches thick above this point. The ceilings over the sidewalks are barrelled and cross-vaulted.

The cross galleries, which have a clear length of 61 feet 4 inches, are supported by hollow girders 2 feet 6 inches wide by 6 feet 3 inches deep with sixteen 1⅛-inch round bars as tension reinforcement. The walls above the girders which extend to the bottom of the windows, are 8 inches thick and the 4-inch roof slabs are covered with Spanish tile. Over the centre of the roadway is the city coat of arms, and over each sidewalk entrance is a precast concrete prow of a boat with the bust of Captain Vancouver as the figurehead on the west pylon and Captain Burrard

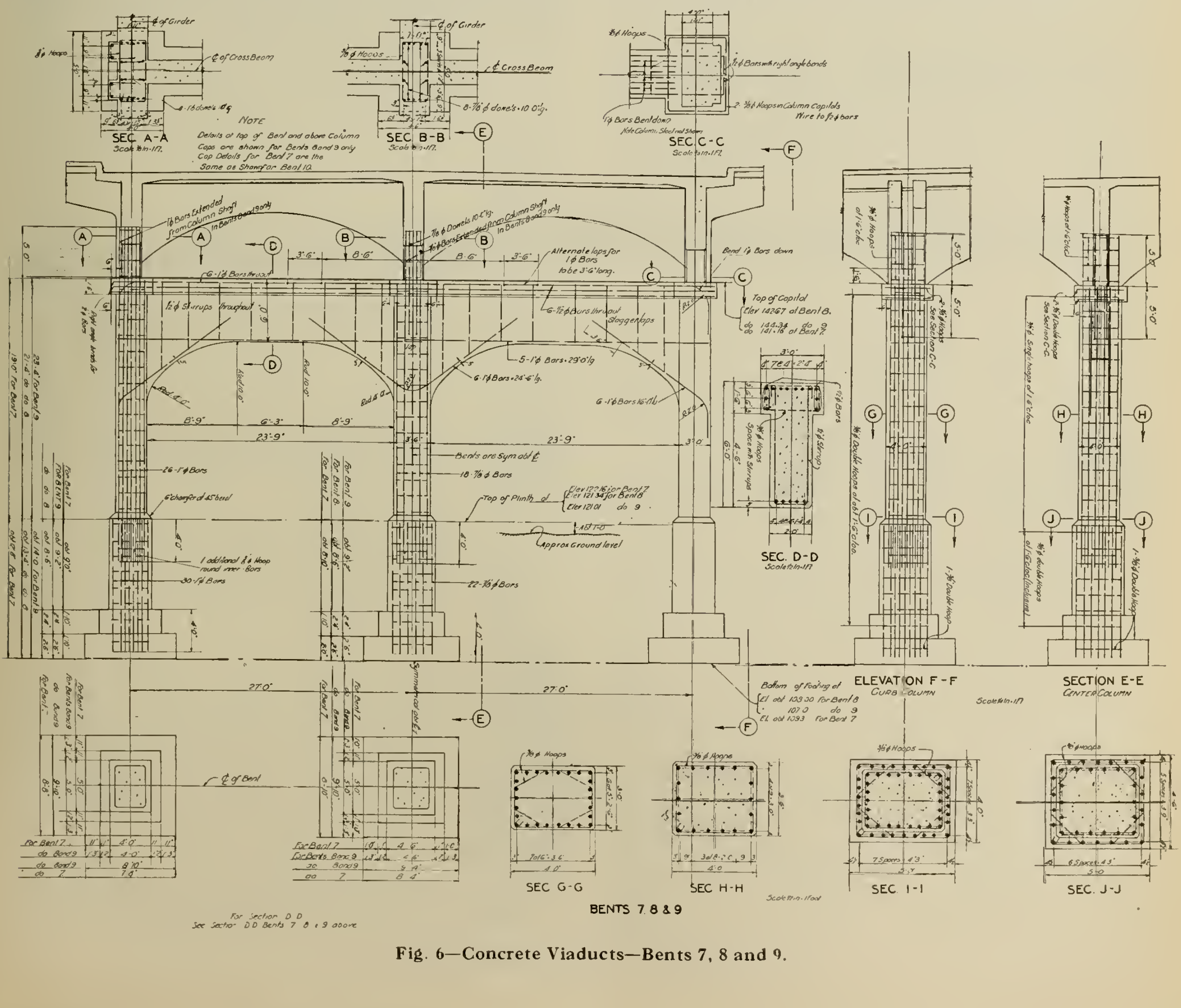

Fig. 6—Concrete Viaducts—Bents 7, 8 and 9.

on the east. Lion heads finish the projecting roof beams, and above the windows for a depth of 3 feet the concrete is marked to represent tile and is coloured two shades of green. Wrought iron grilles, painted black, are used on all windows. (Fig. 8.)

Pier 3 has its foundation at elevation 54.4 and pier 4 at elevation 50.4, both on sandstone. The total quantity of concrete in the two piers is about 23,500 cubic yards. Creosoted timber fenders at each end and along the channel side of each pier are added for the protection of navigation, particularly for booms of logs being towed to mills located above the bridge.

Design of Floor Slabs, Steel Spans

The concrete roadway slab for the steel spans has a thickness of 6½ inches haunched to give a 9-inch thickness at the steel joists spaced 5- and 6-foot centres. The transverse reinforcement consists of ½-inch square deformed bars 5-inch centres at the bottom and 15-inch centres at the top with every third bottom bar bent up and extended over the joists. Deformed ½-inch bars spaced 12-inch centres are provided for longitudinal reinforcement. The slab is anchored to the steel joists by means of 2½ inches by ⅜ inch U bars welded to the joists at 5-foot centres. These anchors support the reinforcing steel during construction.

The sidewalk slabs are similar to those on the viaducts, but the width is increased over the through truss span and the adjoining panels of the deck truss spans from 10 to 14 feet. Beams, containing eight fibre conduits, are located under each sidewalk adjoining the curb on the deck spans and outside the trusses on the through span. Concrete fascia beams, 3 feet 1 inch deep, are reinforced with structural steel lattice girders and with ⅞-inch round bars over the supports. In addition to carrying their portion of the sidewalks and handrails, and masking the ends of the cantilever brackets, these fascia beams, which with the concrete railings form a girder 6 feet 9 inches deep across the steel spans, have considerable aesthetic value, as illustrated in Fig. 1.

Design of Steel Spans

The 176-foot and 216-foot 8-inch deck truss spans are of the Warren type. The former has eight and the latter ten panels. The depth of the chords, and also the depth of truss, 30-foot centre to centre of chords, for aesthetic reasons are the same for both spans. The trusses are spaced 43-foot centres and the floor-beams, which are 5 feet 6 inches deep and taper to one foot deep at the ends, are supported on top of the upper chords and cantilevered out to support the 80-foot deck.

The trusses of the channel span, which are spaced 65-foot centres and have ten panels with a length of 294 feet 2 inches centre to centre of end pins or bearings, are of the through Pratt type with curved chords. The depth centre to centre of chords at the centre is 50 feet. The heaviest section has an area of 204.3 square inches and the total weight of structural steel in the span is 1,151 tons.

An unusual feature of the design is the curved lower chord, the four end panels having a slope of two feet. This, with vertical curves over the piers and over the two centre panels provides a smooth transition between the two 3 per cent grades on the approaches. The maximum moment in the intermediate floorbeams is 4,575,000 foot pounds, and the 288,500 pounds shear requires fifty one-inch field rivets for the end connections. To avoid excesssive bending

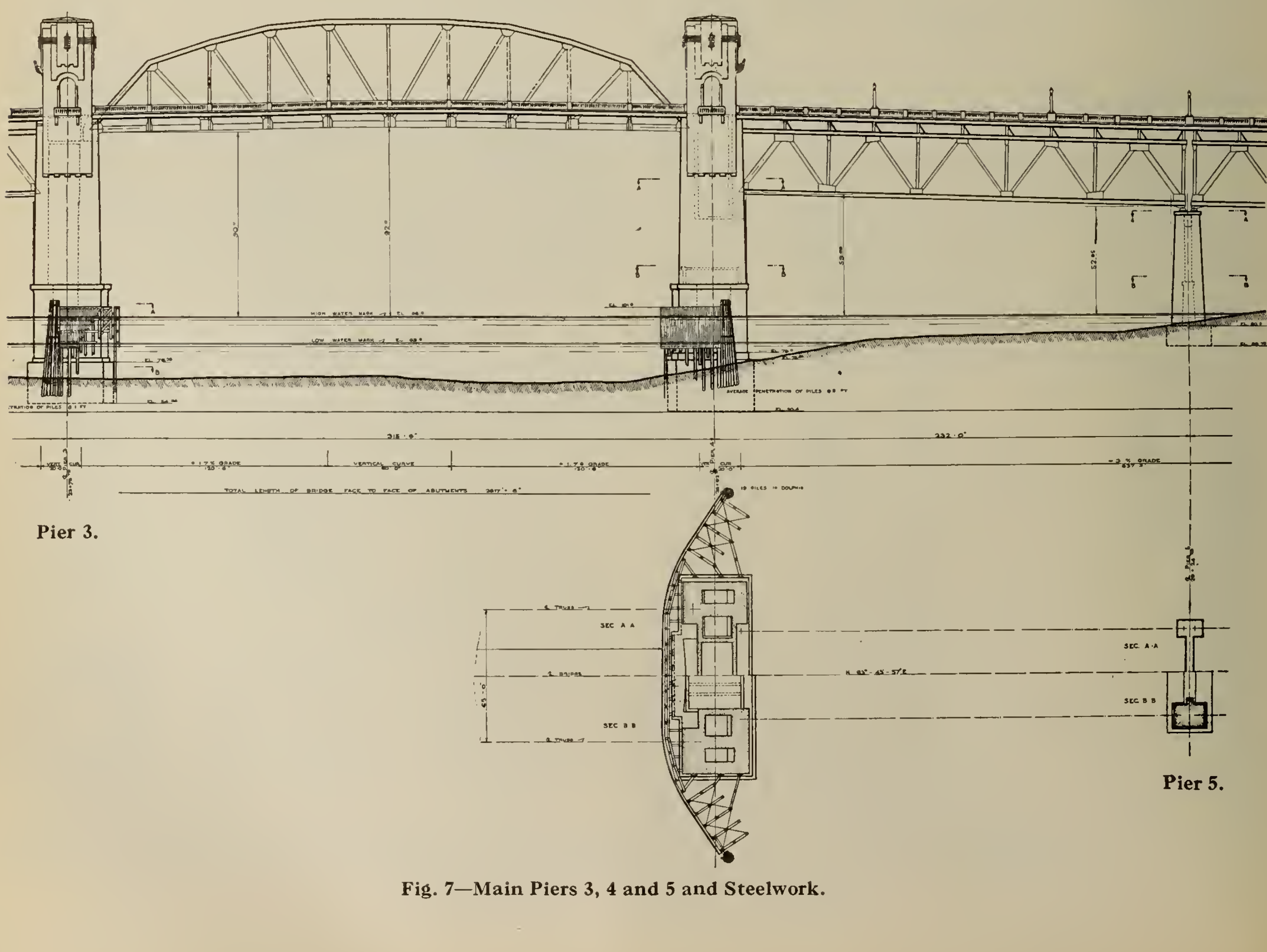

Fig. 7—Main Piers 3, 4 and 5 and Steelwork.

in the truss verticals, due to the deflection of the long floor-beams, the end connections are set and milled so as to be vertical under full dead load.

The 6-inch diameter rockers of all expansion bearings for the trusses are immersed in oil. A minimum depth of 7 inches of oil is specified, as it is very important that the oil be kept above the tops of the rockers to avoid excessive condensation of water vapour inside the reservoirs. It is also necessary to prevent water getting into the reservoirs, and provision has been made for testing to determine the presence of water. On account of the large pylons at piers 3 and 4, it was necessary to provide separate bearings, with cast iron rollers and plates 3 feet 1 inch from the truss bearings, for the conduit and fascia girders, which support the sidewalks of the channel span.

Design of Railing

The railings throughout are of reinforced concrete cast in place. The lamp standards are supported by main posts 4 feet by 4 feet and 16 inches thick, placed over the bents of the concrete viaducts, and similarly spaced over the steel deck truss spans. Intermediate posts 2 feet long, 3 feet 10 inches high and 12 inches thick, are situated at the intermediate cantilever brackets of the concrete viaducts and are similarly located on the steel truss spans. The railings between posts have a uniform height of 3 feet 8 inches and thickness of 8 inches, and, except over the retaining walls at the approaches, are pierced at about 12-inch centres by openings 5½ inches wide by 2 feet 3 inches high. The railings are strongly reinforced to withstand the impact of a car which may jump the 12½-inch curb.

Drainage

Drainage is provided by cast iron inlets adjoining the curbs on the upper side of each expansion joint on the viaducts and truss spans, with a maximum spacing of 242 feet 6 inches. Cast steel gratings 15⅛ inches wide by 25¾ inches long with longitudinal bars 3½ inches deep at the centre, bear on machined surfaces at each end of the openings in the cast iron inlets. A light cast iron grating is also provided above the connection to the 6-inch diameter down pipes.

On the viaducts, all the pipes are cast iron. The 6-inch pipes from the two sides are run through the ends of the girders and are drained by one 8-inch pipe carried down the inner face of one curb column to a concrete catch basin at the foot of the column. The catch basins are drained by vitrified pipe to a special stormwater drain on the south shore and to existing sewers on the north shore. On the steel truss spans the 6-inch down pipes are wrought iron, except where carried in the wells of piers 1, 3, 4 and 6, where they are cast iron. Copper water stops are provided below each expansion joint in the deck, and these are drained to the 6-inch down pipes or to wells in the piers. Standard city inlets and catch basins were used for the approaches, connected to storm water drains installed in the fills and connected to the existing drainage systems.

Approaches

The approaches to the bridge were designed with the collaboration of the staffs of the city engineer and traffic department. On the south it was necessary to provide for traffic to and from the west on Cornwall street and the south on Cedar street, both major arteries with proposed future width of 100 feet for Cornwall and 99 feet for Cedar street. (Fig. 2). Four lanes are provided in each direction and the width of lanes on curves increased to 11 feet 3 inches, the lanes being marked by the longitudinal construction joints in the pavement. The path of the traffic from the bridge to Cedar street crosses the path of traffic from Cornwall street and the traffic is controlled by an automatic signal light over the centre of the intersection.

The design of the north approach provides for the future widening of Pacific street as proposed by the Vancouver Town Planning Commission, but the pavement layout conforms to the present street widths with accommodation for six lanes on Burrard and four lanes on Pacific street. Separate lanes are provided for traffic from the bridge to the east, and from the west to the bridge. Other traffic is controlled by an automatic signal light over the centre of the intersection of Burrard and Pacific streets.

Fig. 8—Main Pylons and Cross Gallery, Pier 3.

On both approaches, points on the islands facing traffic are marked by flashing red beacons, 12 inches above the curb. The pedestrian crossings to and from the walks on the islands are clearly marked. The concrete pavement on the approaches has a thickness of 9 inches and transverse through expansion joints are spaced approximately 90-foot centres with dummy joints about 15-foot centres. At through joints ¾-inch dowels 2-foot 6-inch centres are embedded 18 inches in the first section of pavement laid and are free to slide in ¾-inch pipe in the adjoining section. Transverse ½-inch round bars reinforce the concrete over the dowels. At all transverse through joints the slabs are separated by ¾-inch thickness of Type "R" expansion joint, consisting of asphalt, rubber and filler. One-half inch thickness of the same material is used at the longitudinal through joints spaced two traffic lanes apart with one-half inch longitudinal dummy joints midway between the through joints.

Bridge Lighting

The lighting system for the bridge was designed with the assistance of Mr. C. H. Fletcher, the city electrician. The lighting units for the bridge consist of 600-candlepower series lamps on four lighting circuits arranged so that alternative lighting is provided on both sides of the bridge. The lamps are installed in Westinghouse Paragon units with Holophane two-way refractors. The lighting units on the channel span and sides of the end pylons are supported by bronze brackets, elsewhere they are attached to bronze stands on spun concrete lamp standards with the light centre 15 feet above the roadway. Six street hoods with 600-candlepower lamps are provided on the centre line of the channel span.

At piers 3 and 4, four floodlights back of the figureheads light the exposed faces of the pylons and four located on the fenders illuminate the ends of the piers. These, with the navigation lights located below the bottom chords at each end of the through truss span, clearly mark the navigable channel. The bridge lighting is controlled from the city ornamental street lighting circuit and the transformer and control equipment is mounted in the gallery and east pylon of pier 3.

Contract

The city of Vancouver called for tenders for the construction of the bridge in August, 1930, and in November, 1930, awarded the contract to the low bidders, the combined local firms of Hodgson, King and Marble and Dawson, Wade and Company, Ltd., who named as subcontractors for the fabrication in local shops and erection of the structural steel, the Dominion Bridge Company and Western Bridge Company.

Preliminary Work

The work order was issued on December 8th, 1930, and while the contractors were clearing the right-of-way through the Kitsilano Indian Reserve and building plank roads to site of offices and yards, the resident engineer, A. J. Leamy and his staff were checking the preliminary surveys and establishing additional base line and reference points.

The contractors built a 20-foot plank road parallel to and 50 feet west of the centre line of the bridge from the south abutment to the navigable channel, about 710 feet of which was on piles, and constructed a wharf adjoining the channel with cement shed, bunkers for sand and gravel, and derrick. The necessary dredging was done to enable cement, sand and gravel scows to be unloaded by the derrick from either side of the wharf.

The bunkers, two for gravel and a centre one for sand, delivered to two Heltzel duplex weighing agrabatchers, which dumped directly into trucks. The cement, which was delivered to the platform above the trucks from the cement shed by a belt conveyor, was dumped directly into the truck with the sand and gravel. A similar wharf with cement shed, bunkers and derrick, but without the belt conveyor. was constructed for the work on the north shore.

Testing of Concrete Materials

The cement was tested at the Vancouver Island plant of the B.C. Cement Company, and delivered directly to the wharves at the bridge. All other concrete materials were tested by the city engineer's testing department. Each scow of sand and gravel was tested on delivery to see that the material conformed to the specifications and had been graded to the specified sizes. Only satisfactory material was placed in the bunkers.

Before the commencement of concrete operations, the inspector at the bunkers and the man in charge of the weigh batchers were notified as to the number of bags of cement and the weight of sand and gravel which, after allowance for moisture content, were required for each batch. Batches were loaded directly into trucks and delivered to paving mixers, conveniently located for placing the concrete. The water tank on the mixer was set for the correct amount of water required for the batch, after making allowance for free moisture in the aggregate. Test cylinders were taken from the concrete as poured. A total of three hundred and eighteen cylinders were taken and tested, and the twenty-eight-day breaking strength varied from 2,476 to 5,325 pounds per square inch for the different classes of concrete.

Reinforcement for Concrete

The reinforcing bars for concrete consist of billet steel, structural grade, conforming to the standard specifications of the Canadian Engineering Standards Association. The largest bar is 1½ inch in diameter and the maximum length 90 feet. All bars were cut to length, the necessary bending done, under careful inspection in the shop, and delivered to the site as required.

Construction of Abutments and Piers

The excavation for the south abutment was commenced on January 29th, and on March 2nd, 1931, the first concrete for the structure was placed in the footing of this abutment, which was completed with the exception of the pylons and railings on March 24th. The first concrete for the north abutment was poured on June 22nd, 1931, and the placing of concrete for the abutment, exclusive of railing and pylons, but including east and west stairways, was finished on August 6th.

The base for pier 1 is U-shaped. The two end sections are 28 feet by 29 feet and they are connected on the north side by cross section 13 feet 6 inches by 39 feet, making a total length of 97 feet. After the site had been excavated by clamshell bucket to about the footing elevation, the driving of the sheet piling for the cofferdam was started on February 21st and completed on March 13th, 1931. The excavation was completed and the driving of bearing piles commenced on March 20th, the two hundred and thirty-six piles being driven to refusal by a 4,500-pound drop hammer.

The pouring of the concrete seal, by means of a one-yard bottom dump bucket, handled by a truck crane mounted on a temporary dock north of the pier, was commenced on April 21st, 1931, and the 880 cubic yards in the seal were placed in about forty-four hours continuous operation. The cofferdam was pumped out and concreting in the dry was commenced on May 6th and completed to the deck level on September 1st, 1931.

After the site of pier 2 had been excavated by clamshell bucket to about the proposed footing elevation, the bottom section of the timber crib, 22 feet by 60 feet, was floated into position on March 18th, built up and sunk. The number of large boulders encountered made the excavation for this pier very difficult.

The pouring of the concrete seal for pier 2, with the same equipment previously used for pier 1, was commenced on April 29th, 1931, and the 700 cubic yards were placed in about thirty-eight hours of continuous operation. The crib was pumped out, and concreting in the dry was commenced on May 16th and completed on July 3rd, 1931.

While the crib for pier 3 was being built, a drilling scow commenced drilling and shooting for the foundation of this pier on January 2nd, 1931. The sandstone broken up by the shooting at both piers 3 and 4 was excavated by a heavy dipper dredge.

The bottom section of the timber crib for pier 3 was floated into position on March 31st, built up and sunk by sand placed in a continuous box 5 feet wide by 4 feet deep around the outside of the crib. The foundation was cleaned off at an average elevation 56.0, and the contractors assembled the equipment for placing the 2,770 cubic yards of concrete required for the seal. The equipment consisted of three paving mixers; two of these discharged into two-yard bottom dump buckets, one handled by each of two floating derricks located north of the crib; the other mixer discharged into a one-yard bucket which was handled by a small floating derrick at the south-east corner of the crib. The operation, which was started on May 18th and carried on continuously for sixty-two hours, was not very satisfactory.

The crib was pumped out on June 2nd, but leaks forced the removal of the pumps and it was not until the 8th that the crib was finally unwatered to permit the removal of laitance. This work was not completed when the seal and crib lifted from the foundation during high tide on June 14th. As it was not considered that the method proposed for salvaging the footing would give a satisfactory foundation, the concrete was entirely removed and the crib rebuilt.

The bottom section of the crib for pier 4 was floated into position on April 27th, built up, sunk and the foundation cleaned off at an average elevation of 50.4. Over the crib was constructed a braced frame about 26 feet high, which supported two 10-foot square hoppers and eight 10-inch tremies 50 feet long with one 10-foot removable section. Each tremie was hung by a wire rope, which passed over a sheave to one of the winding drums of one of four hoists supported on platforms at the top of the crib. A light floating derrick was also available for handling any tremie.

By means of a two-yard bottom dump bucket, the derrick back of the crib handled the concrete from two one-yard paving mixers to the west hopper and the floating derrick handled concrete, delivered by two-yard trucks from a mixing plant on Granville Island, to the east hopper. The concrete from each hopper was delivered by chutes to four tremies, each controlled by an operator who was carefully instructed as to his duties. The concreting was started July 8th and the 3,400 cubic yards required for the seal were deposited in forty-seven hours of continuous operation. The crib was pumped out, laitance removed and concreting in the dry was commenced on August 7th and the pier was constructed to elevation 182.32, the level of the through truss bearing, by October 16th, 1931.

The method adopted for the reconstruction of the footing of pier 3 was similar to that used for pier 4, except that the concrete was elevated by towers instead of derricks. The operation was started on September 4th and the 2,900 cubic yards of concrete required for the seal were poured in thirty-eight hours of continuous operation. The crib was pumped out, laitance removed and concreting in the dry commenced on September 21st. Every effort was made to speed up the construction of the pier. Much of the concrete was placed at night to allow forms to be built and reinforcing steel placed during the day. The pier was completed to elevation 182.32, requiring 7,014 cubic yards exclusive of the seal, by November 24th, 1931.

Pier 5 is located at the north shore line and the concrete footing was placed in the dry on October 19th, and the last concrete for the pier was placed on November 18th, 1931. The footing of pier 6 was poured on August 14th, and by October 8th the pier was completed up to the underside of the deck slab, which was added after the erection of the steel spans.

Construction of Concrete Viaducts

The construction of the viaducts proceeded from the abutments. Few of the excavations for the footings required timbering, except those for the south viaduct near the shore line. The concrete for the first footing, bent 1, was poured on March 4th, 1931, and the last footing of the south viaduct on August 4th, and of the north viaduct on September 11th.

For the construction of the deck of the viaduct, which for the longer spans contained about ten tons of concrete per foot of length, the contractors built a working platform, at approximately the level of the tops of the columns, of 2-inch plank on 8-inch by 8-inch cross timbers, and in most cases supported by eighteen longitudinal 15-inch steel I beams. The working platform for each girder span was supported by four timber falsework bents of ten 10-inch or 12-inch square posts with 3-inch by 8-inch bracing. For the end bents, the posts adjoining the girders were supported on the stepped column footings. Other posts were on timber footings or pile bents. Fig. 9 shows the falsework for a portion of the south viaduct.

The concrete for the deck and upper sections of the bents was elevated by a tower, conveyed by chutes to a hopper and transported and deposited by buggies. The concreting tower had a maximum height of 158 feet and with a steam boiler and hoisting engine was constructed on heavy timbers and skidded along the plank roadway adjoining the bridge, as the work on the viaduct progressed. When feasible, forms for the concrete work were built in the yard adjoining the bridge, and erected in place. The forms for the cantilever brackets are shown in Fig. 9, also the two derricks on the working platform for handling the falsework, forms, etc.

The first section of the concrete deck adjoining the south abutment was poured on April 20th, 1931, and the last section of the south viaduct, from bent 20 to pier 1, was poured on October 27th. The first section of the north viaduct, from the abutment to bent 25, was poured on November 27th and the last section, from bent 22 to pier 6, on December 12th, the sidewalk being completed on December 22nd. The girders, cross beams, cantilever brackets, roadway slab and a 7-inch depth of the curbs were poured monolithically and construction joints at right angles to the centre line of the bridge, when required, were

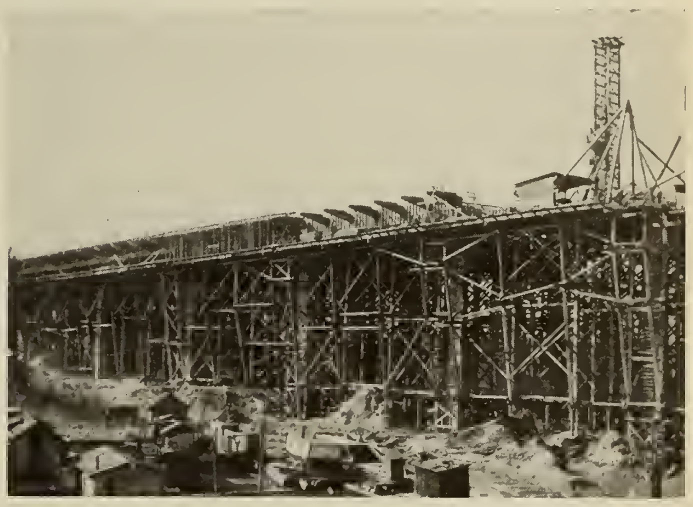

Fig. 9—Falsework for Viaduct—Bent 16 to Pier 1.

made over the bents except on the 19-foot span adjoining bent 4, where a construction joint was placed about 5 feet from the support. The sidewalk slabs, fascia beams and upper section of the curbs for the full length between expansion joints, were poured in one operation.

Construction of Truss Spans

The structural steel for the bridge, with the exception of a few sections not there obtainable, was rolled in Great Britain, and delivered in Vancouver by boat. The south 176-foot deck truss span and the through truss span were fabricated at the Burnaby plant of the Dominion Bridge Company, and the north 176-foot span and the two 216-foot 8-inch spans were fabricated at the False Creek plant of the Western Bridge Company. All field connections, except those for bracing, were drilled or reamed to steel templates or while the connecting members were assembled in the shops. The Western Bridge Company shop assembled the trusses fabricated by them and reamed all field connections.

The five steel spans were erected from the south end by a specially constructed 28-ton traveller mounted on fir skids 20 inches by 24 inches by 60 feet long spaced 30-foot centres, which was assembled on the viaduct adjoining pier 1. The main or forward boom of the traveller had a capacity of 28 tons at 54-foot radius, 25 tons at 60-foot and 16 tons at 71 feet 6 inches, while an auxiliary boom mounted 23 feet back of the main boom, had a capacity of 3 tons at 60-foot radius.

For the erection of the deck truss spans, falsework towers fabricated at the False Creek plant of the Dominion Bridge Co. were placed by the traveller on pile bents under each of the lower chord panel points. The first steel of the 176-foot span was placed on December 2nd. The steel for the truss spans, except a portion for the north end, which had to be delivered by truck, was delivered by scow and handled directly therefrom by the traveller.

The south portion of the through truss span was erected on falsework towers on pile bents under each panel point. To provide for navigation during erection, a horizontal and vertical clearance of 90 feet had to be maintained. This was provided by the cantilever erection of the four north panels of the through truss span, which required, under the sixth panel point from the south end, two falsework towers, each consisting of eighteen timbers, varying in size from 12 inches by 14 inches to 14 inches by 18 inches and supported by thirty-six fir piles. The towers were braced together and protected from navigation by dolphins and boom logs. Sand boxes were provided for the truss bearings at the tops of the towers. The erection of the deck truss spans between piers 4 and 6 was completed on March 8th, 1932.

The forms for the concrete deck of the steel spans were supported from the bottom flanges of the roadway joists and the lattice girders. The U-bar anchors were welded to the top flanges of the joists, the reinforcing steel and the fibre conduits for electric cables placed, and the concreting of the deck commenced on March 3rd, and was finished on April 29th, 1932.

Construction of Main Pylons and Galleries

Piers 3 and 4 were poured to the deck level as soon as the construction of the channel span permitted. The forms for the main pylons and cross galleries were to a large extent fabricated at the shop adjoining pier 6 while the steel spans were being erected, so that no time was lost in proceeding with the work after the deck was in place.

Particular care was taken during the placing of the concrete to secure at the face a uniform texture, and freedom from voids or pockets, and to avoid unsightly construction joints. To avoid strain in the light upper structure of the cross galleries, the walls and roofs were not poured until the shores under the supporting girders had been removed. To form the band of tile over the windows, the concrete was marked off by battens, and after the forms were removed the tiles were coloured two shades of green.

Construction of Railing

The railings, as previously described, were cast in place in sections with expansion joints at each post. The forms, which were in two sections, were bolted together through the openings in the railing and were easily removable. The concrete for the railings was mixed in a small mixer operated on the deck of the bridge, and particular care was taken in the placing and tamping. The entire surface of the railings, the end and main pylons and cross galleries, the outer surface of the fascia girders, and the surface of the walls at the stairways was machine rubbed to produce a smooth and uniform finish.

Electrical Work

The 1½-inch fibre conduits in the plinth of the railing and the pull boxes and metal conduits in the main posts were placed before the concrete was poured, as were also the conduits and connections in the piers and pylons, and the fibre conduits over the steel portion of the bridge. The city electrical department installed the lighting fixtures and equipment on the approaches.

Embankments

The fill at the south approach and the railway fill between the present tracks and pier 1 were placed with a 21-inch hydraulic dredge equipped with 900-h.p. pumps. For the south approach, the material was pumped from False creek east of the Kitsilano railway bridge. The maximum lift was 69 feet above the water and the pipe line was 2,550 feet long. This fill was commenced on December 12th and finished on January 14th, 1932, when the railway fill was begun, using material pumped from False creek west of the bridge. The maximum quantity of material placed in twenty-four hours was 6,000 cubic yards. The fill was finished on February 5th.

Construction of Pavement

The mastic cove and gutter, which extends 6 inches from the curb and has a height of 5½ inches with the outer surface flush with upper concrete section of the curb, was placed and compacted by hand before the 2-inch granular surface type Warrenite-Bitulithic pavement was laid and well compacted by heavy rollers, working both longitudinally and transversely. The concrete paving on the south approach was commenced on April 14th and completed on May 15th, and the north approach paving and sidewalks were completed on May 30th, 1932.

The bridge was opened to traffic after a ceremony held at the north approach to the bridge on July 1st, 1932.

Costs

The total cost of the bridge and approaches exclusive of certain work done directly by the city and land damages, was $1,844,932.24. Some of the detail costs were:—

Pier 1 (stairway tower)	$ 58,517.26
Pier 2	30,478.95
Piers 3 and 4, inc. pylons and galleries	396,352.86
Pier 5	16,842.30
Pier 6	22,812.93
Bridge lighting equipment	30,208.28

The costs per lineal foot of bridge were:—

Through truss span	$ 767.15
Deck truss spans	564.70
Concrete Viaducts:	
S. abutment to bent 4	210.55
Bent 4 to bent 7	273.85
Bent 7 to bent 10	210.95
Bent 10 to pier 1	244.92
Pier 6 to n. abutment	221.11

The progress chart, Fig. 10, shows the quantities of excavation, concrete, reinforcing steel and structural steel in the structure, also the number of workmen employed at the site, the pay-roll and the cost as given by the monthly estimates.

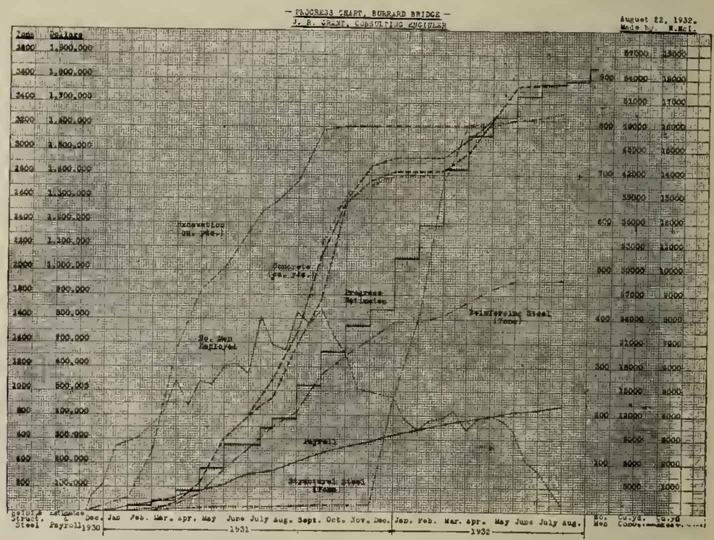

Fig. 10—Progress Chart.

Test Loading

After the opening of the bridge, a test loading consisting of three road rollers and six flushers, having a total weight of 118 tons on a length of 124 feet, or 1,900 pounds per foot, was run across the two west lanes of the bridge. The maximum deflection at the centre of the curb girder over Beach avenue, which has a clear span of 75 feet, was 1/20th inch, and the centre deflection of the 176-foot deck truss span was slightly over ⅛th inch.

In conclusion the author desires to express his deep appreciation of the support and assistance given by the city engineer and the city electrician and their staffs and his office and field staffs, including the resident engineer, during the design and construction of the bridge. He would also congratulate the contractors and sub-contractors, their officials and employees on the rapid progress made and the excellent results achieved.

The Traffic-Actuated Traffic Control System as Adopted in Montreal

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Presented before the Montreal Branch of The Engineering Institute of Canada, April 6th, 1933

SUMMARY—After sketching briefly the development of city traffic control systems as a result of the growth of automobile traffic, the paper describes the arrangement and operation of a system which has been largely adopted in Montreal, in which the signal lights are actuated by the passage of the vehicles themselves, such systems differing essentially from those in which the signal light changes are on a fixed time schedule. The operation and the control mechanism of the traffic-actuated system are discussed, and some results of its operation are given.

The first generally used means of controlling city traffic was the traffic officer located in the middle of the intersection. In the early days, before the rapid development of the automobile, the controlled intersections were limited to the larger industrial centres. However, as traffic increased, accidents and congestion mounted also, and more and more intersections had to be controlled. Such control by traffic officers was found far from perfect and increasingly expensive, and some better and less costly method of controlling traffic had to be devised.

The first installation of traffic control signals was in Cleveland, Ohio, on August 5th, 1914. The signals were operated by a traffic officer located in a booth. There was no mechanical means of operating the signals automatically. After some months, a second installation of this type was made in Cleveland, but later both were discontinued as being unnecessary.

The next signal installation of record was in Salt Lake City, Utah, in 1916. The signal was of sheet metal, the main body of which was circular and about 20 inches in diameter. It had eight standard lenses (four reds and four greens) 8⅜ inches in diameter. In this case also the signals were controlled by an officer with a manual switch. On March 14th, 1917, six more installations were made at adjoining intersections, and all were connected to the one manual control. The lights were staggered, giving an arrangement similar to what is now called an alternate synchronous system, except that the control was manual.

The first traffic tower in New York was put into operation on March 4th, 1920, at 42nd street and Fifth avenue. About fifty other towers were erected in the next two years. These towers were not electrically interconnected for simultaneous operation. When the officer in charge of the master tower changed his signals, those in charge of adjacent towers did likewise, the co-ordination depending on the alertness of the officers and the visibility under different conditions. Some of these towers are still in use, but those on Fifth avenue were replaced by bronze towers in 1922, which soon became obsolete and were replaced by curb mounted mast arm signals in 1929; these in turn have been recently replaced by the bronze corner post signals.

During the period from 1920 to 1922, other cities, such as Detroit, and Knoxville, Tennessee, installed similar traffic towers, but in all these cases the signals were controlled manually.

The signal towers had certain advantages over the officer in the centre of the intersection, for instance, the red and green signals were definite and unmistakable and much more easily understood than the officer's hand signals, and the officer in the tower had much better visibility and was free from danger. The cost and space requirement, however, made this method impossible for general application.

The first installation of electrically interconnected signals that could be controlled automatically, was made in Houston, Texas, early in 1922, where signals were installed at twelve intersections. They could be operated either manually or automatically, but in either case were operated as a simultaneous system—all of the signals flashing the same coloured lights in the same direction at the same time.

The first modern four-way signal of the general appearance of the present day signal was installed at State and James streets in Syracuse, New York, December 29th, 1922.

A year later the famous Michigan avenue system was installed in Chicago. It extended for two and one half miles and included twenty-four intersections. The signals were interconnected in a simultaneous system.

It was during subsequent years, beginning about 1923, that what is now commonly known as fixed time traffic control began to grow in favour. The rapid development of the automobile had intensified the traffic problem, and had forced its recognition even in smaller cities. Officers could not be used at every dangerous corner, because of the prohibitive cost. The new fixed time traffic control was unquestionably the answer. Compared to the cost of an officer, it was inexpensive. The result was it began to be adopted even in small towns and villages where, in order to be considered progressive, it was felt necessary to install a certain number of signals whether needed or not.

In those days traffic engineering was unknown, and there were no traffic studies. Thus, in some cases, signals were installed indiscriminately and the timing was often left set the way the control happened to come from the factory, with no regard for the relative traffic densities.

The result was that the general motoring public was subjected to unreasonable delays which were very annoying, and motorists began to regard the traffic signals generally as a nuisance. Violations increased rapidly, and the more conscientious drivers dodged the signalized intersections, thereby creating congestion and accidents and the necessity of signals at other intersections.

About 1926 the first flexible progressive system was installed. This system was designed to permit continuous movement of traffic along a given street without stops, but at a fixed average speed. It has not been found entirely practical, due to the many disturbing factors which prevent traffic from moving along the given street at the designed average speed. This system too was fundamentally of the fixed time type and the timing of the signals at best was based on average traffic conditions, which seldom actually exist at an intersection, so that while it was intended to minimize delays on the main thoroughfare, it usually penalized traffic on the cross streets. This system also depended for its success on intersections being approximately equally spaced, and generally upon rather long blocks. Its application is therefore limited to streets which carry a consistent through movement of traffic. The result is that its use is somewhat restricted.

It was also subsequent to 1926 that scientific traffic studies were inaugurated. Such studies soon revealed the surprising fact that accidents had actually increased at from forty to sixty percent of the intersections which had been signalized. This is generally conceded to be due largely to the excessive use of the fixed time traffic control and the disregard for the signals because of excessive unnecessary delays. Further, the rapidly increasing use of the automobile caused the streets to be choked with traffic, and a more efficient type of traffic control was required to meet the increasing demands.

No doubt these circumstances led a Yale professor to invent a control system which permitted the signals to be controlled entirely by the traffic. The first installation of this system was made in New Haven, Connecticut, on April 10th, 1928. It is commonly referred to in the United States as the traffic-actuated traffic control system, and in Canada has been called the "robot system." It is based on the principle of actuating traffic signals by means of the traffic itself, and has seen its entire development during the past five years.

This system has recently been installed at approximately fifty of the most important intersections in the city of Montreal, which has been somewhat conservative in adopting a mechanical device to take over the work of traffic officers in the direction of its traffic. Thus the city has been able to profit by the experience of others and to take advantage of recent progress in the art.

This system consists of three major parts—the traffic signals, the traffic detectors and the control mechanism. The traffic detectors are placed in all approaches to each signalized intersection to record approaching traffic. The control mechanism receives the information from the detectors and assigns the right of way, by means of standard traffic signals, to the different streets in accordance with the traffic flow as indicated by the detectors.

Signals

The signals are mounted on a one-piece drawn steel post with an enlarged section at the base with a door to provide facilities for pulling in and connecting the wiring; the top portion is reduced in diameter to receive the standard signal head and also provides a space for mounting traffic signs, such as "No Left Turn," etc. This type of post has been adopted as it requires a minimum sidewalk space and provides maximum strength owing to its one-piece heavy steel post construction.

The signal bodies are of cast aluminum and are fitted with silvered glass reflectors and standard roundel lenses; the reflectors and lenses are each carried in a cast aluminum carrier hinged to the signal body to facilitate wiring and re-lamping.

All of the signals are of the standard three-colour type with red, amber and green lenses, and have been wired to give the following colour sequence:

Street A...	Green	Amber	Red	Red	Green
Street B...	Red	Red	Green	Amber	Red

This is called the "split-amber" colour sequence. The amber light is shown as a clearance interval only to the street losing the right of way and not to the street receiving the right of way. This sequence has the advantage of preventing the dangerous practice of motorists who insist on starting on the amber light before green and, hence, makes for greater safety. The flexibility and design of the system is such that any desired standard colour sequence can be obtained, but it is believed that the above sequence is the most satisfactory.

At all intersections the signals are located on the far right-hand corner of each approach. This is now the generally accepted standard location. At intersections in the downtown area, and at other locations where there is a substantial volume of pedestrian traffic, there are two signal faces mounted on each of the signal posts. This arrangement ensures that pedestrians have a signal in their line of vision, regardless of the direction in which they are moving.

At intersections where there is no appreciable movement of pedestrians and extra signal faces are not required, only one signal face is mounted on each post. This gives motorists approaching the intersection a signal indication on the far right-hand corner of each approach.

Power Supply

Power is supplied at each intersection to the control unit. The control unit is mounted on one of the signal posts and a cast aluminum box is provided for the reception of the power company's meter and the main switch; power is supplied at 110 volts, 60 cycles. The direct current required for charging the condensers, and the low voltage current for detector relays are provided by means of transformers and a rectifier included in the controller itself.

The Traffic Detectors

The traffic detector is a pressure-sensitive contact-making device connected to a relay in the control mechanism and is actuated by the pressure of a wheel passing over it at any point. One or more detectors are installed in each approach to the intersections in the normal path of movement of vehicles. The detectors are placed in the pavement and their surface is flush with the road surface (Fig. 2). They are located in each approach a distance of from seventy-five to one hundred and fifty feet back from the stop line, depending on the stopping distance required for the normal speed of traffic on the particular approach.

At certain intersections where tramcars use the intersection on one or more approaches, special detectors are used for the tramcars. The tramcar detector operates as follows. A section of the trolley wire, six inches in length, is covered by a sleeve insulated from the trolley wire by heavy insulation. The sleeve is electrically connected to the trolley wire by means of a piece of nichrome wire. When the trolley wheel passes over the insulated section, the current is drawn through the nichrome wire and a small

Fig. 1—Two-way, Three-light Traffic Signal.

relay is operated by the voltage drop in the nichrome wire. When the relay is closed it in turn operates a relay in the control mechanism in exactly the same manner as the standard traffic detector described above.

The Control

The control mechanism is the most important part of the robot system. Its function is to receive the impulses from the detectors and then assign the right of way, by means of the signals, in accordance with the traffic demand from instant to instant, as indicated by the detectors.

Many more problems are involved in the design of a control which accurately registers, remembers, and responds to actual traffic demands that vary widely from minute to minute, than in the fixed time control which repeats a fixed control cycle, irrespective of the presence or absence of traffic.

With the robot control system the traffic cycle is divided into an initial "go" interval, a vehicle "go" interval, an "amber" or cautionary interval and a "red" or "stop" period.

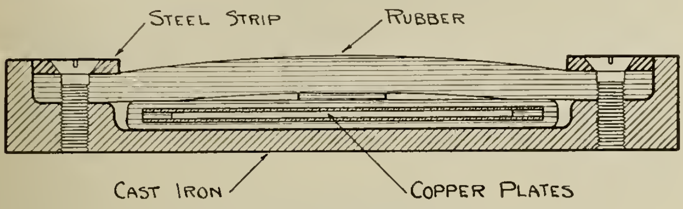

Fig. 2—Traffic Detector.

The initial interval is a pre-determined time period which commences at the start of the green signal and allows time for vehicles to get into motion. After this interval the length of the green signal is controlled by the vehicle interval, which is also a pre-determined time period, equal to the time required to drive a vehicle from the detector to the centre of the intersection. This interval is lengthened on the "green" period each time a vehicle passes over the detector.

The "amber" period is a pre-determined time interval following the display of the "green" signal. There is also a maximum traffic interval which is also pre-determined. This is the maximum time which traffic may be required to wait for the "green" signal after passing over a detector.

All of these intervals are separately adjustable for each thoroughfare.

The timing of the various intervals is based on the principle that a definite period of time is required to charge a condenser to a definite difference in potential through a fixed value of resistance. The elementary timing circuit used in this equipment is shown diagrammatically in Fig. 3. The initiating switch, a contact on the cam of the control, is closed to start the time interval. The condenser, having previously been drained of residual charge, begins to charge at a rate inversely proportional to the total amount of resistance in series with it.

The tube shunted across the condenser through the terminating relay is a flasher tube of special design, which will conduct no current until the voltage across its terminals reaches the ionizing point. The tube, upon ionizing, instantly reduces its internal drop to a value considerably less than the flash-over value, and maintains this reduced drop until it is extinguished. When the voltage across the condenser reaches a critical value for the flasher tube, it flashes over and the difference in potential between the condenser and tube-drop is developed across the terminating relay. This produces an inductive resistive current impulse in the relay, which lasts until the surplus energy in the condenser is exhausted and the tube extinguishes.

The contact on the terminating relay in the delayed impulse circuit is so arranged that it connects 110 volts a.c. to a solenoid (not shown in circuit) which thus becomes energized for a short time when the condenser discharges through the terminating relay. The solenoid by a ratchet mechanism notches the cam shaft around one notch. The cam in the new position closes the proper cam contact or initiating switch for the next time interval.

The control provides for a total of eight time intervals each independently adjustable over a suitable range. The fundamental timing circuit for all of the intervals is the same as that in Fig. 3 described above, but some special features are applicable only to certain of the intervals. For example, the time extension feature, one of the most important in the traffic-actuated control, applies only to the two vehicle intervals. Time extension is defined as the progressive extension of the green signal interval by successive vehicles crossing the detector approaching the green signal.

Time extension is accomplished as shown in Fig. 3 by short circuiting the condenser through a suitable low resistance by means of a contact on the vehicle detector relay which is operated by each car crossing the detector when the signal is green. Thus each time the detector relay is operated by a car crossing it, the condenser is short circuited and discharged, and the vehicle interval is reset. The green signal time is thereby extended by the length of the vehicle interval from the instant of actuation of each car crossing the detector.

Actually, the method of draining or resetting the condenser is not quite that shown in the diagram, for in practice the terminating relay itself does not have a reset contact. Such a contact is shown in the diagram in order to avoid the complication of showing all the mechanical operations resulting from the working of the terminating relay. The circuit shown in the figure for shunting the condenser through the reset resistor is really controlled by the solenoid on the delayed impulse circuit. This solenoid not only works the initiating switch as already described, but is also connected mechanically to a rocker arm which closes a contact in the reset circuit and thus drains the residual charge in the condenser so that each time interval is started with the condenser completely discharged.

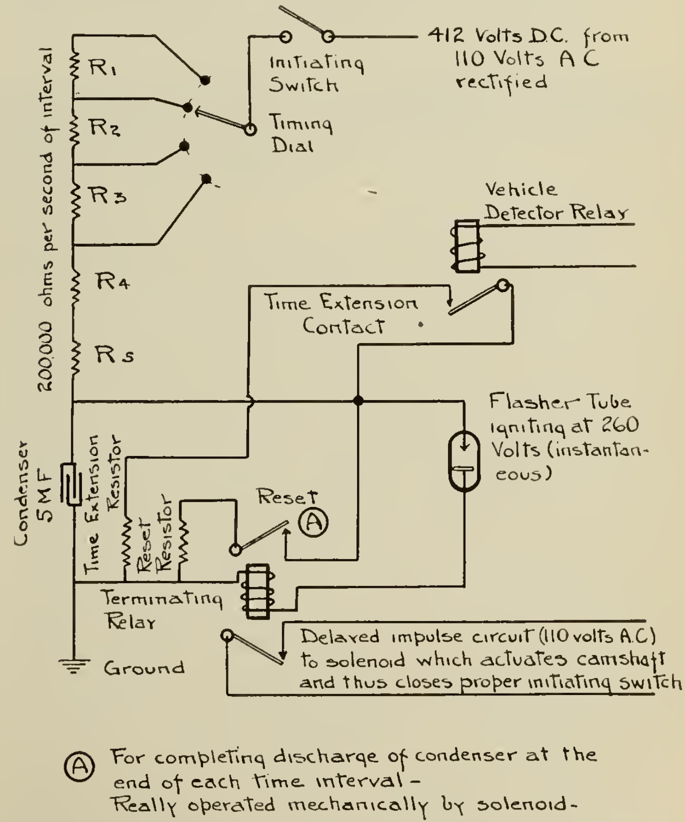

Fig. 3—Diagram of Connection of Timing Mechanism.

The length of the impulses which the detector relay receives is approximately inversely proportional to the speed of the car crossing the detector. Therefore, since the rate of discharge of the condenser is inversely proportional to the resistance in the discharge circuit, it is obvious that by choice of a suitable resistance in series with the detector relay contact (in the discharge circuit) the length of the vehicle interval time extension can be made to vary automatically with the speed of the car, and thus increase the efficiency of operation.

The resistor in series with the time extension contact is usually 2,000 ohms. If, however, it is desired to incorporate in the control system the special feature of time extension in proportion to car speed, this resistance is increased to about 20,000 ohms. In this case a car going approximately 15 miles an hour will completely discharge the condenser and thus extend the time a full vehicle inter-

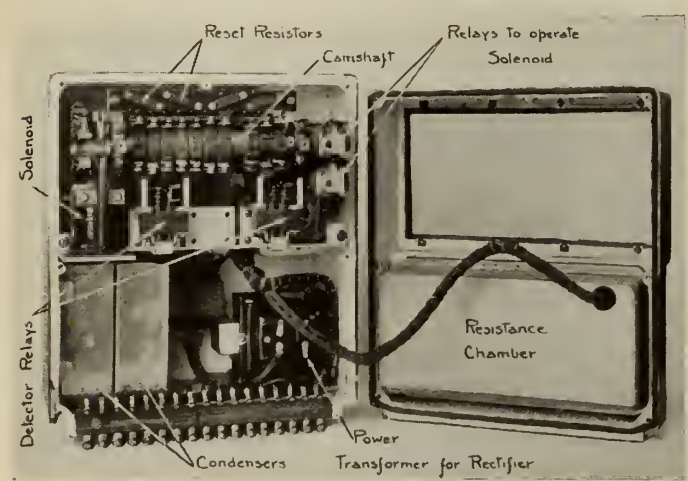

Fig. 4—Interior of Control Cabinet.

val, whereas a car going more than 15 miles an hour would not complete the discharge of the condenser and would only extend the time a fraction of a vehicle interval proportionately to the speed. For example, a car moving 30 miles an hour would extend the time approximately one half of the vehicle interval.

The timing mechanism operates on a step-by-step principle, rather than by cyclic timing. This is accomplished by using a cam shaft (shown in Fig. 4) with a six-position cycle, one position for the "amber" light and two for the "green" (one for the initial and one for the vehicle interval), on each street. The cams operate a system of contacts and set up the proper electrical connections for each position. As already explained, the cam-shaft is notched over by an a.c. solenoid and ratchet system, which in turn is operated by the terminating relay of the proper interval-timer at the end of each interval. When the cam takes a new position, it lights the proper traffic signal lights and closes the initiating switch of the proper interval timer. Each time the solenoid operates, it closes the discharge contacts of all timing condensers, thus draining them for a fresh start on the next interval. This insures against errors in timing due to a residual charge in the condenser. Each of the eight time-intervals operated by the dials on the front of the control panel is individually adjustable and completely independent of the others.

This control equipment is wholly enclosed in a dust-tight aluminum casing with a glass window for viewing all contacts and moving parts. A dial panel mounted below provides means for adjusting all time intervals from the outside. The whole control unit is mounted inside a weatherproof housing for protection against the elements and unauthorized persons tampering with it. The door of the housing is also fitted with a door giving access to a small compartment which contains switches for turning the signals on and off and for the manual control of the intersection by a traffic officer if desired at any time.

The cost of operation of the system is low, the average energy consumption of the control equipment, exclusive of lamps, being about fifteen watts per intersection.

Features of Operation of System

The control is arranged so that the right of way remains continuously on the street which used it last until called by traffic approaching on the other street. Switches are provided, however, which can be set, if desired, so that the right of way will return automatically to rest on any selected street in the absence of traffic.

Cars approaching a "red" light on any street are given the right of way immediately unless traffic on the other street is using the intersection.

If the intersection is actually being used by traffic on the opposing street, the waiting cars are given the right of way to proceed at the first break in the opposing traffic.

If no break occurs naturally in the opposing traffic, this traffic is automatically stopped at the end of a reasonable maximum period and the waiting cars are given the right of way.

When continuous traffic on either street is stopped by the operation of the maximum period to allow waiting traffic on the other street to use the intersection, the right of way reverts at the first opportunity to the street on which the continuous traffic was interrupted.

The maximum period of either street is measured from the time at which the first waiting car arrived on the other street.

Each car approaching the intersection against a "red" light at a time when the opposing street is using the right of way is automatically recorded and remembered by the control so that the right of way will later be transferred to it without the necessity of recrossing the detector.

The time of the "green" period on each street is governed by the flow of traffic on that street, each vehicle approaching the intersection under such conditions affecting the control so as to extend the "green" period for its protection. The control, therefore, allows only such time as is actually needed on each street in accordance with the immediate traffic demands. The timing of the traffic periods is thus automatically adjusted by the traffic itself.

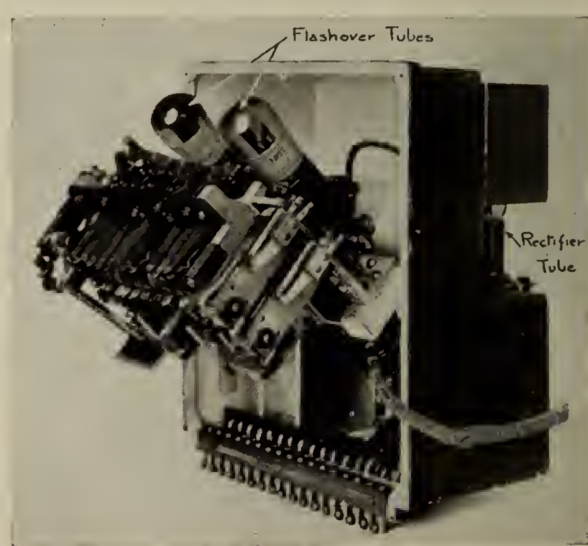

Fig. 5—Control Mechanism Showing Flasher Tubes.

The control is arranged so that push buttons for pedestrians may be connected to it to permit the pedestrians to operate the control in exactly the same manner as vehicles.

In the downtown district of Montreal there are a number of narrow streets which are in some cases used for traffic in two directions. In these locations directional detectors are installed whereby cars travelling in one direction only will operate the control.

There are also several intersections at the top of fairly steep grades on which it was desired to give the tramways the right of way. At these locations pre-emptor equipment has been installed, so that, when the tramcar passes its detector, a special relay is closed in the control, which immediately switches on the "amber" period, if the cross street has the right of way at the time, so that by the time the tramcar reaches the intersection it has the "green" signal. This type of control has also been installed at one intersection where there are no tramway cars, to provide similar conditions for vehicles, as this particular thoroughfare is used by a large number of vehicles, a number of them being heavily laden trucks, that would find it extremely difficult to start on the grade.

Below are recorded some sample typical observations of the length of the "green" interval allotted to each movement during consecutive cycles at different hours of the day.

Intersection of University and Sherbrooke Streets
April 22, 1932

Length of Green Interval (seconds) Sherbrooke St.	University St.	Total Cycle
	9.00 a.m. to 9.05 a.m.	
38	16	54
29	22	51
30	12	42
14	22	36
45	30	75
	2.30 p.m. to 2.35 p.m.	
15	12	27
22	14	36
12	26	38
31	20	51
14	12	26
	5.30 p.m. to 5.35 p.m.	
50	20	70
44	28	72
24	36	60
32	28	60
41	30	71

The above records, obtained at one of Montreal's heaviest travelled intersections, show the wide variation in the length of the "green" interval allotted to the two movements as determined by the actual traffic from cycle to cycle. This is of considerably greater importance than the variation in the total cycle, because the total cycle length might remain substantially constant and still permit the saving of a large amount of time, due to the wide fluctuation in the distribution of the "green" time between the two movements. Time saved in this manner is of great importance.

The system is operated continuously, since the objection to all night operation is removed by the elimination of unnecessary stops and delays and thus the safety element of continuous operation is retained.

During the past few years both accidents and congestion in most cities have been increasing at a high rate, due to the fact that the growth in the amount of traffic on the streets and highways has been much more rapid than the development of facilities for handling it. The comparatively recent development of the traffic-actuated system of traffic control should serve to change this condition in so far as the control of traffic at intersections is concerned.

Modern Practice in the Construction of Portland Cement Concrete Road Surfaces

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Paper presented at the Maritime Professional Meeting of The Engineering Institute of Canada, July 14th, 1933.

The design and methods of construction of Portland cement concrete highway surfaces have been subjected, in recent years, to very exhaustive studies and tests, with the result that modern practice reveals many revolutionary changes when compared with standards formerly employed. Whereas these surfaces were formerly constructed as a single undivided slab for the full width of the surfaced roadway, with the centre of the slab several inches thicker than the edges, we find to-day an almost universal acceptance of half width slabs divided by centre longitudinal joints with the edges of the slab several inches thicker than the centre. Thickened slab ends are no longer considered good practice as they tend to anchor the slab and produce transverse cracks. Transverse joints are now spaced from thirty to one hundred feet apart according to subgrade, climatic conditions and weight of steel reinforcement used. Less crown is used, and the parabolic crown is being replaced by a crown having a straight slope from centre line to edge of pavement in order to facilitate future widening of the surface. Normal highway slab widths for two-lane traffic have shown a gradual increase from a maximum of fourteen feet to widths of twenty feet as a minimum. Increased widths are usually made in multiples of ten feet. Thicknesses of surface have increased from a maximum of five inches to an almost universal standard having a cross section of nine inches at the edges and seven inches at the centre of slab, thus indicating a decided change and in some cases a complete reversal of former practice with respect to the size and shape of the slab.

Concrete surfaces, as laid to-day, are divided into two distinct classes, reinforced and plain concrete. A reinforced concrete surface embodies a complete net-work of steel bonded with concrete and distributed throughout the entire area of each individual slab. The tendency toward reinforced concrete has shown a decided upward trend in recent years. A conservative estimate is that 30 per cent of the total pavement laid in 1931 was reinforced throughout, with weights of 45 to 50 pounds of steel bars or expanded metal per 100 square feet prevailing, the tendency being towards heavier reinforcement and of the fabric type, and the placing of extra sheets of reinforcement at the slab ends. Some of the benefits derived from reinforcement are that well distributed steel delays the formation of shrinkage cracks and resists the opening of these fissures into cracks of visible width as well as helping to prevent corner cracks and bridging weak places in the subgrade. Small members spaced close together have proved more effective than large members widely spaced. The ratio of cross sectional area of longitudinal to transverse reinforcement should be in direct proportion as the length of the slab is to the width. In order to furnish an additional concentration of steel near the inner and outer edges of pavement slabs there is now extensively used a fabric design wherein the members along the edges of each sheet are of heavier gauge than the members in the interior of the sheet, the spacing of all longitudinal members remaining the same.

Prevailing practice is to place reinforcement about two inches below the surface of the slab. When double layer reinforcement is used, the second layer is placed two inches above the subgrade.

The experience of engineers and contractors long identified with constructing reinforced concrete pavements

Fig. 1—Premoulded Expansion Joint—Dowels and Sleeves in Place.

Fig. 2—Mechanical Finisher with Belt.

has indicated clearly that the strike-off method of reinforcement installation is, in general, to be preferred. By this method, concrete is deposited on the subgrade and is roughly levelled by means of a strike-off board or template to the elevation at which it is desired to place the reinforcement. The reinforcement sheet is placed on this bed of pre-struck concrete and immediately covered with additional concrete which is screeded and finished to the required pavement surface. The total cost of hauling out and placing fabric reinforcement by the strike-off method usually runs about one cent per square yard. Some reasons why the strike-off method is desirable are: good positioning of reinforcement, immunity against aggregate segregation, freedom from delay and economy in construction cost.

Plain concrete surfaces sometimes have marginal bars of ¾-inch smooth round steel placed six inches from the edge of the slab in the mid section of the slab depth, sometimes bonded and sometimes made bondless by painting or oiling. Corner bars placed in a horizontal plane to bisect the corner angle are sometimes used to prevent corner breaks but the trend is away from the use of both marginal and corner bars.

Expansion of concrete pavement is caused by an increased moisture condition or a rise in temperature. This movement is provided for by the installation of transverse expansion joints, which, if spaced at 30- to 100-foot intervals, depending on local conditions, will provide for any anticipated movement of the slab. Often, and it is considered good practice, one inch expansion material is placed in every third joint and two deformed metal contraction joints divide the section between the expansion joints into three distinct slabs. Experience has shown that ½ inch of expansion space per 100 feet of pavement is sufficient to prevent blow ups, except for very unusual extremes. The width of expansion joints should be limited to one inch. They should be perpendicular to the subgrade and the longitudinal axis of the pavement and fully occupy a uniform space for the entire width and depth of the slab. Some type of bituminous filler is most extensively used to provide or fill these joints. The metal encased air cushioned joint is being used experimentally. Longitudinal joints, usually of deformed metal, are used to divide the pavement into widths not greater than ten feet. Joints not perpendicular to the subgrade may cause breakage to the slab ends. Improper finishing at joints will cause spalling of the slab as will expansion material not being placed for the full width and depth of pavement. Hence great care must be exercised in the installing of joints, and modern practice is, not to specify how the work of installing joints shall be carried out, but rather to state the desired objectives and allow the contractor to use his own methods of obtaining them.

Dowels are ½-inch to ¾-inch smooth round bars which are placed through expansion joints or transverse contraction joints at about 36-inch intervals, the bars being free to slip within at least one of the adjoining slabs which they connect. Bonded steel members are not in any case termed dowels. In dowel installation free slippage must be provided for with the minimum clearance on one-half of the dowel, and a space in excess of joint width must be provided at the free end of the dowel to allow for expansion. The structural efficiency of slab dowels is now being seriously questioned by designers, as at best the dowel is a dubious means of maintaining slab alignment or of transferring loads across joints, etc. Since the play of the dowel in its bondless socket tends to permit movement, the efficacy of dowels seems questionable. It is self-evident that, if efficiency is to be obtained, close

Fig. 3—Curing—covering with Burlap and Spraying.

Fig. 4—Finished Pavement, Amherst, N.S.

spacing is required. At the present time, therefore, dowels constitute a feature of concrete pavement design which is receiving the serious attention of many designers. It has become almost universal practice to tie together adjoining slabs at longitudinal joints with tie bars which are similar to dowels except that they are bonded to the concrete for the full length of the bar.

The type and character of the subgrade have considerable influence on cracking and displacement of slabs, hence great care must be taken in its preparation. The objective is not necessarily to prepare or treat a subgrade in such a way as to produce a hard unyielding surface but rather to prepare a subgrade having good drainage, uniform bearing qualities and of constant volume. The contour of the subgrade surface is checked by means of a scratch template which rides on the forms ahead of the concrete. It is usually attached to the mixer by a cable which draws it forward as the work progresses.

The use of metal forms is being demanded under modern specifications due to the increased use of mechanical finishing machines and the demand of modern traffic for a uniformly smooth driving surface.

In specifying the concrete mix the selection of aggregates is of vital importance. The aggregates must have, within practical limits, a definite range of sizes that will produce a concrete with the lowest possible percentage of voids, they must be structurally sound and free from organic impurities. After the aggregates have been selected it is standard practice of the Department to design by the water cement ratio, a 3,000-pound concrete having a minimum slump of ½ inch and a maximum of 1½ inches. When the mix has thus been determined, the mineral aggregates and cement are proportioned by weight at a central proportioning or central mixing plant. If in a central mixing plant, the mixed concrete is conveyed to the roadway in water-tight trucks, if in a central proportioning plant, then either the mixed-in-transit method may be used, or the aggregates and cement may be conveyed direct to a concrete mixer, located at the site of the work and equipped with accurate water control, automatic timing device and boom and bucket delivery. Here the proper quantity of water is added and the whole allowed to remain in the mixer for at least one and one-quarter minutes. When the concrete is deposited on the subgrade it is thoroughly spaded to produce a dense mass free from air pockets or honeycombing. It is then brought to a uniform surface of the desired contour by using a mechanical finishing machine, wooden belt, longitudinal float and screeds of various descriptions. The surface is then checked for uniformity by means of a 10-foot aluminum straight-edge. Some engineers prefer a broom finish, which is provided by brushing the surface longitudinally with an ordinary stable broom.

Immediately after the final belting and checking, the surface is covered with wet burlap and kept sprinkled with water for a period of twenty-four hours and until some other method of curing is provided, such as ponding, earth, straw or clean sawdust kept wet, or calcium chloride spread uniformly over the surface, using approximately three pounds per square yard of surface. Curing is continued and no traffic allowed for at least twenty-one days or until a core taken from the slab shows a compressive strength of 3,000 pounds or until a beam test shows the concrete to have a modulus of rupture of at least 500 pounds per square inch.

It must be recognized that the construction of concrete road surfaces requires intelligent effort, faithfulness to details, proper materials, proper design, proper mixing and transporting and special care in placing and protecting. It must not be assumed, however, that because it requires well directed effort to procure a uniformly good surface that the cost is necessarily increased. There are many examples where rigid control has not only produced the desired results but has shown a distinct saving in the first cost, but even if the first cost is slightly increased by the requirements, the ultimate cost, which must include maintenance, will be greatly decreased.

A Variable Speed Hydraulic Coupling

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Crude Oil Engine and Engineering Company Limited, Montreal.

Paper presented before the Montreal Branch of The Engineering Institute of Canada, March 2nd, 1933.

SUMMARY—The author deals with a type of coupling between a driving and a driven member which permits changes in the velocity ratio to be made during operation, any desired speed of the driven member being obtainable between zero and 98 per cent of the speed of the driving member. A number of industrial applications of this device are described and illustrated.

This type of coupling is a device whereby any driving and driven members can be coupled in such a way that the driven member can have any desired temporary or permanent slip between the limits of 2 per cent and 100 per cent by simple variation of the fluid content of the coupling.

The hydraulic couplings described in this paper are a logical development of the Vulcan hydraulic coupling, originated by the Vulcan-Werk, Hamburg, which again was a development of the, at one time, well known Föttinger transmitter.

The original investigation, undertaken some ten years ago by the Vulcan-Werk, was directed towards the production of a suitable coupling, or clutch, for marine use in connection with high power Diesel engine propulsion in conjunction with mechanical reduction gear. It met with success, and for this purpose upwards of 600,000 coupling horse power has now been installed.

In 1926 Mr. Harold Sinclair* saw the possible industrial applications of the coupling and began, in close co-operation with Vulcan-Werk, to develop suitable forms for such purposes as the driving of forced and induced draught fans, centrifugal pumps, turbo-blowers, Diesel locomotives, etc., and with such success that since the beginning of 1930, when the first coupling was installed in England, over 50,000 coupling horse power has been installed for these services. In addition to these purely industrial applications, an increasing number of British automobile builders are incorporating hydraulic couplings in their cars, in place of the ordinary friction clutch. This application has received the rather happy name of "Fluid Flywheel."

*Managing Director of the Hydraulic Coupling and Engineering Company, of Isleworth, England.

Principle

A hydraulic coupling is shown in elementary form in Fig. 1. It consists of an impeller (A) and a runner (B), of similar general form, except that the impeller is provided with a dished cover (C) bolted to its periphery and provided with a suitable gland around the runner shaft. Both impeller and runner are provided with radial vanes, forming with the inner and outer profiles of the impeller and runner a series of passages of approximately semi-circular form. The whole coupling is filled with a fluid, usually oil.

Assuming starting conditions, with the runner stationary, rotation of the impeller will carry round the entrained oil and set up a centrifugal pressure in it.

This centrifugal pressure being greater at the outer diameter than at the centre, the fluid will be caused to pass through the clearance space between the two members and through the channels in the runner to the inner diameter of the impeller. Thus a series of fluid vortices will be set up, the flow being outward in the impeller and inward in the runner. The shearing of these vortices by the assumed stationary runner vanes sets up a tangential pressure on the latter thus causing the runner to rotate.

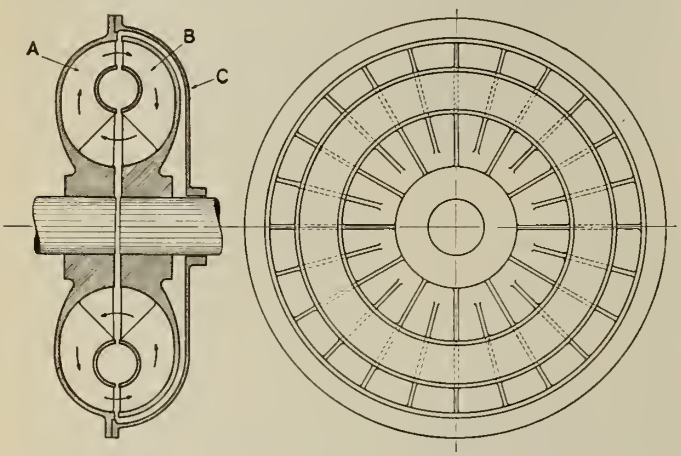


Fig. 1—Elementary Hydraulic Coupling.

It will be obvious that the runner must at all times rotate at a somewhat slower speed than the impeller as otherwise the centrifugal pressures at the periphery of both members would be equal and circulation would cease. This relative rotation, or slip, is not, however, more than 2 per cent at the full designed speed and can, where necessary, be reduced somewhat.

If, by any of the methods to be described later, the quantity of the fluid in the coupling is reduced, the energy of the vortices tends to be reduced correspondingly. As it is a characteristic of the coupling that the output torque is equal to the input torque, the rate of circulation of the vortices must be increased to maintain the same energy content, and this increase in circulation can only be obtained by increasing the pressure difference between impeller and runner, or, as the impeller speed is assumed constant, by a reduction in runner speed. The slip can therefore be adjusted to any desired amount by variation of the fluid content of the coupling. Until comparatively recently certain difficulties due to instability of fluid flow were experienced at slips greater than 75 per cent but recent developments enable permanent slips of any amount to be maintained.

Characteristics

In order to appreciate the various applications of the coupling, the following peculiar characteristics should be borne in mind:—

(*a*) The output torque is at all times equal to the input torque. The power transmitted, and efficiency are therefore inversely proportional to the slip.

(*b*) The coupling is incapable of transmitting cyclic variations in driving torque or torsional oscillations. Toothed gearing can therefore be used in connection with a fluctuating drive such as a Diesel engine without difficulty.

(*c*) The output torque cannot under any circumstances exceed the designed maximum. Sudden stoppage of the driven mechanism cannot throw undue strains on the driving mechanism.

(*d*) The slip increases rapidly with reduction in impeller speed below a designed minimum, so that where a hydraulic coupling is used in conjunction with an internal combustion engine it is impossible to stall the engine through inadvertently overloading the output shaft.

Applications

The applications made up to the present include:—

Marine.

(*a*) Diesel propulsion, either direct or through mechanical gearing.

(*b*) Bauer-Wach exhaust steam turbine system.

(*c*) Direct Diesel drive of suction pumps in dredges.

(*d*) In Diesel tugs, to provide smooth take up of the tow.

(*e*) In fishing vessels for operating winches and trawls direct from the main propelling engines.

Industrial.

(*f*) Fan, centrifugal pump, and turbo-blower drives, controlling delivery by speed reduction instead of by damper or valve control.

(*g*) Flywheel motor generator sets, to vary the flywheel speed and its energy output when driven by constant speed motors of the synchronous type.

(*h*) Diesel locomotives when employing mechanical change speed gearing.

(*i*) Diesel and gasoline engine driven shovels, excavators, etc., to prevent engine stalling and overloading.

(*j*) Mechanical stokers and conveyors, to give accurate and infinitely variable speed control.

(*k*) As clutches, enabling apparatus requiring high starting torque to be started by electric motors, internal combustion engines, etc., having low starting torque characteristics.

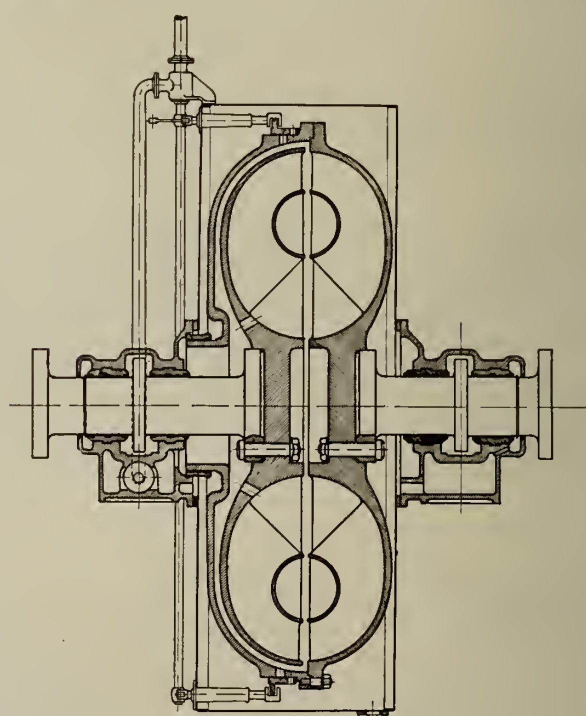


Fig. 2—Hydraulic Coupling—Marine Type.

(*l*) In automobiles, in place of the conventional clutch and flywheel.

Description of the Various Forms of Coupling

As the marine coupling was the original form it is proposed to describe it first.

Fig. 2 is a drawing of a marine hydraulic coupling. It will be noted that the impeller and runner are of the same general form as shown in the elementary coupling, but certain modifications are made so that it can be emptied and filled as desired.

Emptying is accomplished by means of a series of ports in the outer periphery of the impeller, normally covered by a ring valve, Axial movement of the ring valve by the linkage shown opens the ports and permits the fluid to be ejected by centrifugal force. The discharged fluid is caught in the outer casing and is delivered to a gravity tank by a pump driven from the impeller shaft. The coupling is replenished by the valve shown, this valve being interconnected with the ring valve.

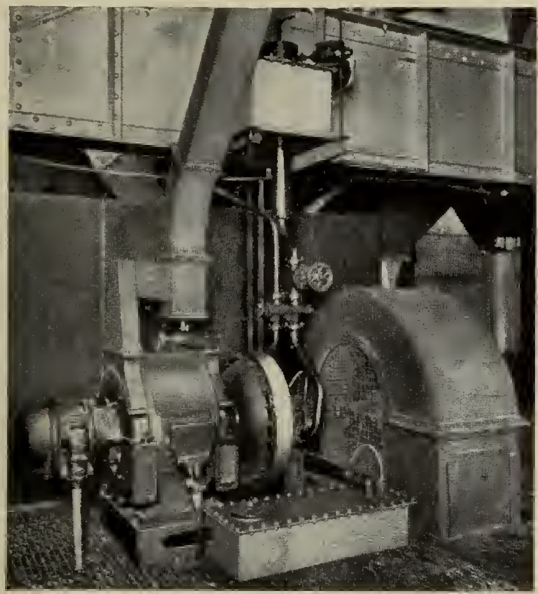


Fig. 3—Vulcan-Sinclair Hydraulic Coupling, 65 h.p. at 720 r.p.m., Driving Forced Draught Fan.

Any variation in the quantity of fluid in the coupling varies the slip, and it will be obvious that the Diesel engine could be running at any desired speed and the coupling gradually filled, thus rotating the propeller.

An arrangement of hydraulic couplings and reduction gearing has been used in the Hamburg-America liner *St. Louis* for coupling two Diesel engines to a common propeller shaft. There are four engines, each of 3,900 b.h.p., coupled in pairs. In this installation the oil is returned to the coupling via the hollow runner shafts, the arrangement of the gearing making this possible.

A somewhat similar arrangement has been adopted in the new German battleship *Deutschland*, but in this case four engines, each of 7,100 b.h.p., are geared to a common shaft. Each or all of the engines can be instantly disconnected from the system by emptying its coupling, which is of considerable advantage in the event of engine trouble. Although the engines are directly reversible, manoeuvring is carried out by running one pair of engines ahead and the other pair astern, the direction of rotation of the propeller being controlled by filling and emptying the appropriate couplings, thus obtaining ease and rapidity of control comparable to Diesel-electric transmission without certain attendant disadvantages.

A number of hydraulic coupling installations have been made in connection with Diesel tugs. The type of coupling used is similar to the marine coupling shown previously. At idling speeds the coupling slip is high and the tug can therefore be brought up to the tow as gently as is desired, which is quite difficult in the case of a direct drive job, where the slowest possible engine speed usually gives too high a tug speed when running light. The coupling also acts as a species of safety valve to the load in the tow line, as should this exceed a predetermined maximum the coupling will slip. A further arrangement is available where complete wheel house control is desired. This consists of two couplings, with ahead and astern gearing, either coupling being engaged as required by the simple throwing of a small valve.

Reference was made above in the list of marine applications to the use of the coupling in Diesel suction dredges, where the suction pump is directly driven from the engine. The obvious reason for this application is to prevent undue strain on the engine due to rocks of excess size passing into the pump.

One further application in the marine field may be noted. The well-known Bauer-Wach exhaust steam turbine system, in which a small high speed exhaust steam turbine is connected through reduction gearing to the shaft of a slow speed reciprocating steam engine, incorporates an hydraulic coupling between the turbine and gearing in order to prevent the uneven turning moment of the engine from being transmitted to the turbine, thus avoiding the high tooth loading that would occur if the turbine, with its high rotor inertia, were compelled to follow the cyclic variations of the engine. The coupling also fulfils the function of a clutch, the emptying and filling system being interconnected to the reversing weigh-shaft of the engine.

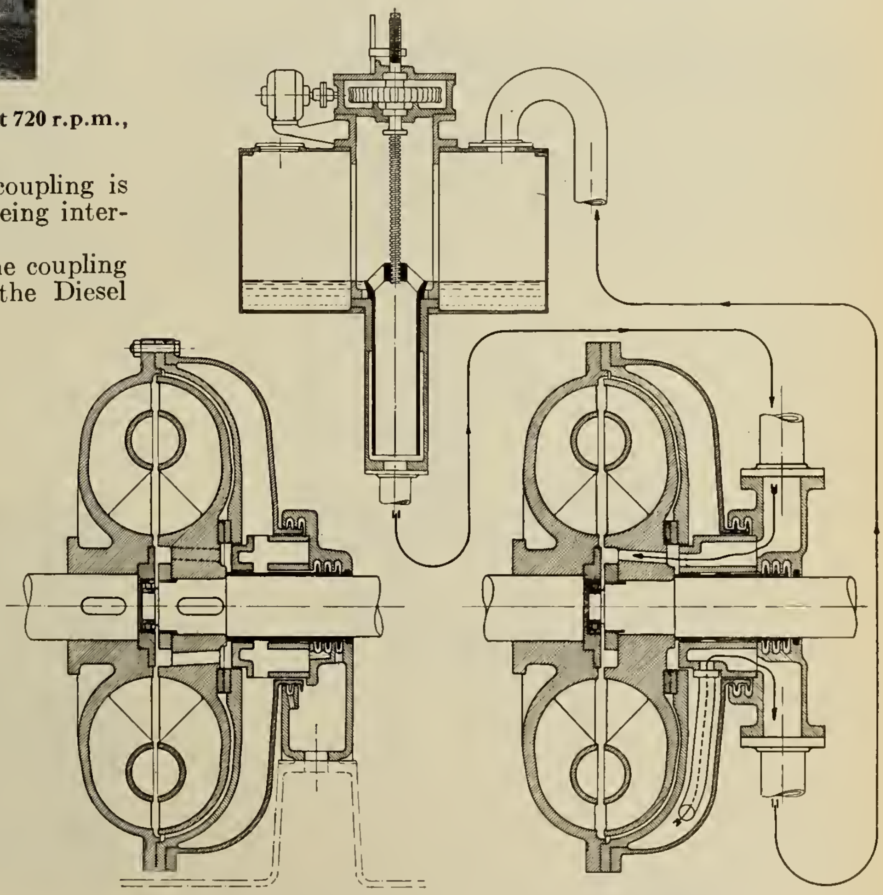


Fig. 4—Scoop Tube Type with Weir-Tank Control.

The turbine is therefore not reversed but is automatically clutched and declutched with complete freedom from shock.

Industrial Applications

Fan and pump drives.

One of the early industrial applications of the hydraulic coupling was directed towards the production of a suitable speed control mechanism for forced and induced draught fans when driven by a constant speed motor, which would be more efficient than the usual damper control. For this purpose a special form of coupling known as the "scoop tube" type was developed by the Hydraulic Coupling and Engineering Company, and a typical installation is shown in Fig. 3.

This type of coupling differs from the marine type in that the impeller is provided with inner and outer cover plates. (See Fig. 4.) A stationary scoop tube which is mounted on a manifold of pedestal form, extends into the space between the two cover plates. The centrifugal

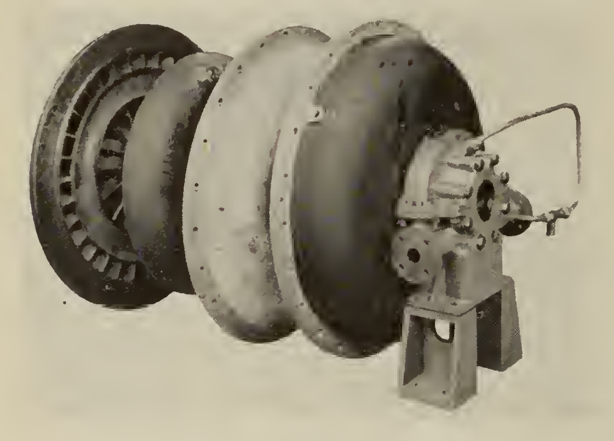


Fig. 5—Hydraulic Coupling, Expanded View.

pressure in the coupling causes a continuous discharge of the fluid through the stationary scoop tube and thence to a gravity tank containing the slip control gear. A return pipe from the tank to the coupling completes a circuit through which the oil is continuously circulating.

It will be noted that the slip control gear consists of a tubular weir arranged so that its discharge edge can be raised and lowered as desired, by hand or by a small electric motor, the motor being controlled manually or automatically.

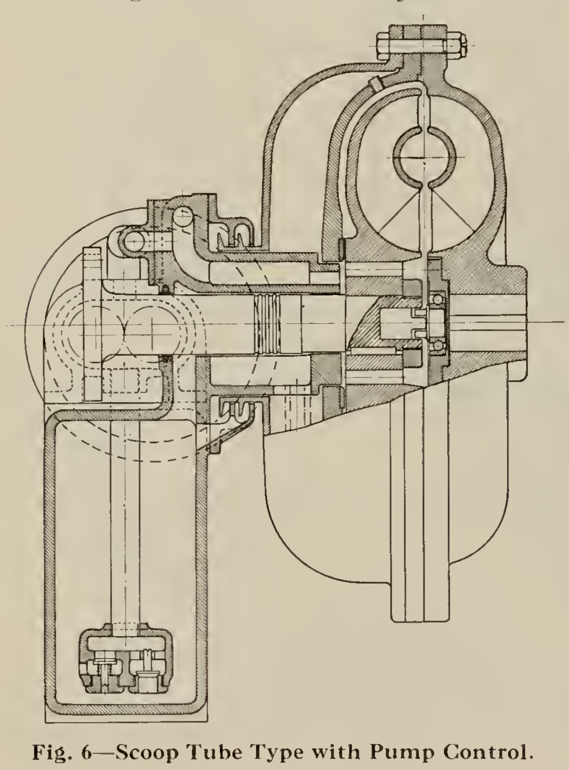


Fig. 6—Scoop Tube Type with Pump Control.

When the weir is at its lowest position no fluid is retained in the tank; the coupling is therefore full and operates at its minimum slip of 2 per cent. For any other position of the weir a corresponding amount of fluid is trapped in the tank with the result that the coupling is only partly filled with corresponding increase in slip. At the highest position of the weir there is no return to the coupling and no torque is transmitted. In this way an infinitely variable speed control is obtainable over the whole speed range. (See Fig. 5.)

This scoop tube type of coupling has been used in the majority of installations for fan drive and is still employed where a number of fans are required to run in parallel. A later type of coupling known as the pump control type is more commonly used for single units and is illustrated in section in Fig. 6. In this form of coupling a small hand operated pump is mounted directly on the manifold pedestal, which is of sufficient size to contain the whole of the fluid. Rotation of the pump handwheel in one direction withdraws the fluid from the coupling while rotation in the opposite direction returns it to the coupling. There is, therefore, no external piping or tank and the combination of motor, coupling, and fan forms a self-contained unit.

As previously stated, the power output from the runner is inversely proportional to the slip. The efficiency is therefore also inversely proportional to the slip and it would appear at first sight that the low efficiency at high slip would militate against the use of the coupling.

In the case of a fan drive, however, the power required varies very nearly as the cube of the speed, and, therefore, while the output of the coupling at 50 per cent slip would only be 50 per cent of the input, the power required to drive

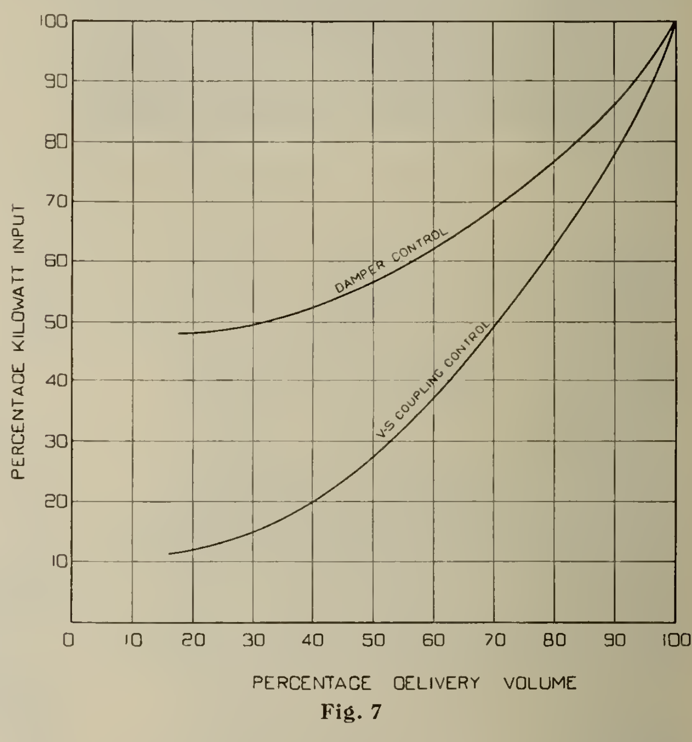


Fig. 7

the fan at this speed would only be some 12½ per cent of the full speed power. The relatively low efficiency is therefore of small moment and the overall efficiency of a fan drive incorporating a hydraulic coupling is very much higher at partial deliveries than the usual constant-speed drive with damper control.

Fig. 7 shows curves of power input against delivery for constant speed drive with coupling speed control and with damper control and it will be seen that the input at 50 per cent of maximum delivery is, with coupling control, only some 50 per cent of the input with damper control.

Similar curves on a basis of delivery pressure instead of volume indicate similar power economies.

A further incidental advantage of speed control of delivery as against damper control is the reduction in fan erosion in the case of induced draught fans due to the normally lower speeds of rotation.

Due to the fact that the electrical equipment is of the simplest, the delivery control of the finest, and the power consumption lower, large numbers of hydraulic couplings have been installed in steam-electric generating plants in England, such important plants as the Lot's Road plant of the London Underground Railways (fifteen couplings totalling 1,485 h.p.), the London County Council Tramways power station (twenty couplings, 1,700 h.p.), the Dunston-

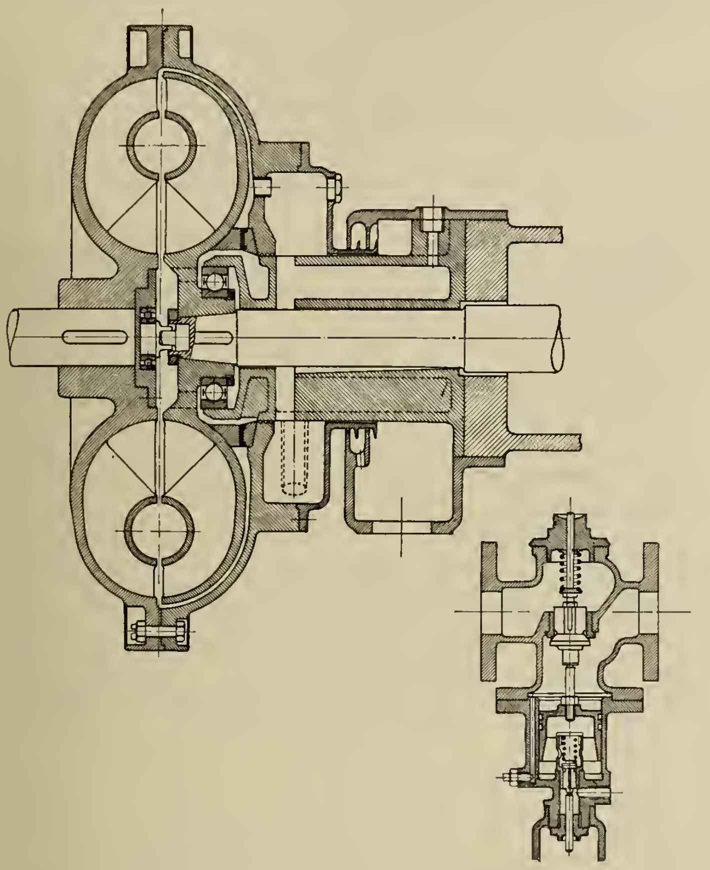


Fig. 8—Scoop Tube Type—Pump Drive, Pressure Valve Control.

on-Tyne plant (forty-eight couplings, 5,080 h.p.), the Clarence Dock plant, Liverpool (sixteen couplings, 1,600 h.p.) and numerous others, are being or have been completely equipped with hydraulic couplings for their forced and induced fan drives. The ventilation system for the new

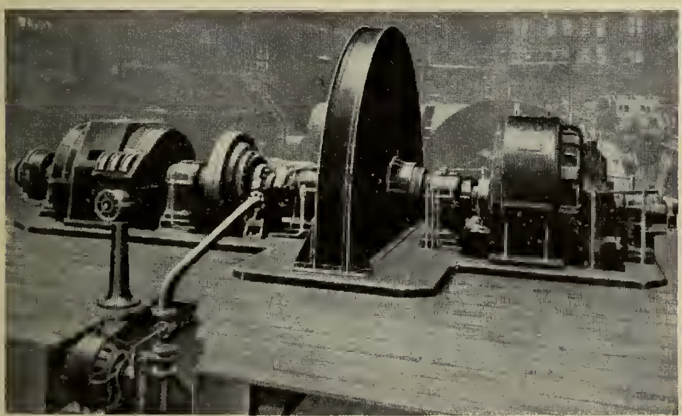


Fig. 9—Flywheel Generator Set with Vulcan-Sinclair Hydraulic Slip Regulator, Driven by Synchronous Motor of 1,000 h.p. at 1,000 r.p.m.

Mersey tunnel is also hydraulic coupling-controlled, the couplings numbering twenty-nine, totalling 5,100 h.p.

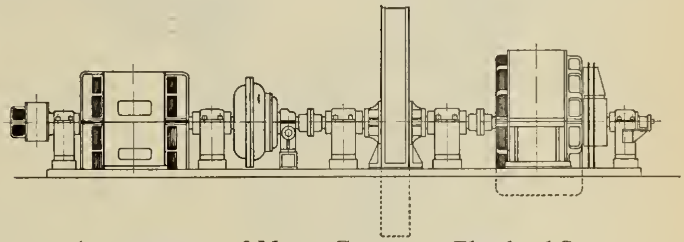
Centrifugal pumps, having similar characteristics, have also had hydraulic couplings incorporated in their drives in a number of installations. The scoop tube type of coupling is used, with slight mechanical modifications, but the delivery is controlled by a special valve in the return pipe, the valve being controlled by the pressure in the delivery pipe of the pump. As the delivery pressure tends to rise with reducing output the control valve closes and the coupling is partially emptied, the slip increases and the pump slows down somewhat. The reduction in power consumption is due to the fact that the pump is delivering its reduced output against a lower head than would be the case if full revolutions were maintained.

Fig. 8 shows the type of coupling employed for this service, the difference between it and the fan type coupling being the incorporation of a large ball-bearing to take the weight of the runner off the relatively light pump shaft.

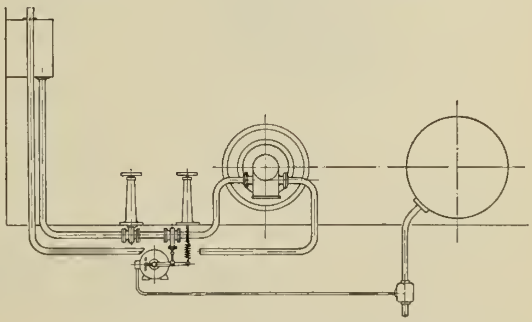
In cases where any particular partial delivery is desired for long periods and where non-automatic speed control will suffice the pump control type shown previously in Fig. 8 is employed.

Flywheel Generator Slip Regulator

Electric winding and rolling mill drives requiring large power input for short periods with intervening periods of low or zero power input commonly use the well-known motor-generator-flywheel system, in which a motor, usually a.c., drives a d.c. generator and a large flywheel, the latter storing up energy during periods of small generator output and giving up energy during the rolling or winding period. In order that the flywheel may slow down so as to give up its stored energy a motor of non-synchronous



Arrangement of Motor Generator Flywheel Set.



Arrangement of Slip Regulator Gear.
Fig. 10

type must normally be used, with detrimental effect on the power factor in the case of large units.

The Metropolitan-Vickers Company have developed a system of this type using a synchronous motor with a hydraulic coupling interposed between the motor and flywheel, the necessary speed variation of the flywheel being obtained by slip control. (See Fig. 9.)

Fig. 10 shows the layout of such a system and also a diagrammatic arrangement of the slip regulator. The coupling is of the scoop tube type and the fluid content and consequent slip is controlled by a valve in the return pipe to the coupling, this valve being operated by a torque motor energized from a series transformer in the motor circuit. As the motor input rises at the beginning of a roll or wind the torque motor gradually closes the control valve, thus increasing the slip and allowing the flywheel to slow down and give up its stored energy to the generator. During the periods of low input the reverse action takes place and the flywheel speeds up to normal.

A point of some interest, obviously applying to other applications, is the use of the coupling as a clutch for starting the flywheel from rest. By use of a hand operated valve in the return circuit the coupling can be completely emptied at the end of a shift. When restarting, the synchronous motor is first brought up to speed and the flywheel then accelerated by opening the valve slowly, an ammeter in front of the operator enabling him to keep the input down to any desired figure.

Diesel Locomotives

Hydraulic couplings have been used with considerable success in Diesel locomotives fitted with mechanical change-speed gearing, although the installations are not quite as numerous as those for other purposes, possibly because of the undue caution shown in the adoption of mechanical gearing for this service.

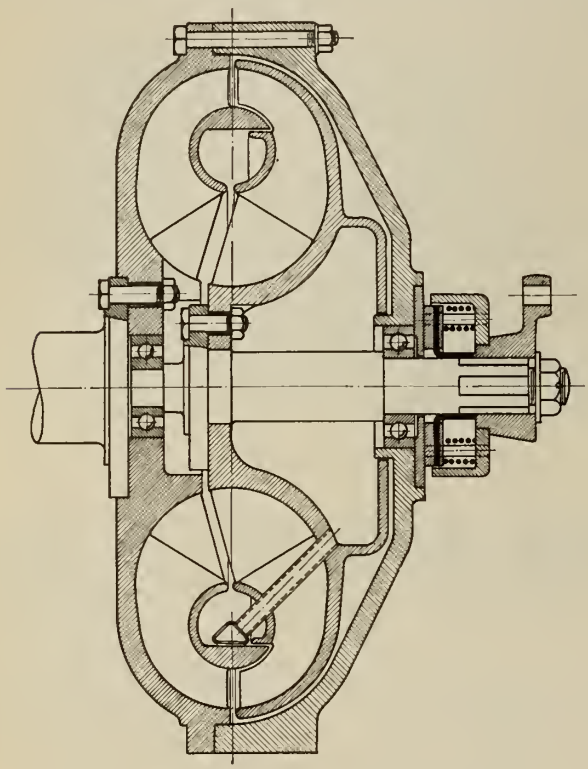


Fig. 11—Hydraulic Coupling—Traction Type.

The couplings used for this purpose are known as the traction type. This form of coupling is an extremely ingenious combination of the plain and scoop tube types, and one that does not involve any external tank, piping or control mechanism.

Fig. 11 shows a traction coupling in section. It will be noticed that an annular reservoir is formed round the runner shaft and in one with the runner. From this reservoir scoop tubes extend into the dead area between impeller and runner, and revolve with the latter.

The coupling is so proportioned that at low runner speeds the scoop tube effect is high and the fluid is abstracted from the coupling and retained in the reservoir. As the runner speed increases, however, the centrifugal effect overcomes the scoop tube effect and the fluid is ejected back into the coupling. Abstraction and replenishment take place over a comparatively small range of revolutions, but perfectly smoothly and obviously without shock.

Fig. 12 shows slip curves for a coupling of this type from which it will be seen that the slip is of the order of 2 per cent at full revolutions, rising to 10 per cent at 30 per cent of full speed. The slip then rises rapidly until at around 15 per cent of full speed it is 100 per cent thus avoiding all possibility of stalling the engine.

In operation, assuming the locomotive starting from rest, bottom gear would be engaged with the engine idling; accelerating the engine will immediately reduce the slip and the train will move away smoothly. Should for any reason the engine be incapable of moving the load with the torque available nothing more serious will happen than that the coupling will slip and continue to do so indefinitely and with but slight rise in temperature.

To date the largest locomotive in which a hydraulic coupling has been fitted is a 300-h.p. engine built by Messrs. Hudswell Clarke in England.

The Fluid Flywheel

One of the most important and epoch making developments in automobile transmission systems has been the substitution of the hydraulic coupling in place of the conventional clutch and flywheel, usually in combination with a self-changing or pre-selective gearbox of the Wilson type.

This innovation, which is likely to receive wide acceptance, was initiated by the Daimler Company in England who obtained the rights for this particular application of the hydraulic coupling.

The "fluid flywheel" is a simple form of coupling very similar to the elementary coupling previously illustrated, and is mounted on the crankshaft flange, taking the place of both flywheel and clutch. The characteristics are similar to those of the traction type except that the full speed slip is somewhat higher, and the operation is as described under the Diesel locomotive.

The smoothness of car control as compared with the usual clutch, which requires a certain amount of pedal dexterity to operate perfectly, the power to move off smoothly from a traffic stop on an incline, and the ability to travel at extremely slow speeds in top gear make the fluid flywheel a fascinating device and one which is being incorporated in an increasing number of British cars and heavier vehicles. Fluid flywheels are fitted on two auto-busses which Associated Equipment of Canada have supplied for operation between Hamilton and Buffalo.

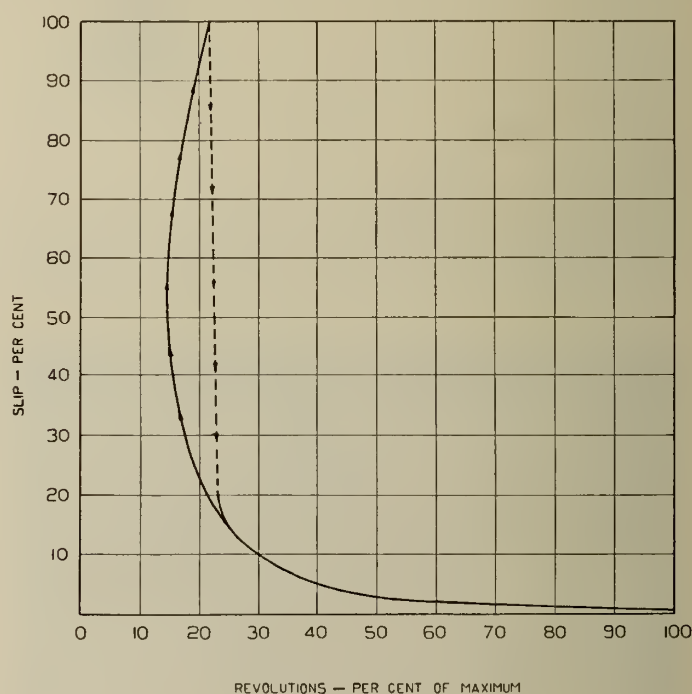


Fig. 12

It is hoped that the foregoing description of the Vulcan-Sinclair hydraulic coupling in some of its forms and applications will be found of interest as indicating some of the possibilities of this ingenious engineering development, which while originating with Vulcan-Werk has been developed for so many industrial uses through the inventive ability of a British engineer.

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VOLUME XVI SEPTEMBER 1933 No. 9

The Sixth Plenary Meeting of Council

It is two years since the last Plenary Meeting of Council was held, and at that time the full effect of present conditions upon engineering work had hardly been realized. Since then, The Institute's members, like those of other national engineering societies, have suffered severely from the present economic situation, and this has been reflected in a reduction in The Institute's revenues, though not in any diminution of the services desired by members.

The Institute has two principal sources of income: members' fees and income from advertising; both of these have shown marked recession during the period named. As far as can now be judged, the total revenue from fees and Journal advertising in 1933 will not be much more than one half of the corresponding figures for 1931.

As regards future income from fees, no immediate improvement seems likely, for those of our members who are out of employment must provide for living expenses before they can meet their obligations to The Institute.

The Council accordingly has had to deal with the problem of how to make ends meet with as little disturbance as possible in the active work of The Institute, at the same time making due allowance for the difficulties of those members who find themselves partly or entirely unable to pay their fees to The Institute.

The task before the sixth Plenary Meeting of Council, which will convene in Montreal, on Monday, September 25th, will not be an easy one. It will first be necessary to place before the councillors, assembled from all parts of Canada, a statement as to the exigencies of the present situation and the means which have been adopted in dealing with them, so that a reasoned estimate may be made of The Institute's financial prospects and the resulting modifications in policies which will be necessary during the next few years.

Up to the present it has been found possible to carry on The Institute's work with but slight curtailment of any of the Headquarters or Branch activities, but this has only been accomplished by the most rigid economy, by reduction of salaries and by cutting out all expenditure not found to be absolutely necessary.

The Plenary Meeting of Council will also be faced with the consideration of the future of The Institute with respect to development. The Committee of Council, which for some months has been studying the proposals of the Committee on Development and the various opinions and comments which those proposals called forth, will, it is hoped, be able to submit a report presenting both a summary of general opinion and a series of definite suggestions upon which the councillors in session will be able to base their discussion. This Committee's report has not yet been formulated and, no doubt, considerable difficulty is being encountered in producing a statement satisfactory to the various schools of thought existing in The Institute membership.

After dealing with problems of finance and development, the Council will be able to discuss the means necessary to maintain and increase The Institute's active membership. In order to meet the case of members who find themselves quite unable to meet their obligations to The Institute for the time being, Council has directed that when adequate reasons are given, their names can be placed temporarily on a "suspended list" and a considerable number have had to make this arrangement, with the inevitable result of a drop in The Institute's revenue. The question of additional membership, therefore, requires consideration, and is also of special moment at this time, when the interests of engineers as a body are affected so adversely by the course of events. The need for a strong association of Canadian engineers of all branches was never greater than now, in order to deal effectively with questions concerning the profession as a whole; to study and do what is possible to relieve the situation as regards unemployment, and to discuss other problems of common interest. Every additional member increases the usefulness of The Institute in this regard.

During the past two years an increased proportion of the time of the Headquarters' staff has been taken up with work in connection with unemployment. A general survey of the situation has been made by an Institute committee appointed for that purpose, and the members present at the Plenary Meeting will be interested in the information which has been brought out by this survey regarding the extent to which members are unemployed, the cases in which real distress has been found to exist, and the measures taken at Headquarters and at the various Branches to alleviate the situation. This topic will form another major division of the Plenary Meeting's activities.

The importance attached by the membership at large to such a meeting of Council, which is in fact an assembly of all the councillors of The Institute, may be judged by the fact that the Branches without exception have been willing to make from their own revenues substantial contributions towards the cost of the meeting.

It is more than ever realized that gatherings of this kind, in which Branch representatives can personally exchange views and opinions, are an essential feature of Council's work, because they enable Council to shape its policies so as to fulfil as far as possible the aims of the membership as a whole.

Former Plenary Meetings have shown conclusively that personal contact and round table discussion are the only effective means of smoothing out those differences of opinion which are inevitable in a deliberative body whose members are so widely scattered geographically, and whose viewpoints are correspondingly dissimilar. At all these earlier meetings there was exhibited a desire for co-operation, care for the welfare of The Institute as a whole, and a willingness on the part of all members to adopt a spirit of reasonable compromise and appreciate the opinions of others. The Plenary Meeting of 1933 will not fall behind in these respects.

Unauthorized Solicitation of Journal Subscriptions

Access to an industrial plant in Hamilton was recently granted to a young man falsely representing himself as associated with The Institute, who also gave the impression that he was authorized to solicit subscriptions to certain magazines, including The Engineering Journal.

Members will please note that The Institute has never employed or authorized any solicitors for subscriptions to The Journal.

The Secretary would appreciate receiving particulars of any further cases of this kind which may come to members' notice.

R. J. DURLEY,
Secretary.

OBITUARIES

John Donald Robertson, A.M.E.I.C.

The death is recorded at Edmonton, Alta., on August 3rd, 1933, of John Donald Robertson, A.M.E.I.C.

Born at Ottawa, Ont., on June 1st, 1880, Mr. Robertson was employed as draughtsman in the Surveyor-General's branch of the Department of the Interior, Ottawa, from 1896 to 1900, later becoming assistant to J. E. Woods, at Frank, Alta., carrying on a general engineering practice and making a specialty of the examination of coal properties. In 1903 Mr. Robertson was in charge of construction of the West Canadian Collieries Railway between Frank and Lille, Alta., and in 1904 and 1905 was mining engineer for the Canadian American Coal and Coke Company. From January to June 1906, he was transitman, also taking astronomical observations on the production of the fourteenth base line west of the fourth meridian, and from that date until December 1907 was employed by the Department of Public Works of the province of Alberta on the survey of roads, irrigation, ditches and location of bridges. In 1908 Mr. Robertson was engaged on preliminary work for the parliament buildings for the province of Alberta, and from May 1908 to April 1909 was in charge of the survey of roads, ditches and location of bridges in the Edmonton district for the Department of Public Works, Alberta. From May 1909 to February 1910 he was assistant to the director of surveys for the province of Alberta, and in June 1910 was appointed drainage engineer for the province. Subsequently Mr. Robertson was appointed engineer of highways, and some years later was made Deputy Minister of Public Works, which office he held up to the time of his death.

Mr. Robertson became an Associate Member of The Institute on October 14th, 1911.

Byron Angus Yandall, A.M.E.I.C.

It is with deep regret that the death in Boston, Mass., on July 8th, 1933, of Byron Angus Yandall, A.M.E.I.C., is placed on record.

Mr. Yandall was born at Long Point, Kings county, N.B., on December 5th, 1881, and received his early education at schools in Long Point and Saint John, graduating from the University of New Brunswick in 1904 with the degree of B.A.I.

Following graduation Mr. Yandall was employed until 1906 on the Toronto-Sudbury Branch of the Canadian Pacific Railway Company, and from that date until 1910 was engaged in various capacities with the Grand Trunk Pacific Railway at Winnipeg, Man., and Fort George and Hazelton, B.C. From 1910 to 1916 Mr. Yandall was employed in the engineering field in Vancouver and Rossland, B.C., and from 1916 to 1920 he was with the West Kootenay Power and Light Company Limited at Rossland, B.C. In 1920-1922, he was occupied in engineering and prospecting in Swastika, New Liskeard and Kirkland Lake, Ont., and from 1922 to 1924 was employed by the Temiskaming and Northern Ontario Railway at East Kirkland, Larder Lake and Rouyn, Ont. From 1924 to 1928 he was with the New England Power Company at Worcester, Mass., and from then until the time of his death was employed as instrumentman and later bridge inspector with the Boston and Albany Railroad Company.

Mr. Yandall joined The Institute as an Associate Member on February 20th, 1917.

Samuel Fortier

Dr. Samuel Fortier, professor at the University of California, and former chief of the irrigation investigation bureau of the United States Department of Agriculture, died at Oakland, Calif., on August 18th, 1933.

Born at Leeds, Que., on April 24th, 1855, Dr. Fortier graduated from McGill University in 1885 with the degree of B.A.Sc.

Subsequent to graduation, Dr. Fortier was until March 1886 designing and erecting municipal bridges in Megantic county, Que. From 1886 to 1889 he was first assistant engineer of the Denver Water Company, and in 1889-1890 he held a similar position on the staff of the Citizens' Water Company of Denver, Colo. In 1890 Dr. Fortier was engineer and superintendent of the Ogden City Water Works, and in 1891 he was appointed chief engineer of the Water Works and in addition held the same office in connection with the Bear River canal, both plants being owned by the Bear Lake and River Water Works and Irrigation Company. Dr. Fortier had charge of the Pacific Coast District of the irrigation investigations of the United States office of Experimental Stations in 1903-1907, and from 1905 to 1915 was chief of irrigation investigations. For the next seven years he was at the head of irrigation investigations for the United States Bureau of Public Works, and in 1924 was appointed senior irrigation engineer for the Department of Agriculture.

Dr. Fortier joined The Institute (then the Canadian Society of Civil Engineers) as a Member on December 28th, 1892, and in 1897 was the recipient of the Gzowski medal for his paper on "The Storage of Water in Earthen Reservoirs."

PERSONALS

Brigadier J. Sutherland Brown, C.M.G., D.S.O., Affil.E.I.C., Retires

The retirement of Brigadier J. Sutherland Brown, C.M.G., D.S.O., Affil.E.I.C., officer commanding Military District No. 11 at Victoria, B.C., has been announced by the Department of National Defence.

Brigadier Brown took a number of courses at Royal Schools of Instruction, including the long course of the Royal Military College in 1905, and was commissioned to the Permanent Force from the Active Militia in June, 1906, when he joined the Royal Canadian Regiment, serving throughout the Great War in various headquarters capacities at the front. In recognition of his services he was awarded the C.M.G. and D.S.O., and was five times mentioned in despatches. Following his return to Canada, Brigadier Brown became successively director of organization, director of military operations and intelligence, and Officer Commanding Military District No. 11.

E. E. Brydone-Jack, M.E.I.C., Retires

E. E. Brydone-Jack, M.E.I.C., who has since 1921 been supervising district engineer for the prairie provinces, Northwest Territories, British Columbia and Yukon

Districts, for the Department of Public Works of Canada, with headquarters at Victoria and Vancouver, B.C., is retiring from the service.

Mr. Brydone-Jack graduated from the University of New Brunswick in 1891 with the degree of B.A., and obtained the degree of C.E. from the Rensselaer Polytechnic Institute in 1894. During the year 1894-1895 he was a draughtsman with the Pottsville Iron and Steel Company at Pottsville, Pa., and from 1895 to 1898 was draughtsman and checker with the Pennsylvania Steel Company, Steelton, Pa. From 1898 to 1900 he was engineer in charge of the Siebert House branch office of the Keystone Bridge Works of the Carnegie Steel Company, and in 1900 and 1901 was engineer in charge of detail designing with the Fort Pitt Bridge Works, Canonsburg, Pa. During the sessions 1901 to 1905, Mr. Brydone-Jack was professor of civil engineering at the University of New Brunswick, and in 1905 was appointed to the professorship of civil engineering at Dalhousie University, Halifax, engaging also in private consulting practice. In 1907 Mr. Brydone-Jack joined the staff of the University of Manitoba in the same capacity. In 1917 he was appointed supervising district engineer for the Prairie Provinces' districts for the Department of Public Works of Canada, and in 1921 received the appointment from which he now retires.

RECENT ADDITIONS TO THE LIBRARY

Proceedings, Transactions, etc.

New Zealand Society of Civil Engineers: Proceedings 1932-1933.
Association of Professional Engineers of Nova Scotia: Minutes of Annual Meeting 1932, List of Members and Officers for 1933.
Punjab Engineering Congress: Proceedings, 1932.
Institution of Mining and Metallurgy: Transactions 1931-1932.
Institution of Mechanical Engineers: Proceedings 1932.
American Institute of Electrical Engineers: Quarterly Transactions, June, 1933.

Reports, etc.

Air Ministry, Aeronautical Research Committee, Great Britain:

Reports and Memoranda:

- No. 1519: Lateral Stability of an Aeroplane beyond the Stall.
- No. 1514: Full Scale Experiments with Servo Rudders.
- No. 1422: Experiments on the Hawker Hornbill Biplane.
- No. 1507: Distortions of Stripped Aeroplane Wings Under Torsional Loading.
- No. 1531: Vortex System behind a Sphere moving through Viscous Fluid.
- No. 1505: Statistical Method of Investigating Relations between Elastic Stiffnesses of Aeroplane Wings and Wing Aileron Flutter.
- No. 1509: Stability of Static Equilibrium of Elastic and Aerodynamic Actions on a Wing.
- No. 1517: Lubrication in Oxidising Conditions.
- No. 1529: Abstract—Flexural Centre and Centre of Twist of an Elastic Cylinder.
- No. 1530: Possible Increase in Level Speed of High Speed Aircraft caused by a Diving Start.
- No. 1526: Abstract—Calculation of Stresses in Braced Frameworks.

World Power Conference, Sectional Meeting, Scandinavia, 1933.

- Electrical Energy.
- Gas.
- Solid and Liquid Fuels.
- Power and Heat Combinations.
- Special Energy Problems of the Steam Heat Consuming Industries.
- Special Energy Problems of the Iron and Steel Industry.
- Electrical Heating.
- Transmission and Adaptation of Motive Power for Industrial Machinery.
- The Power Questions of the Railways.
- Energy Problems of Urban and Suburban Traffic.
- Energy Problems of Marine Transport.

Technical Books, etc., Received

The New Canada, *by E. E. H. Hugli, Toronto, Ont.*
The Application of Steel Sheet Piling to Engineering Construction, by S. Packshaw. (*Distributed by Canadian Sheet Piling Company Ltd.*)

The Contribution of Engineering to Progress

Edward J. Mehren,
President, Portland Cement Association.

An address delivered during Engineers' Week at A Century of Progress Exposition, Chicago, June 28th, 1933

(Abridged, and reprinted by permission)

The Vicissitudes of Progress

When we speak of progress we mean movement or development in a desirable direction. I conceive that humanity is travelling a long road whose desirable direction and goal are the happiness of all mankind, accompanied, first, by a wide diffusion of this world's goods; second, by the highest order of intellectual development of which individual men are severally capable, and third, by high moral attainment, which may be expressed as that "peace with God and peace with ourselves that surpasseth all understanding." This is the goal, this the ideal.

Let us note that the goal of humanity at large cannot be defined solely in terms of happiness. Happiness is contentment with one's condition. The anchorite on the desert, with no family to care for, with few wants, sunk in contemplation and service of his Maker, was happy. So are the tribes of the South Seas. But neither condition can be the ideal for the race as a whole. The one is an unsocial life; the other, untouched by intellectual fire. Therefore, while some may stop by the wayside and be content with their lot, the race must go to a higher common destiny, and that destiny includes not only happiness but social development and spiritual achievement.

But the long road that mankind is travelling is cut by ravines and chasms, some shallow, some deep and precipitous. The ravines and chasms are greed, exploitation, oppression, war, hunger and famine, insanitary surroundings, disease, ignorance, vice—and all those other hindrances which interfere with man's progress. At the beginning of recorded history, humanity toiled down into each of the chasms, forded the streams, and toiled up the opposing banks. Progress was slow.

In time, advancement of the arts, better social organization, education and religion, built bridges across the streams, at first only high enough to clear the flood. Further advances raised the bridges to higher levels, made them safer against floods, and reduced both the descent and the upward climb. Could the job ever be completed, we would build a bridge over every chasm from bank top to bank top. The chasms in effect would disappear and humanity would go forward joyously on a high road—a true *high* way—to its destiny.

Using the simile of the road, our questions can be paraphrased in this way:

"Has engineering helped to build bridges over the chasms, has it raised them to higher levels, has it made them more secure, has it brought nearer that high road without dips, on which humanity can go forward joyously to happiness, to more uniform enjoyment of this world's goods, to high intellectual and moral attainment?"

Contribution to Social Progress

Our first inquiry properly relates to the influence of engineering on social progress; that is, on the distribution of wealth, on its effect on men—its effect on them externally and in their relations to others.

We are here not in the realm of conjecture but of fact. We find that in the western world to-day, more than ever in man's history, the mass of men are better fed, better clothed, better housed; health is better, life has been prolonged, infant mortality reduced; elementary education well-nigh universal; secondary and advanced education available to all who would have it; liberty greater; opportunity for individual advancement unhampered; justice more equitably distributed. In fine, there is a higher standard of living, and a very high order of social advancement.

The question of wealth deserves special consideration. Wealth to-day is not only greater in the aggregate, but more widely diffused. The distribution is not entirely equitable, but it not so disproportionate as those imagine who think only of private property and forget the immense treasury of community wealth. The first is the possession of the individual; the second, the possession of all, for their comfort, convenience and use. In community wealth never were people richer—in the number and quality of streets and roads, in the purity and amplitude of water supply, in the sanitation and lighting of cities, in fire and police protection, in courts of justice, in medical, educational and recreational facilities.

How can we account for this increase in the standard of living, this extraordinary social progress, this wide diffusion of wealth?

The explanation lies in a profound but very simple fact. That fact is this:

that through the engineer's development of power we produce wealth more rapidly to-day than at any previous period in man's history.

It is this increase in the rate of wealth production that has given us the facilities, conveniences, comforts and advantages of which I have spoken. To this do we owe our great private and community wealth, our high standard of living, our high level of social advancement.

We must conclude, therefore, that engineering, by increasing the production of wealth, has made an extraordinary contribution to man's social progress, it has builded high the bridges over the chasms that hindered his social advancement.

Thus do we answer the first part of our inquiry.

Intellectual Development

We come now to the second part. Has engineering contributed to intellectual and moral development, has it bridged at higher levels the chasms that have held back his spiritual progress?

Here our critics will rage. The age is decadent, they tell us; we are flabby intellectually, we have backslid morally. We have much information, they say, but little wisdom; alert perceptions but little culture; athletic bodies, but no rigidity of moral character.

Are we able to answer the indictment?

There may not be a single luminary to-day of the brilliance of Shakespeare, or Dante, or Aristotle, but our age *is* one of striking intellectual vigour and activity. We must not make the mistake of colouring the entire Elizabethan age with the stature of Shakespeare, nor think that the whole Greek world was up to Aristotle's level.

If our galaxy has not a dominant luminary, it nevertheless has many great suns. In every line of human thought, the output of our researchers is prodigious. If an age is to be judged by the sum total of its contribution to human knowledge, then ours must be given high rank.

Each age, too, has its own *Zeitgeist*, the spirit of the age. Ours is science, pure and applied. In those fields we are making an intellectual contribution of stupendous proportions. In astronomy, physics, chemistry, biology, medicine, engineering, we stride with seven-league boots.

We claim, too, as an intellectual accomplishment the spread of education, common, secondary and higher, to the masses of men in the western world. To reclaim people from ignorance, to open to them the storehouses of knowledge and of wisdom, to make possible, yes easy, for anyone who wishes to secure it the very highest education, is indeed an accomplishment of which the machine age may justly be proud. That the education of the will has not gone along as lustily as the education of the intellect is a charge we will have to admit, but it does not completely negative the intellectual achievement.

Yes, my friends, even in the intellectual sphere, the resources of wealth furnished the western world by engineering have enabled mankind to raise higher the bridges that span the chasms of ignorance and prejudice, and bring nearer the day of the great high road for attaining humanity's goal.

Moral Condition

But what of our moral life? Who shall judge it? Not I. There is no more difficult task for the historian than to determine the moral tone of an age—to strike the average from king to peasant, from president to humble citizen. In this respect no age can be sure of its appraisal of itself. The human soul—the millions of human souls of the western world—cannot be weighed nor calipered.

Certainly we are not morally what we would like to be or ought to be. That can be said of our intellectual stature as well.

But if our age has not risen to the intellectual and moral standard that we would wish, if we have not raised to top height the bridges over the chasms that handicap our intellectual and moral lives, the fault is not that of the engineer, but of the very teachers, religious leaders, economists and statesmen who are to-day his critics. We find here another fundamental and elemental principle that should be stressed as strongly as the rapidity of wealth production. It is this: that the engineer has created an environment far more favourable to widespread intellectual and moral growth than the world hitherto has ever known.

Let that, in turn, be *our* challenge.

Our work has been well done. We have removed the burden of toil from the backs of men; we have made them masters of power rather than power machines; we have discounted their sinews and exalted their minds; in freeing them from drudgery, we have given opportunity for the use of their intellects—that part of their natures made in the image and likeness of God; we have placed education at their disposal; we have assisted in freeing them from disease and prolonging their lives; we have shortened the hours of labour; we have given them leisure in which to invite their souls and grow morally and intellectually.

Here is an environment for spiritual growth such as the world hitherto has never known. Possibly humanity moves too slowly to make full use of this environment at once, but blame not the engineer for the failure.

Failures of Our Critics

It is because the economist, financier, the statesman, the teacher, the religious leader have not been able to keep pace with the engineer that untold difficulties arise. The more rapid creation of wealth has changed the whole base of western civilization. It is the misunderstanding of this factor and the failure to recognize its profound and all-pervasive influence on finance, business, the distribution of wealth, national and international politics, and on human thought and outlook, that have thrown the western world into its present crisis and baffled its statesmen.

A few homely examples will illustrate the point, without going into the intricacies of finance or international politics.

Machine-power agriculture on the one hand, and industrial development on the other, have removed millions from their attachment to the soil, concentrated them in the cities and deprived them of their security. As Dr. Steinmetz put it, they have been exposed to the three great fears—fear of unemployment, fear of illness, fear of an unprovided-for old age. And while this has been brought about by the progress of power, the statesman, the financier, the economist have not kept pace and found ways of banishing these fears and, by using the new wealth, to restore the security that men enjoyed when attached to the land.

Second, there has been tardy recognition that too large a proportion of the wealth created by the machine has been reinvested in more machines and too little diverted to consumable goods and community services. It is one of the keen lessons of this depression that an age that creates wealth as fast as this one does will have much of that wealth confiscated during depressions if too large a proportion goes back into the extension of production facilities. Here again, finance and political economy lag behind the work of the engineer.

A final illustration: Highway transport—the combination of the hard road and the automobile—has made township government and small counties obsolete—survivals of the horse-and-buggy days. Township governments should be abolished, counties consolidated. The automobile makes it logical, but the politician insists that the anachronism continue.

Not Entirely to Blame

But if these other groups have not been able to keep pace with the engineer, we should not be too critical. We have behind us sixty centuries of recorded history, in only two of which has modern engineering been a factor. In fact, Watt was a man of only yesterday. We can almost touch his times. He died in 1819, and the grandparents of many of us might well have known him.

The machine age, then, has been operative for less than 3 per cent of recorded history. It is still a new instrument in the life of the race. We have not learned its mastery. We have not made it fully servant of the whole of mankind.

In the early days of steam engineering there were heaven-crying cruelties in its application. Strong hands seized the new wealth-creating mechanism and turned it to their own selfish ends. Engineering at that time, instead of bridging chasms, was used by greed to dig them deeper.

Later, as its benefits became more widely diffused, we used its gifts too lavishly. Our whole age, everyone of us, is of the new rich in a large sense; and we used the new wealth—as the new rich always do—extravagantly, lavishly, even boisterously. We have not had the strength to resist the complexity and material temptations of the new wealth and patiently, calmly, taking advantage of the superior environment, let it work out in us a holy enlargement of intellect and soul.

But be assured that we are mastering, we will master the new instrument. Much of what has been going on in Washington in the last three months is an effort in this direction. The phrase "the forgotten man" is not a mere political catchword but the expression of a fundamental social philosophy.

Our contention, then, is that we engineers have not only builded higher bridges across the chasms, but have furnished the materials for still higher bridges if the statesmen, economists, teachers can learn to use them.

We believe that there *has* been a century of progress.

It is in the faith that he was making a contribution to the race that the engineer has worked in the past one hundred years, faith that he was bridging the chasms on the highway of mankind.

In that faith will we work, not primarily that man may have greater comfort and more leisure, but that these may contribute to a more vigorous intellectual and a higher moral life.

BULLETINS

Tarvia retread—The Barrett Company Limited have issued a four-page pamphlet, the fourth of a series outlining the uses of tarvia retread, which includes information on construction work and the method of application.

Pumps—A thirty-six page catalogue has been distributed by the Viking Pump Company of Canada, Walkerville, Ont., which lists the various types of pumps manufactured by this company. The booklet also contains data on the uses to which these pumps may be put, and includes a number of tables of sizes and capacities, and gives prices.

Concrete Bridges—A four-page folder has been received from the Portland Cement Association, Chicago, illustrating a number of designs for rigid frame concrete bridges, and listing the advantages of this type of construction.

Belt idlers—The Jeffrey Manufacturing Company, Montreal, have issued a sixteen-page booklet illustrating the uses, applications and advantages of various types of belt idlers, together with a number of tables giving the dimensions, weights and prices of the various types of idlers for a number of belt widths.

List of New and Revised British Standard Specifications

(Issued during June, 1933)

B.S.S. No.

185—1933. *British Standard Glossary of Aeronautical Terms.* (Revision.) Enlarged edition of the original issue in 1923 including 14 sections as follows:—Aeronautical (general), general motion of aircraft, aerodynamics, heavier-than-air aircraft, lighter-than-air aircraft, power plant, airscrews, navigation, instruments and equipment, radio-communication apparatus, armament, parachutes, ground organization and meteorology.

437—1933. *Cast Iron Drain Pipes.* (Revision.) As a result of certain anomalies in the maximum weights of the pipes a revised table has been inserted.

490—1933. *Rubber Conveyor and Elevator Belting.* Three grades of belt are specified. The requirements laid down include details of the quality of rubber and cotton duck, workmanship, spacing of joints and methods of testing. The classes of material for which the three grades of belt are suitable and some general useful service conditions are amongst the information given in the eight appendices.

491—1933. *British Standard Nomenclature of Timber for Aircraft Purposes.* A revision and amplification of the aircraft timber nomenclature originally included in the 1923 edition of the B.S. Glossary of Aeronautical Terms. Contains the standard names of timbers whose use in aircraft has been investigated, the corresponding botanical names, the sources of supply and application to aircraft.

492—1933. *Precast Concrete Partition Slabs (Solid).* Relates to quality of material, design and testing of precast concrete solid partition slabs. The requirements provide a reliable standard—representative of good quality and performance.

493—1933. *Cast Iron Airbricks and Gratings (for use in Brickwork).* Relates to the essential requirements of cast iron airbricks and gratings for use in building and provides three British Standard patterns.

494—1933. *Cold Drawn Weldless Steel Boiler and Superheater Tubes.* Relates to the quality and permissible variations in thickness and diameter of cold drawn steel boiler and superheater tubes for designed steam temperatures not exceeding 850° F.

495—1933. *Fittings for Double-Capped Tubular Lamps.* This specification covers trough reflector fittings for shop window lighting and the modern decorative fittings used in "architectural" lighting.

Prices:—No. 185—1933, 5s. 6d. post free; remainder 2s. 2d. each, post free.

British Standards Institution,
Publications Dept.,
28, Victoria Street, London,
S.W. 1.

Sound Control in Buildings of the Future

Paul E. Sabine,
Department of Acoustics, Riverbank Laboratories, Geneva, Ill.

Reproduced from the August, 1933, issue of Civil Engineering.

In considering the problem of sound control as it relates specifically to the buildings of the future, the physical nature of the phenomenon that is to be controlled should be understood. Attention should be paid particularly to the quantitative relations involved and to the recently developed terminology of acoustical engineering.

Sound may be defined as any pressure variation in the atmosphere that is capable of stimulating the hearing sense. Fundamentally, therefore, the practical aspects of sound control will be connected with the performance of the ear as a sound-detecting instrument. Sound originates in the gross mechanical vibrations of some material body and is propagated as compressional waves with a velocity at usual temperatures of about 1,120 feet per second.

Sounds may be classified roughly either as musical sounds or noises. Musical sounds or tones are produced by more or less sustained periodical vibrations of harmonic type and are characterized by definite frequencies which determine the pitch sensations they produce. Noises differ from musical sounds in not having any very definite pitch and in having components whose frequencies bear no simple or fixed relation to one another. Any undesired sound, musical or otherwise, is ordinarily spoken of as a noise.

The frequency range of normal auditory experience extends from 20 to 20,000 vibrations or cycles per second. Subaudible vibrations may give rise to audible sounds by exciting higher frequency vibrations that fall within the audible range.

The physical intensity of sound is measured by the energy transmitted per second through a unit cross section of the sound wave. Even in the case of painfully loud sounds, the amount of energy transmitted is minute. It has been estimated that a football crowd of 20,000 yelling at full lung capacity for two hours would generate in that time barely enough sound energy to heat the water for a single cup of tea at the end of the game. The intensity of a barely audible sound vibrating at 1,000 cycles per second is about 2×10^{-16} watts. In other words, the ratio of the intensity of a painfully loud sound to one that is barely audible is something like 50 trillion to one. The sensitivity of the ear to vibrational stimuli is so great that a quiver of the air with an amplitude of about one-third of the diameter of a nitrogen molecule is sufficient to produce an audible sensation. This tremendous intensity range explains the difficulties to be overcome in jobs of practical sound insulation.

To avoid the use of unwieldy figures, acoustical engineers have employed a logarithmic scale on which to express the relative intensity of sound, called the decibel scale. The difference in decibels between two sound levels is ten times the logarithm of the ratio of the physical intensities of the two sounds. Thus, if the ratio of two intensities is 100 to one, the difference in intensity levels is 10 times the logarithm of 100, or 20 decibels. In Table I are given approximate values for various noise intensities above the audible threshold, expressed in decibels.

TABLE I

INTENSITY OF VARIOUS NOISES ABOVE AUDIBLE THRESHOLD

Intensity Level in Decibels Above Audible Threshold	Physical Intensity	Example
0	1	Barely audible sound
10	10	Whisper at 1½ m.
20	100	Quiet room
30	1,000	Quiet office
40	10,000	Quiet conversation
50	100,000	Noisy office
60	1,000,000	Loud conversation
70	10,000,000	Loud radio music
80	100,000,000	Very loud radio music or subway train
90	1,000,000,000	Pneumatic drill at 10 ft.
100	10,000,000,000	Airplane motor at 10 ft.

Sound consists of vibrational energy in the air, minute in quantity when expressed in terms of ordinary energy units, but in general very large when measured in terms of the minimum energy necessary for audition. As a practical matter, the frequency range from 100 to 5,000 cycles per second is all that need be considered. The intensity range is from about 10,000 microwatts to two ten-billionths of a microwatt.

By controlling sounds in buildings is meant ensuring, first, that useful sounds will produce the desired auditory effects and, second, that unwanted sounds will be reduced below the annoyance level. Under the first head is included the problem of providing rooms with good acoustic properties. Under the second, engineers are concerned with the reduction of noise that originates within the room, and with preventing the transmission of sound from out-of-doors or from other parts of the building.

THEORY AND PRACTICE OF ACOUSTICS

The study of the acoustic properties of rooms was first undertaken in a scientific manner some forty years ago by Wallace C. Sabine of Harvard University. As a result of his work and that of followers of the principles and theory that he established, it can be said that there is no more excuse to-day for poor acoustics than for poor lighting or bad ventilation.

Good hearing conditions depend upon what Sabine called the "reverberation time" of the room, that is, the time required after the source of sound has stopped for the sound energy that fills the room to die away to one-millionth of its original intensity. This time of decay varies directly as the volume in cubic feet and inversely as the total absorbing power of the surfaces exposed to sound in the room. The absorbing power of a surface is the product of the area and the sound absorption coefficient of the material. The total absorbing power is the sum of these products for all exposed surfaces in the room. Thus the reverberation time, T, of any proposed room can be calculated by Sabine's reverberation equation:

$$T = \frac{0.05\ V}{a} \qquad (1)$$

in which V equals the volume in cubic feet and a equals the total absorbing power in units of square feet.

By making this calculation for rooms that are acoustically good, values for the reverberation time that rooms should have in order to be acoustically satisfactory have been established. These are shown in Fig. 1. In current practice a room is treated, when necessary, by attaching to its walls or ceiling the proper area of some one of the numerous types of commercial sound absorbents now on the market. Among these absorbents are highly porous tile, fabricated from mineral, vegetable or hair fibre; granulated pumice or slag pressed with a low percentage of binder to permit of intergranular interstices in which the energy of sound waves is dissipated; and one of the various sound-absorbing plaster materials now available.

The use of steel and concrete framing in construction and of electrical sound-amplifying equipment make it practicable to construct rooms of much greater volume than was possible thirty years ago. Accordingly, the necessity for increased use of artificial absorbents in the theatres and concert halls of the future seems a perfectly safe prediction. The future of this field lies in the development of normal materials of only moderate absorbing efficiency that can be applied easily and naturally over large areas and at a cost so low as to make their use in every room intended for audience purposes a matter of course.

In rooms with highly reflective walls and ceilings, every sound that is produced is prolonged by being reflected back and forth many times. As a result of this cumulative action, the noise caused by the repeated operation of a machine may be several times louder than that produced at each operation. Quite apart from consideration of the comfort of office workers, the known increase in efficiency resulting from noise reduction seems to be a sufficient basis for predicting that, in the office buildings of the future, the use of sound-absorbent ceilings will be taken for granted.

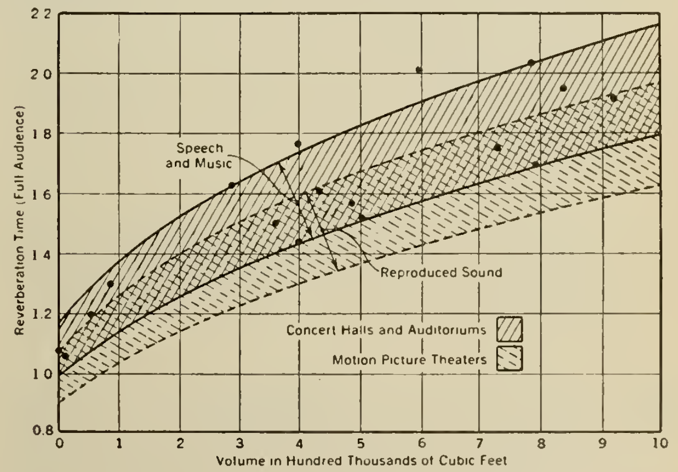


Fig. 1—Satisfactory Reverberation Time in Different Rooms.

ELIMINATING OUTSIDE SOURCES OF NOISE

Protecting the occupants of a room from noises originating outside the building or from noises created elsewhere within the building calls for quantitative data on the various factors that affect the transmission of sound through walls or partitions. Prior to the erection, some fourteen years ago, of the sound laboratory at Riverbank, Ill., practically nothing of a scientific nature was known as to just what characteristics were essential to the sound-insulating properties of a partition. Using large-scale methods, tests were made on the reduction of sound in transmission by various types of partition construction. A summary of some of the more important results of this programme of research follows, and some of the results are illustrated in Fig. 2.

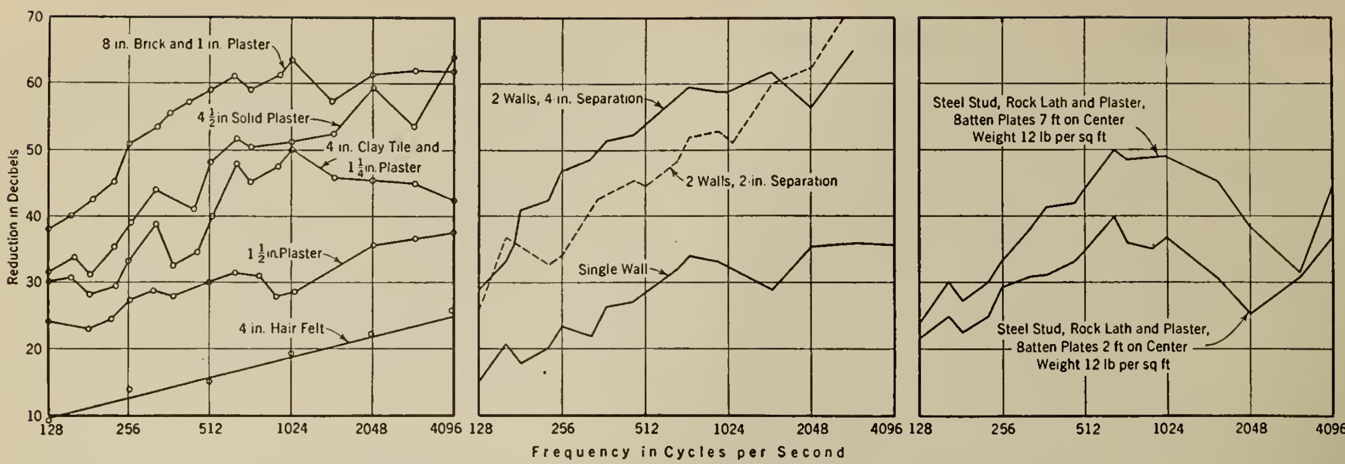


Fig. 2—Effect of Construction on Noise Transmission Through Partitions.

(a) Various materials have different effects.
(b) Increasing air space in double partitions increases sound insulation.
(c) Increasing structural tying decreases insulation.

1. Reduction of sound in transmission through porous, flexible materials, such as felt and fibre board, is an absorptive process, so that the logarithm of the reduction by such materials increases in a straight-line ratio with the increase in thickness.
2. The reduction in transmission of sound by porous materials that are good absorbers and poor reflectors is small in comparison with that by impervious materials which are good reflectors and poor absorbers. Thus the reduction resulting from using 4 inches of hair felt is less than is produced by one inch of solid plaster.
3. The transmission of sound through solid impervious partitions results from the forced vibration of such structures under the alternating pressures of sound waves. These vibrations set up sound waves on the farther side of the partitions. Sound transmission is therefore a matter of the over-all mass, stiffness, and frictional damping of the structure as a whole.
4. The sound reduction averaged over the whole range of frequencies produced by simple partitions of masonry (plaster, clay and gypsum tile, and brick) is very nearly proportional to the cube of the weight per square foot, regardless of the masonry material of the partition.
5. Sound reduction resulting from double-wall construction is conditioned by the degree to which the two units of such construction are structurally and spatially separated. In case of an otherwise complete structural separation, filling the inter-wall space with fibrous or granular material increases sound transmission. In fact, even slight structural tying increases it.
6. A combination of a heavy construction and a light construction elastically coupled is the most effective means of securing high acoustic insulation without excessive weight or thickness.
7. In a broad sense, the mass of a partition plays the predominating role in determining its sound-insulating value. The sound reduction increases with the mass, although variation in stiffness and internal damping may, in cases of marked variation in these properties, mask the effect of mass alone. Sound insulation is a problem of structure rather than of materials.

Obviously, if building in the future is to follow the trend toward lighter construction, the problem of securing adequate sound insulation with such construction is one calling for further research. To secure the maximum sound insulation between apartments, current practice in steel and concrete construction employs floors floated on resilient mounting and ceilings suspended from floor slabs rather than attached directly to them. Walls between adjoining apartments are of heavy tile construction, to which the plaster base is attached by resilient clips.

Relation of Ventilation to Noise Reduction

Reduction of the volume of sound transmitted into rooms by way of open windows is a problem that has not as yet been adequately solved. Any opening sufficiently large to admit air in any degree will also enable the entrance of sound. Various types of window mufflers designed to lessen sound by the use of absorbent materials acting as sound baffles have been devised, but the best of these are only moderately successful. Experience shows that people generally will prefer to tolerate the evil of noise rather than forego the doubtful blessing of questionably fresh air from out-of-doors. The advent of the air-conditioned building will bring with it a solution of this problem. With properly designed double windows, always kept closed, an entirely sufficient degree of sound insulation can be secured.

Opportunities for Research and Invention

No doubt it will be apparent from the foregoing that the problems of sound control in buildings of the future are not essentially different from those of the present and that their solution will be along existing lines of procedure. The increasing trend away from all stuffiness in room furnishings and the greater severity of architectural treatment in better homes increase the necessity for walls and ceilings that are more absorbent than are hard, non-porous plaster surfaces. The sense of quiet that one gets in heavily carpeted living rooms with fabric draperies and heavily upholstered furniture, can easily be duplicated in an ultra-modern room severely furnished and decorated but equipped with absorbent walls and ceiling.

In sound insulation, relatively little has been done in devising light wall and floor construction of high insulating value but without excessive weight. Research and invention along this line should yield profitable results whatever direction the course of future construction may take. To the pioneer in the new era of building construction it may well be said: Do not neglect the necessity for sound control.

Attractive and serviceable cases feature a new line of portable electrical instruments which has been announced by *Canadian General Electric Limited.* The instruments, designated at Type AP-9, include medium-size voltmeters, milliammeters, ammeters and wattmeters.

The case measures 2½ by 6½ by 4¾ inches and has no projecting parts when the cover is closed. The new instruments are but slightly higher in price than the small pocket instruments. The length of the scale in mean arc is 4½ inches. The accuracy is 0.75 per cent of full-scale value, except in the case of the triple-range voltmeters in which it is 1½ per cent, and can be improved by special calibration on the job. An AP-9 instrument can be read easily to within 0.5 per cent of full-scale value.

Canadian Sheet Piling Company Limited, Montreal, have issued a reprint of two articles entitled "The Application of Steel Sheet Piling to Engineering Construction." The second part of this pamphlet deals with certain new methods of calculation developed in Germany and here presented in English for the first time. The company has a limited number of these reprints available, and will supply these to the members of The Institute who have a special interest in this type of work.

Canadian Wood Pipe and Tanks Limited, Vancouver, B.C., have just issued a comprehensive new catalogue which should prove a handy book of reference for engineers, and those connected with the hydraulic field.

This publication, which was issued on the 29th anniversary of the company's formation, is bound in leather and contains a graphic story of the growth and achievements of the wood pipe industry in Canada.

Of particular interest are the chapters covering the modern uses and new features of continuous stave and wire wound wood pipe, wood culverts, flumes, tanks and other Canadian products, together with full details of mechanical construction, specifications and tables of capacity, curvature calculations and other useful data.

The new twin steel coupling for wire wound wood pipe and malleable iron combination butt joint for continuous stave pipe, which caused an advance in the efficiency of wood pipe lines, are described and illustrated. Copies may be obtained on request from Canadian Wood Pipe and Tanks Limited, 550 Pacific street, Vancouver, B.C.

BRANCH NEWS

Hamilton Branch

Alex. Love, A.M.E.I.C., Secretary-Treasurer.
V. S. Thompson, A.M.E.I.C., Branch News Editor.

VISIT TO REGAL BREWERY ON JULY 25TH, 1933

Through the courtesy of the officials of the Regal Brewing Company the members of the Hamilton Branch were invited to visit the brewery of the company while in operation. Many of the Branch members took advantage of this opportunity of inspecting this highly interesting process.

The principal ingredient used in the manufacture of Regal beer is barley malt, the barley being permitted to sprout before it is dried and crushed. It is interesting to note that after crushing, the hulls serve as a filter for the extract, which represents 65 per cent of the original weight of the dry malt. This malt is then transferred to the kettle and hops added to suit the various flavours required. After the mash leaves the kettle it is cooled and transferred to the fermentation tanks where yeast is added. The fermentation is allowed to proceed for about ten days, after which the beer is separated from the yeast and placed in storage tanks where it is maintained at a temperature of 32 degrees F. for a period of two months. It is then drawn off and transferred to finishing tanks where the carbon dioxide lost after fermentation is returned. After this, of course, the beer has to be kept under pressure. The final stage is filtration when it is forced through wood fibre. All bottled beer is pasteurized after bottling, but this is not necessary in the case of kegs sold for immediate consumption.

After a few words of thanks from the Branch Chairman to the company officials the visitors adjourned with the unanimous opinion that the cold storage rooms of such a plant can be very pleasant on a hot summer afternoon.

Saguenay Branch

G. H. Kirby, A.M.E.I.C., Secretary-Treasurer.

On June 3rd, 27 members and guests attended a dinner meeting of the Saguenay Branch of The Engineering Institute of Canada at the Union Hotel, St. Joseph d'Alma. The guest of honour was O. O. Lefebvre, D.Sc., M.E.I.C., President, The Engineering Institute of Canada.

Preceding the dinner a number of the members participated in a round of golf at the Birchdale Golf and Country Club.

After dinner Dr. Lefebvre was introduced by the chairman, N. F. McCaghey, A.M.E.I.C.

Dr. Lefebvre said that he felt at home whenever he visited the Saguenay Branch. He expressed his appreciation of the honour The Institute had conferred upon him in electing him President of The Institute, particularly as the honour had been conferred on a member of the French-Canadian minority.

After reviewing the problems of The Institute, he referred to economies being effected by temporary curtailment of certain services, such as the publication of the list of members, and of the Transactions, in order to balance the budget.

He spoke of his visit to the Branches in the west and struck an optimistic note in speaking of the condition in which he found these branches.

He discussed the forthcoming Plenary Meeting of Council and the interest being taken in the work of the Committee on Development, and mentioned the action of Council as regards the suspended list, on which members who were forced by economic conditions to become inactive were being placed, though he hoped that a better name could be found for it. Council's action had been appreciated by many of the unemployed members.

A vote of thanks to Dr. Lefebvre for his interesting talk was proposed by A. W. Whitaker, Jr., A.M.E.I.C.

A proposal that the Executive Committee act as nominating committee for the forthcoming annual election of officers was approved unanimously.

Attention was drawn to prizes open to the membership for suitable papers, etc., especially those available for Juniors' or Students' papers.

The need for increased membership was stressed.

It was decided to hold the annual meeting of the Branch in Arvida, date to be announced later, and if possible an outside speaker was to be secured to address the meeting. The engineer members of the Saguenay Golf and Country Club at Arvida extended an invitation to a game of golf before the meeting.

Winnipeg Branch

E. W. M. James, A.M.E.I.C., Secretary-Treasurer.
E. V. Caton, M.E.I.C., Branch News Editor.

The Dominion government has decided to proceed with the clearing of the Lac Seul area to permit of raising the levels of the lake and improving storage and flowage conditions on the Winnipeg river.

This work is to be done as an unemployment relief measure and under the direction of the Department of National Defence.

Several of the local members have obtained employment on the engineering work in connection with this project, among them being D. L. McLean, A.M.E.I.C. Mr. McLean is assistant superintendent on the work.

The Working of the Six-Hour Day

The United States Bureau of Labour Statistics carried out some time ago a survey of the results of the six-hour day in a manufacturing plant which introduced the system in December, 1930. The management reported, it is stated, that the six-hour day had led to increased daily production from the plant, an increased return from capital invested, decreased overhead expenses, and the elimination of the luncheon and refreshment room expenses. The change had caused reductions in pay for about three-quarters of the workers involved, but was nevertheless preferred by 77 per cent of the workers, the remainder preferring the eight-hour shift because they received more pay. The workers liked the system because they had more time for home duties, leisure, and study, and to work a home garden, less fatigue at the end of the day, a chance for outdoor pleasures, and time to buy more economically at a time when the shops were less crowded.

The weekly organ of the International Labour Office at Geneva prints an interesting summary of the replies received to a questionnaire on the six-hour day sent out by the Department of Industrial Engineering of Cornell University. Companies employing about 165,000 persons replied. Seventy-two per cent of the replies expressed the personal opinion of the managers in favour of the six-hour day, and most of those opposed to the change based their opposition upon operating conditions in their particular businesses. Further, many of those opposed to the six-hour day did not object to a shorter working week. Sixty per cent of those replying recognized that the general trend was towards shorter hours. Sixty-eight per cent agreed that the six-hour day was feasible. A question was also put as to whether a shift system would be introduced if hours were shortened. Sixty-seven per cent of those replying were working only one shift, 7 per cent two shifts, and 26 per cent three shifts a day. With the introduction of a six-hour day, a significant number (25 per cent) would apparently work two shifts, while 23 per cent stated they would work four shifts a day.

With regard to wages, the majority (66 per cent) expected the hourly rate to be raised, though only 38 per cent expected the daily wage to be maintained. A study of the replies shows that many expected that the hourly rate would be increased but not enough to make the daily rate equal to the previous daily rate for a longer day. There was a general feeling on the part of those who predicted a decreased daily wage that this decrease would be only temporary and that in the long run a way would be found to increase the daily wage even above that formerly paid.—*Engineering.*

National Construction Council of Canada

At a meeting of the Survey Committee of the National Construction Council held in Hamilton, Ont., on July 4th, it was reported that of the questionnaires sent to fifty-four of the larger municipalities in Canada, twenty-six had been returned, indicating that the value of the possible construction projects which are reasonably available to be undertaken in the twenty-six centres reporting amounted to $160,000,000. It is expected that the final figure for engineering and building projects will reach $350,000,000 to $400,000,000 when the remaining twenty-eight cities have reported.

Twelve local committees are to be appointed at strategic points in Canada, to be formed along similar lines to the National Construction Council, in order to carry out survey and research work in the various provinces for the national body.

Darling Brothers of Montreal announce that they have completed arrangements with the American Air Filter Company, Inc., of Louisville, Ky., for the exclusive manufacturing and selling rights for their entire product for the Dominion of Canada and Newfoundland.

The American Air Filter Company is a corporation which resulted from the consolidation of the Reed Air Filter Company, Midwest Air Filters, Inc., the National Air Filter Company and five smaller companies. They have had over twelve years experience in designing, building and testing air filters for all types of service.

The American Air Filter Company's products consist of the following air cleaning equipment:—airmat dry type filters; airmat dust arresters; filters for warm air furnaces; filters for engines and compressors; multi-panel automatic air filters; Phoenix constant-effect air filters; unit type filters; dynamic precipitators.

In order to study under actual working conditions the requirements of Canadian users of pneumatic tools, the famous British firm of Armstrong Whitworth is shortly to send a mission to tour the Dominion and to demonstrate the company's pneumatic tools at the Canadian National Exhibition at Toronto.

The New Graving Dock at Southampton

The new graving dock at Southampton was opened by H.M. the King, on Wednesday, July 26th, 1933, in the presence of a large number of people. Some comment must be made on the size of this work, for, although it would be a justifiable source of national pride to think that Great Britain possessed the largest graving dock in the world, such a claim is hardly likely to pass without challenge. It is undoubtedly the longest, but there are others elsewhere either wider or deeper over the sills or blocks. Of the eight dry docks over 1,000 feet in length situated in different countries, the Southampton dock with its length of 1,200 feet heads the list, its nearest competitor being the U.S. Navy dock at Boston, which is 1,170 feet long. As regards width, the combined lock and dry dock at St. Nazaire comes first with 164 feet, and Southampton takes second place with 135 feet. France also has the deepest dry dock, viz., that at Havre, which is 52.5 feet, though Southampton is again second, with 48.5 feet. If a comparison is made by approximating the cubic contents of the several docks, i.e., by multiplying length, width and depth together, that at St. Nazaire works out to 8,189,832 cubic feet as against the 7,857,000 cubic feet of Southampton, the remaining six docks ranging from 4,765,860 cubic feet to 6,713,437 cubic feet on the same basis.—*Engineering*.

American Standards Association Takes Over Activities of U.S. National Bureau of Standards

The following activities of the United States National Bureau of Standards are to be transferred to the American Standards Association, a federation of thirty-seven national technical societies, trade associations and governmental bodies, with headquarters in the Engineering Societies Building, 29 West 39th Street, New York, as the result of an arrangement worked out between Secretary of Commerce Daniel C. Roper and President Howard Coonley of the American Standards Association:

- Division of trade standards.
- Division of specifications.
- Division of simplified practice.
- Building code and plumbing code sections of the building and housing division.
- Safety code section.

Savings amounting to hundred of millions of dollars, ranging from $1,000,000 for the paving brick industry to $200,000,000 for the lumber industry, have resulted from the work which the Bureau of Standards is discontinuing and which the American Standards Association hopes to carry on in behalf of industry, according to estimates made by the industries. In addition to actual money savings, the public is benefiting by getting better values, prompt deliveries, quick replacement service and lower maintenance cost on many of the industrial products which it purchases.

Furnace Refractories Made in Canada

Furnaces of one kind or another are essential to almost every modern industry.

All of these furnaces require a suitable type of refractory lining, to withstand the heat and the corrosive action of its contents. Until recent years a large part of these furnace refractories was imported, though now a considerable part of these have been replaced by Canadian made products through the researches and enterprise of Canadian Refractories Ltd., whose quarries and plant are at Kilman, Quebec. This company makes a range of basic refractories from magnesian dolomite and the manufacture and uses of these is described in a paper appearing in the September Bulletin of the Canadian Institute of Mining and Metallurgy.

In July, *Canadian Vickers Limited* acquired all manufacturing and sales rights controlled by William Hamilton Limited of Peterborough, Ont., heralding a further step in the constructive programme of expansion of this Canadian organization.

Since 1856 William Hamilton Limited has had an enviable reputation as founders and builders of specialized equipment for the pulp and paper, mining and construction industries, and were making, either under their own patents or on a royalty basis, many lines of equipment such as: Marcy rod and ball mills, Wilfley pumps, Lidgerwood hoists, Southwestern ore reduction units, Barlow marine hoists and Leffel turbines.

In order that the identity of the William Hamilton Company may not be lost, Canadian Vickers Limited has decided to carry on their lines as the William Hamilton Division of Canadian Vickers Limited, and has taken over the following key men of the William Hamilton Company,—L. D. Palmer, former president of this company, J. S. T. Bethune, R. C. Flitton, A.M.E.I.C., and stationed at Haileybury, J. L. McArthur.

The Vickers' officials state that the matter of agencies elsewhere in Canada is now occupying their active attention with a view to bringing into line the former agency arrangements of the two companies.

Stronger Lead Alloys for Building Applications

Some time ago the British Non-Ferrous Metals Research Association was confronted with the problem of dealing with the cracking of the lead sheathing used on electric cables. This trouble was experienced when the cables were subjected to excessive vibration on board ship, in submarine cable applications, and in railway service on bridges and in tunnels. It was also sometimes found to occur in the transport of new cable overseas. Alloy sheathing with four times the resistance to vibration of pure lead was developed and proved a complete solution. At the present time large quantities of such alloys are used for the sheathing of cables on naval ships, and by the Post Office for submarine cables. The interest of those concerned with other applications of lead where vibration causes trouble was aroused, and further fields of service for the alloys have been found. The Building Research Board of the Department of Scientific and Industrial Research has now issued a report entitled "B. N. F. Ternary Alloys of Lead—their Use in Buildings," recently published by His Majesty's Stationery Office, at a price of 9d. net.

Investigation has now shown that, on the score of economy, as well as on account of resistance to damage from vibration, the lead-cadmium-antimony and lead-cadmium-tin alloys can be used with advantage in a number of building operations. These alloys have the compositions:—No. 1, 99.25 per cent lead, 0.25 per cent cadmium, and 0.50 per cent antimony; and No. 2, 98.25 per cent lead, 0.25 per cent cadmium, and 1.50 per cent tin.

The cracking of lead used as sheathing generally started on the inside, and thus did not become visible until complete breakdown had occurred. Investigation established that vibration alone could cause the cracking, and was in most cases the primary cause of breakdown. It was clearly demonstrated that there was a quantitative relationship between the periodic variations in stress and the failure, and thus this was proved to be due to fatigue. After a study of the binary alloys, constituting the well-known hard leads, the ternary alloys were considered and the solution to the trouble was found. Both the No. 1 and No. 2 alloys are possessed of greater mechanical strength and resistance to fatigue than lead, while they retain, to a surprising degree, the fine working properties of lead—*Engineering*.

Earthquakes and Modern Buildings

Dr. Bailey Willis of Stanford University, after a survey of the buildings which withstood the earth tremors at Long Beach, Calif., declared that present day principles of construction had been vindicated. He has investigated the causes and effects of earthquakes all over the world and is responsible for many of the modern building practices on the Pacific Coast. In co-operation with structural engineers of San Francisco and other coast cities these principles were worked out at Stanford with the aid of a shaking table. Miniature buildings were constructed on this table which was subjected to shocks similar to the actions of the earth's surface in a quake.

Professor Willis wrote recently: "Two well established principles have been confirmed and we have gained a better understanding of the reasons for them. They are unity of construction and rigidity of structure.

"In modern practice unity is secured in those structures that are firmly tied together by outside walls and floors of reinforced concrete, whether the frame be of reinforced concrete or steel.

"The earthquake-resistant competency of a building depends upon the unity of its outside walls and floors as parts of a rigid coherent whole.

"Structures which do not possess coherent unity and strength are not earthquake-resistant and constitute a menace to life and property.

"Any building has a definite swinging period which is fixed by its proportions and construction. The maximum stresses develop in a building when it swings in unison with the vibrations of the ground. Coincidence of periods produces resonance.

"If a building can be so rigid that it merely shivers, if its period is less than one-half second, resonance is not likely to occur. For buildings of five or six stories and probably up to ten or twelve stories in most cases, this degree of rigidity can be obtained by monolithic construction of reinforced concrete, or, where for any reason a steel frame is preferred, by imbedding the frame in concrete walls and floors, with suitable reinforcing steel and bonds throughout the structure.

"There is at present in current practice no other material than reinforced concrete or possibly reinforced brick that is strong enough or can be bonded properly to give the required rigidity."

The Hackbridge Transformer Company of Canada, Limited, Montreal, announce the appointment of the Northern Electric Company, Limited, as sole sales agents and distributors in Canada and Newfoundland of "Hewittic" power rectifiers and allied auxiliary equipment. The servicing and maintenance of all "Hewittic" rectifier apparatus now installed in Canada will be undertaken by the Northern Electric Company, Limited.

Preliminary Notice

of Applications for Admission and for Transfer

August 19th, 1933

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 October, 1933.

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

CAMERON—DOUGALD, of 40 Crang Ave., Toronto, Ont., Born at Airdrie, Scotland, August 3rd, 1902; Educ., Coatbridge and Motherwell Tech. Coll., 1916-21; Courses in mech. engrg., elec. engrg., steam theory, engrg. calculations, and chemistry of steel manufacture; 1916-17, ap'tice engr. with The Caledonia Rly. Co. of Scotland; 1918-23, ap'tice engr. with Wm. Beardmore Co. Ltd., Scotland; 1924-30, mgr. of plant, engrg. and sales, with John T. Hepburn Ltd., in the manufacture of pumps, cranes, sand systems for foundries and struct'l. steel dept.;1926-30, director, and 1930 to date, vice-president of above company, and at present vice-president and manager, responsible for all engrg. and sales of the mech'l. dept.

References: I. H. Nevitt, R. E. Smythies, A. W. Connor, D. M. Fraser, W. W. Gunn.

TREGILLUS—ARTHUR LOUIS, of 1328-18th St. West, Calgary, Alta., Born at Jessor, Bengal, India, Nov. 20th, 1888; Educ., 1900-05, Taunton School (British Public), Taunton, Somerset, England. 1906, London Univ., Matriculation Course; I.C.S., surveying and mapping and civil engineering; Officers Training Corps, St. Johns, Que., 1917, and Seaford, England, 1918, qualifying for Commission. 1917-19, served with Royal Flying Corps and Can. Engrs.; 1906, chainman and rodman to A. S. Chapman, C.E., rly. work, Yorkshire, England; 1907, chainman, rodman, etc., to P. N. Johnson, Edmonton, Alta., surveying and highway work; 1908-09, shift foreman at Forest Rose and Waverly Mines, Barkerville, B.C.; 1910-12, instr'man., C.P.R., Calgary, Alta.; 1913-14, assisting A. S. Chapman in drawing of plans and supervision of erection of plant and bldgs., installing machinery, etc., for the Tregillus Clay Products Ltd. Located and let contract and supervised constrn. of railway spur and siding for above company. Also supervised purchase of machinery, supplies and material for above plant; 1915, engr. in charge of party on location work for proposed reservoir and pipe line for a new water supply for the city of Calgary. After completing field work, drew up a set of plans, took off quantities, and made an estimate for the proposed dam, head gates, intake, and pipe line. (Scheme later turned down by ratepayers); 1916, asst. field engr., Lethbridge Northern Irrigation Project; Later transferred to position of asst. office engr. to S. G. Porter, M.E.I.C.; 1919-20, hydrometric engr., C.P.R., Dept. Nat. Resources, Lethbridge; 1920-25, not engaged in engrg. work; 1925, yard foreman, supervising the pressure treating of timber, and later in office, Alberta Wood Preserving Co. Ltd., Calgary; June 1925 to March 1933, res. highway engr., Dept. Public Works, Alberta Provincial Govt.; at present, asst. to the Dist. Engr. Officer, Military District No. 13, Calgary, Alta., on highway mtce., and also on engrg. work in connection with unemployment camps.

References: W. S. Fetherstonhaugh, F. M. Steel, S. G. Porter, A. S. Chapman, G. P. F. Boese, G. H. Patrick.

FOR TRANSFER FROM THE CLASS OF ASSOCIATE MEMBER TO THAT OF MEMBER

NORMANDIN—ARTHUR BENJAMIN, of 164 Fraser St., Quebec, Que., Born at St. Constant, Que., March 29th, 1883; Educ., B.A.Sc., and C.E., Ecole Polytechnique, Laval Univ., 1907; 1905 (summer), with F. C. Laberge, M.E.I.C., consltg. engr., Montreal; 1906 (summer), with Public Works Dept., Montreal; 1907-09, survey and municipal work with F. C. Laberge, M.E.I.C., Montreal; 1909-11, city engr., Three Rivers, Que.; 1911-12, surveying, municipal works, water power developments, as associate with Grenon & Lavoie, Chicoutimi, Que.; 1912 to date, asst. chief engr. of the hydraulic service, Dept. of Lands and Forests, Province of Quebec, and engr. in charge of approval of plans of dams. *(S. 1907, A.M. 1912.)*

References: A. Amos, O. O. Lefebvre, A. R. Decary, A. Lariviere, H. Cimon, A. Frigon.

ROUNTHWAITE, FRANCIS GEORGE, of Tucker's Town, Bermuda., Born at Collingwood, Ont., April 3rd, 1892; Educ., B.Sc. (Civil), McGill Univ., 1916; Summers 1913-1914,rodman and instr'man. on constrn., Algoma Central Rly.; 1916-19, overseas Lieut., Can. Garrison Artillery and Royal Garrison Artillery; 1919 (May-Oct.), county surveying, Cornwall; 1919-20, on constrn., Atlas Constrn. Co. Ltd.; 1920-21, office engr., G.T.R. Arbitration; Aug. 1921 to 1926, supt. in charge of constrn., Bermuda Development Co., Bermuda; 1926-27, res. engr., and 1928 to date, general manager of same company. Responsible for constrn. work in connection with the development with varied degree of engineering, such as the design of water system, two golf courses, semi-residential club house, 17 residential homes, the Castle Harbour Hotel with accommodation for about 600 guests, power plant, sewage disposal, and docks, etc. Employed consltg. engrs. and architects to advise, and personally responsible for decisions arrived at and the constrn. and maintenance. *(St. 1916, Jr. 1920, A.M., 1922.)*

References: J. H. Trimingham, W. G. Mitchell, W. H. Magwood.

FOR TRANSFER FROM THE CLASS OF JUNIOR

KETCHEN—WILLIAM ARTHUR, of Edmundston, N.B., Born at Montreal, Que., July 18th, 1903; Educ., B.Sc. (Chem.), McGill Univ., 1928; 1924 (July-Sept.), machinist, and 1925 (July-Sept.), millwright, B.C. Pulp and Paper Co., Port Alice, B.C.; 1926 (May-Sept.), with Niagara Ammonia Co., Niagara Falls, N.Y., in charge of routine control work as asst. chemist; 1927 (June-Sept.), asst. chemist, Port Alice Plant, B.C. Pulp and Paper Co.; 1928, operator, Electro Products, Shawinigan Falls, Que.; 1930-33, asst. chief chemist, in charge of technical control, Edmundston and Madawaska mills, Fraser Companies Limited. *(S. 1924, Jr. 1928.)*

References: W. L. Ketchen, J. B. Bladon, E. Brown, F. O. White, R. E. Jamieson.

DORMER—WILLIAM JOHN SMYLIE, of 2236 Wilson Ave., Montreal, Que., Born at Middlesborough, Yorks., England, Dec. 2nd, 1899; Educ., B.Sc. (E.E.), McGill Univ., 1923; Summers: 1917, meter dept., Southern Canada Power Co.; 1920, plant dept., same company; 1921, power house asst. operator, and 1922, elec. system operator, City of Sherbrooke, Que.; 1923 to date, with the Bell Telephone Company of Canada as follows: 1923-25, student engr.; 1925-28, asst. field engr., inductive interference studies, minor constrn. work, cost estimates for constrn. work, carrier applications to open wire lines; 1928-29, asst. field engr., res. engr. in charge of survey for new telephone line from Riviere du Loup to Edmundston, N.B., supervision of constrn.; 1929, divn. toll line engr., (6 mos), supervisory position in charge of all toll line constrn. engrg., including design. Budget work; 1929 to date, divn. toll plant engr., supervisory position in charge of all toll plant engrg. work in the Prov. of Quebec. Estimating, design and budget work. *(St. 1920, Jr. 1927.)*

References: L. E. Ennis, J. L. Clarke, G. M. Hudson, A. M. Mackenzie, R. H. Mather.

FOR TRANSFER FROM THE CLASS OF STUDENT

LOGAN—ROBERT SAMUEL, Jr., of 45 Aberdeen Ave., Westmount, Que., Born at St. Albans, Vt., Oct. 16th, 1901; Educ., B.Sc. (M.E.), McGill Univ., 1925; 1917-24, summer work: express messenger on fruit train; assembly dept., factory, Can. Marconi Wireless Co., Montreal; rodman, Riordon Town Planning Dept., Temiskaming; marker on formwork, carpenter shop, LaGabelle power development, Fraser Brace Constrn. Co.; demonstrator, 1st year McGill Survey School, Ste Anne de Bellevue; 1925-26 (9 mos.), owner's representative, cost plus contract, mill extension, Montmorency Falls, for Dominion Textile Co. Ltd.; 1926-28, quantity and piping cost engr., constrn. of International Paper and Fibre Board mills at Gatineau, Que., by Fraser Brace Engrg. Co. Ltd.; 1928-29, asst. supt., (operating night tour boss), International Fibre Board Mill, Gatineau, Que.; 1929 to May 1933, with Canadian Industries Limited, as follows: 1929 (4 mos.), asst. res. engr., constrn. and mtce., Beloeil works, explosives divn., McMasterville, Que.; 1929-31, res. engr. i/c constrn. new synthetic ammonia plant; plant extension and plant mtce., Windsor Works, salt and alkali divn., Sandwich, Ont.; 1931 (1½ mos.), tem. res. engr., constrn. and mtce., Beloeil Works; 1931-32, piping cost engr. and inspr., constrn. of new cellophane plant, Shawinigan Falls, for C.I.L. by Fraser Brace Engrg. Co. Ltd.; 1932 (5 mos), shift engr. on operation, cellophane plant, Shawinigan Falls; Sept. 1932 to May 1933, res. engr., constrn. of cellophane plant extension, Shawinigan Falls, Que.; at present, engr., Accessories Manufacturers Ltd., Montreal, Que. (*S. 1922*).

References: L. de B. McCrady, I. R. Tait, A. B. McEwen, J. H. Brace, A. T. E. Smith, A. R. Roberts, A. I. Cunningham.

MAGOR—PHILIP DOUGLAS, of 5551 Queen Mary Road, Montreal, Que., Born at Montreal, Mar. 27th, 1906; Educ., B.Sc. (E.E.), McGill Univ., 1930; 1927-29, summer work, students' course with Otis Fensom Elevator Co.; 1930 to date, with Southern Canada Power Company, ap'ticeship course, and at present power tester. (*S. 1927.*)

References: C. V. Christie, J. H. Trimingham, J. B. Woodyatt, E. Brown, H. L. Mahaffy, D. Hutchison.

Development of High-Speed Oil Engines

In the vital matter of combustion chamber and injection system design all engines fall within one of three types—namely, direct injection, pre-combustion chamber, or air-storage cell. The remarkable advance of the last-named class within the last two years appears likely to reduce the number of categories to two, for the air-storage cell combines the advantages of the pre-combustion chamber with the advantage of better thermal efficiency. Half a dozen British designs incorporate air-cells, which, among other things, permit of very low injection pressures, 925 pounds per square inch being used in a number of engines having a compression ratio of 17 to 1 and a maximum gas pressure of 800 pounds per square inch.

The increased recognition of the necessity of light weight has led to equally remarkable results in the mechanical design. A dozen makes employed in road and tractor work in 1930 showed the following average values:—Piston speed, 1,420 feet per minute; r.p.m., 1,230; brake m.e.p., 77.7 pounds per square inch; weight, 25 pounds per b.h.p. Similar averages taken over sixteen of the latest engines are:—Piston speed, 1,740 feet per minute; r.p.m., 1,725; brake m.e.p., 85.2 pounds per square inch; weight, 15.1 pounds per b.h.p. Thus in three years the unit weight has been reduced by 40 per cent, while there have been increases of 36 per cent in the r.p.m., of 22 per cent in the piston speed, and of 10 per cent in the m.e.p.

Such high speeds in conjunction with the high pressures are rendered possible by the adoption of a modified constant-volume cycle. While the peak pressures of that cycle have retarded engine construction, through mechanical considerations, the adoption of an air-storage cell, or pre-combustion chamber, enables the maximum gas pressure to be kept within reasonable bounds, with only a slight loss in efficiency. Compression ratios in recent models vary from 15 to 1 to 17.5 to 1, which means a maximum compression pressure of some 600 pounds per square inch; yet in two designs only is a maximum combustion pressure of 725 pounds per square inch exceeded, the majority working at a figure of approximately 700 pounds. The most important of the results obtained by the adoption of the air-cell, however, is the possibility of maintaining a high power output throughout the higher speed range. Previous designs showed a marked falling-off in the brake m.e.p. above 1,200 r.p.m. or so, but the latest units present characteristics which so closely approach those of petrol engines that, for speeds up to 2,000 r.p.m. the oil engine gives nearly the same power per unit of cylinder volume as its rival, and is hampered only by some 8 to 10 per cent of extra weight.

Limitation to the further increase in oil-engine rotational speeds is largely imposed by the ignition time-lag, for at 2,000 r.p.m., a lag of only one-thousandth of a second means over 13 degrees of crank travel. Fortunately fuel-pump design is keeping pace with the desired increase in speed, although at over 2,000 r.p.m. it has been found necessary to begin injection some 25 degrees before top dead centre. The greatest problem confronting fuel-pump designers is not quick delivery but accurate metering over a wide power range. With an output of 17 b.h.p. per cylinder, at 2,000 r.p.m., and a full-load fuel consumption of 0.43 pound per b.h.p. hour, the fuel to be measured and injected per impulse is only 0.0002 pound or 0.00063 cubic inch, while the injection time is barely one three-hundredth of a second; hence the importance of checking the slightest dribbling, while still retaining free movement for the pump plungers.

Progress in metallurgy has been one of the principal factors in enabling a substantial reduction in weight to be made, more especially in the relatively bulky crankcases and cylinder blocks, for which aluminium-silicon alloys and nickel cast-iron are extensively employed. Nickel-chrome and nickel-chrome-molybdenum steels, with tensile strengths ranging from 50 to 100 tons per square inch, are now in favour for crankshafts and connecting rods, but while the use of these materials lowers the inertia forces, the direct effect upon the total weight is inconsiderable compared with the reduction obtained by substituting an aluminium alloy for cast-iron in the construction of the crank case. However, the two run hand in hand, it being frequently possible to use such an alloy only when the inertia forces have been reduced to a minimum by the use of a high-grade steel for the moving parts, and hollow-boring the crankshaft and crankpins.

Correct and careful heat treatment is the key to the successful use of alloy steels, and with similar analyses a wide variation in mechanical properties may be obtained by varying the annealing. A widely used nickel-chrome-molybdenum steel, with a nickel content of 2.5 per cent, gives, when annealed at 1,150 degrees F., an ultimate strength of 65-70 tons per square inch in a minimum elongation of 17.5 per cent, and an Izod value of 40 foot-pounds. If the steel is annealed at 550-600 degrees F., the strength rises to 95-100 tons, the elongation falling to 11 per cent and the Izod value to a minimum of 12 foot-pounds.

—*The Times Trade and Engineering Supplement.*

Periodicals for Sale

Due to the re-arrangement of the library files, it is found necessary to dispose of the periodicals listed below. Offers from anyone interested in purchasing any or all of these should be addressed to Headquarters.

Highway Engineer and Contractor	—	1924-1925 and 1927.
Commercial Intelligence Journal	—	1923 to 1931.
Engineering World	—	1921 and 1922.
Indian Engineering	—	1922 to 1930.
Industries and Iron	—	1895 and 1898.
English Electric Journal	—	1923 to 1929—file incomplete.
Ingenieur Zeitschrift	—	1923 to 1929.
Monthly Weather Review—U.S. Department of Agriculture	—	1923 to 1929.
Overseas Engineer	—	1927 to 1932.
Bulletin of the Mysore Engineers Association	—	1922-1931.
World Ports	—	1927 to 1931.
Engineers and Engineering	—	1924 to 1929.
Arts et Metiers	—	1923 to 1927.
University of California Chronicle	—	1913 to 1928.
Journal of Engineering Education	—	1929 to 1932.
Compressed Air Magazine	—	1923 to 1929.
Bulletin of the Rensselaer Polytechnic	—	1921-1923, 1928 and 1929.

C.E.S.A. Dimensional Standards

The Canadian Engineering Standards Association has just published a standard No. B35-1933, covering Binder Head Screws used in the electrical trade for the purpose of securely holding wires or clips.

This is the sixth of a series of Established Lists of Dimensional Standards which have been issued in pamphlet form since 1930 for the guidance of designing engineers, purchasing agents and the trade generally.

The others issued are as follows:

B18-1930 Established List of Stove Bolts (Second Edition).

B29-1932 Established Lists of Machine Screws and Square and Hexagon Machine Screw Nuts (Second Edition).

B33-1932 Established Lists of Cap Screws, Set Screws and Studs and Semi-finished, Slotted and Castellated Hexagon Nuts.

B34-1933 Established Lists of Machine, Carriage and Plough Bolts and Common Square and Hexagon Nuts.

B37-1932 Standard Blade Punching for Road Grading Machinery.

It is believed that these standards have effected a very valuable simplification in the manufacture of these products as it was found that previously there was an unusually large variety in the designs made which caused great confusion, and also resulted in high manufacturing costs.

As a result of conferences among those interested, the above agreements have been reached. In all cases the form of thread is in accordance with the U.S. National Screw Thread.

Canadian Radium Extraction Process

While all Canadians have heard of the rich radium deposits discovered three years ago at Great Bear Lake, and that a plant for extracting the radium is now in operation at Port Hope, Ontario, few are aware that the process used in this plant has been devised by a Canadian chemist in the Department of Mines in Ottawa and that it is more efficient and economical in operation than any radium extraction process used heretofore.

R. J. Traill, who conducted this rather remarkable research, describes in the September Bulletin of the Canadian Institute of Mining and Metallurgy the successive steps that give an extraction of well over 90 per cent of the radium from the crude ore.

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 Wanted

ELECTRICAL AND RADIO ENGINEER, B.Sc., '28. Experience in the design and testing of broadcast radio receivers, including latest superheterodyne practice, and capable of constructing apparatus for testing same. Also familiar with telephone and telephone repeater engineering. Thorough experience in design, and construction and inspection of municipal power conduits. Apply to Box No. 12-W.

MECHANICAL ENGINEER, Canadian, with technical training and executive experience in both Canadian and American industries, particularly plant layout, equipment, planning and production control methods, is open for employment with company desirous of improving manufacturing methods, lowering costs and preparing for business expansion. Apply to Box No. 35-W.

MECHANICAL ENGINEER, A.M.E.I.C. Married. Experience in machine shops, erection and maintenance of industrial plant mechanical and structural design. Reads German, French, Dutch and Spanish. Seeks any suitable position. Apply to Box No. 84-W.

YOUNG ENGINEER, B.A., B.SC., A.M.E.I.C., R.P.E., Ont. Competent draughtsman and surveyor. Eight years experience including design, superintendence and layout of pulp and paper mills, hydro-electric projects and general construction. Limited experience in mechanical design and industrial plant maintenance. Apply to Box No. 150-W.

PURCHASING ENGINEER, graduate mechanical engineer, Canadian, married, 34 years of age, with 13 years' experience in the industrial field, including design, construction and operation, 8 years of which had to do with the development of specifications and ordering of equipment and materials for plant extensions and maintenance; one year engaged on sale of surplus construction equipment. Full details upon request. Apply to Box No. 161-W.

STRUCTURAL ENGINEER, B.A.SC., '15, A.M.E.I.C., R.P.E., (Ont.) Married. Experience in structural steel and concrete includes ten years design, five years sales, two years shop practice and erection, and one year advertising. Available at two weeks notice. Apply to Box No. 193-W.

CIVIL ENGINEER, age 44, open for employment anywhere, experience covers about 20 years' active work, including 7 years on municipal engineering, 2 years as Town Manager, 3 years on railway construction, 3 years on the staff of a provincial highway department, 2 years as contractor's superintendent on pavement construction. Apply to Box No. 216-W.

REINFORCED CONCRETE ENGINEER, B.SC., P.E.Q., eight years experience in construction design of industrial buildings, office buildings, apartment houses, etc. Age 30. Married. Apply to Box No. 257-W.

MECHANICAL ENGINEER, B.Sc., McGill '19, A.M.E.I.C. Married. Twelve years experience including oil refinery power plant, structural and reinforced concrete design, factory maintenance, steam generation and distribution problems, heating and ventilating. Available at once. Location immaterial. Apply to Box No. 265-W.

ELECTRICAL ENGINEER, B.SC., '28, Canadian. Age 25. Experience includes two summers with power company; thirteen months test course with C.G.E. Co.; telephone engineering, and the past thirty months with a large power company in operation and maintenance engineering. Location immaterial and available immediately. Apply to Box No. 266-W.

PLANE-TABLE TOPOGRAPHER, B.SC., in C.E. Thoroughly experienced in modern field mapping methods including ground control for aerial surveys. Fast and efficient in surveys for construction, hydro-electric and geological investigations. Apply to Box No. 431-W.

ELECTRICAL ENGINEER, B.SC., A.M.E.I.C., AM.A.I.E.E., age 30, single. Eight years experience H.E. and steam power plants, substations, etc., shop layouts, steel and concrete design. Location immaterial. Available immediately. Apply to Box No. 435-W.

CIVIL ENGINEER, B.A.SC., and C.E., A.M.E.I.C., age 30, married. Experience over the last ten years covers construction on hydro-electric and railway work as instrumentman and resident engineer. Also office work on teaching and design, investigations and hydraulic works, reinforced concrete, bridge foundations and caissons. Location immaterial. Available at once. Apply to Box No. 447-W.

CIVIL ENGINEER, B.SC., A.M.E.I.C., with six years experience in paper mill and hydro-electric work, desires position in western Canada. Capable of handling reinforced concrete and steel design, paper mill equipment and piping layout, estimates, field surveys, or acting as resident engineer on construction. Now on west coast and available at once. Apply to Box No. 482-W.

Situations Wanted

MECHANICAL ENGINEER, B.SC. Age 28, married. Four and a half years on industrial plant maintenance and construction, including shop production work and pulp and paper mill control. Also two and a half years on structural steel and reinforced concrete design. Located in Toronto. Available at once. Apply to Box No. 521-W.

CIVIL ENGINEER, Canadian, married, twenty-five years' technical and executive experience, specialized knowledge of industrial housing problems and the administration of industrial towns, also town planning and municipal engineering, desires new connection. Available on reasonable notice. Personal interview sought. Apply to Box No. 544-W.

ELECTRICAL AND MECHANICAL ENGINEER, B.SC., A.M.E.I.C. Experience includes C.G.E. Students Test Course and six years in engrg. dept. of same company on design of electrical equipment. Four summers as instrumentman on surveying and highway construction. Recently completed course in mechanical engineering. Available at once. Location preferred Ontario, Quebec, or Maritimes. Apply to Box No. 564-W.

MECHANICAL ENGINEER, A.M.E.I.C., with twenty years experience on mechanical and structural design, desires connection. Available at once. Apply to Box No. 571-W.

MECHANICAL ENGINEER, B.A.SC., '30, desires position to gain experience, and which offers opportunity for advancement. Experience in pulp and paper mill and one year in mechanical department of large electrical company. Location immaterial. Available immediately Apply to Box No. 577-W.

National Defence Relief Camps

A recent opportunity to inspect four unemployment relief camps in Ontario, one of 1,000, two of 500 and one of 260 men, has made it possible to obtain first hand information of the work at present being undertaken, the living conditions, food, etc., and thus a fairly good idea of the situation confronting members of the E.I.C. and R.P.E. who are employed in supervisory capacities in similar projects throughout Canada.

Unemployed men in over one hundred of these camps are being provided with work of a varied and non-competitive character in which labour plays a large part. It is, however, in many cases of an interesting nature and at times provides considerable opportunity for one with engineering training and experience in handling men.

An idea of the type of work going forward may be gained from the following list: brush clearing, forestry development, road building and improvements, airplane landing fields, both emergency and permanent, repairs to old fortifications, improvement of barrack sites, preparations for new building construction.

In addition to this in many of the camps a large part of the men are just now engaged in the construction of bunk houses, mess buildings, recreation buildings, etc., which are to be used as quarters during the winter months.

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.

MECHANICAL ENGINEER, Canadian, technically trained; eighteen years experience as foreman, superintendent and engineer in manufacturing, repair work of all kinds, maintenance and special machinery building. Location immaterial. Available at once. Apply to Box No. 601-W.

CHEMICAL ENGINEER, S.E.I.C., B.SC., University of Alberta, '30. Age 31. Single. Six seasons' practical laboratory experience, three as chief chemist and three as assistant chemist in cement plant; one year's p.g. work in physical chemistry; three years' experience teaching. Desires position in any industry with chemical control. Available immediately. Apply to Box No. 609-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.

CIVIL ENGINEER, A.M.E.I.C., R.P.E., Ontario; three years construction engineer on industrial plants; fourteen years in charge of construction of hydraulic power developments, tower lines, sub-stations, etc.; four years as executive in charge of construction and development of harbours, including railways, docks, warehouses, hydraulic dredging, land reclamation, etc. Apply to Box No. 647-W.

Situations Wanted

MECHANICAL ENGINEER, A.M.E.I.C., Canadian, technically trained; six years drawing office. Office experience, including general design and plant layout. Also two years general shop work, including machine, pattern and foundry experience, desires position with industrial firm in capacity of production engineer or estimator. Available on short notice. Apply to Box No. 676-W.

ELECTRICAL ENGINEER, B.SC., '29, JR.E.I.C. Age 26. Undergraduate experience in surveying and concrete foundations; also four months with Canadian General Electric Co. Thirty-three months in engineering office of a large electrical manufacturing company since graduation. Good experience in layouts, switching diagrams, specifications and pricing. Best of references. Available immediately. Apply to Box No. 693-W.

MECHANICAL ENGINEER, JR.E.I.C., grad. Tech. Coll., age 29. Seven years experience pulp and paper mill design and maintenance. Hydro developments. Recently designing engineer road making machinery, hoists, crushers, gravel plants, graders, foundry and machine shop supervision. Paper machine design, building construction. Technical advertising. Location immaterial. Apply to Box No. 699-W.

MECHANICAL ENGINEER, B.SC., '27, JR.E.I.C. Four years maintenance of high speed Diesel engines units, 200 to 1,300 h.p. Also maintenance of D.C. and A.C. electrical systems and machinery. Draughting experience. Westinghouse apprenticeship course. Practical mechanical and electrical engineer with a special study of high speed Diesel engine design, application and operation. Location in western or eastern Canada immaterial. Apply to Box No. 703-W.

COMBUSTION ENGINEER, R.P.E., Manitoba. A.M.E.I.C. Wide experience with all classes of fuels. Expert designer and draughtsman on modern steam power plants. Experienced in publicity work. Well known throughout the west. Location, Winnipeg or the west. Available at once. Apply to Box No. 713-W.

YOUNG ENGINEER, B.A.SC., (Univ. Toronto '27), JR.E.I.C. Four years practical experience, buildings, bridges, roadways, as inspector and instrumentman. Available at once. Present location, Montreal. Apply to Box No. 714-W.

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

MECHANICAL ENGINEER, age 41, married. Eleven years designing experience with project of outstanding magnitude. Machinery layouts, checking, estimating and inspecting. Twelve years previous engineering, including draughting, machine shop and two years chemical laboratory. Highest references. Apply to Box No. 723-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.

DESIGNING ENGINEER, M.SC. (McGill Univ.), D.L.S., A.M.E.I.C., P.E.Q. Experience in design and construction of water power plants, transmission lines, field investigations of storage, hydraulic calculations and reports. Also paper mill construction, railways, highways, and in design and construction of bridges and buildings. Available at once. Apply to Box No. 729-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.

CIVIL ENGINEER, M.SC., 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.

ELECTRICAL AND RADIO ENGINEER, B.SC. '31, S.E.I.C. Age 25. Nine months experience on installation of power and lighting equipment. Eight months on extensive survey layouts. Two summers installing telephone equipment. Specialized in radio servicing and merchandising. Available at once. Location immaterial. Apply to Box No. 740-W

CIVIL ENGINEER, graduate '29. Married One year building construction, one year hydro-electric construction in South America, fourteen months resident engineer on road construction. Working knowledge of Spanish. Apply to Box No 744-W.

SALES ENGINEER, B.SC., McGill. 1923. A.M.E.I.C. Age 33. Married Extensive experience in building construction. Thoroughly familiar with steel building products; last five years in charge of structural and reinforcing steel sales for company in New York state. Available at once. Located in Canada. Apply to Box No. 749-W.

DESIGNING ENGINEER, graduate Univ. Toronto '26. Thoroughly experienced in the design of a broad range of structures, desires responsible position. Apply to Box No. 761-W.

Situations Wanted

MECHANICAL ENGINEER, graduate, '23, A.M.E.I.C., P.E.Q., age 32, married. (English and French.) Two years shop, foundry and draughting experience; one year mechanical supt. on construction; six years designing draughtsman in consulting engineers' offices (mechanical equipment of buildings, heating, sanitation, ventilation, power plant equipment, etc.). Present location Montreal. Available immediately. Montreal or Toronto preferred Apply to Box No. 766-W.

CIVIL ENGINEER, S.E.I.C., B.Sc. Queen's Univ '29. Age 25. Married. Three years experience as construction supt. and estimator for contracting firm. Experience includes general building, bridges, sewer work, concrete, boiler settings, sand blasting of bridges and spray painting. Available at once. Apply to Box No. 767-W.

ELECTRICAL ENGINEER, B.Sc. (McGill Univ. '29), S.E.I.C. Married. Experience in pulp and paper mill mechanical maintenance, estimates and costs and machine shop practice. Desires position with industrial or manufacturing concern. Location immaterial. Available on short notice. References. Apply to Box No. 770-W.

ELECTRICAL ENGINEER, Queen's Univ. '24, JR.E.I.C., age 32, married. Experience includes, student Test Course, Can. Gen. Elec. Co., four years dial system telephone engineering with large manufacturing company. Available at once. Apply to Box No. 772-W.

CIVIL ENGINEER, B.Sc., '25, JR.E.I.C., P.E.Q., married. Desires position, preferably with construction firm. Experience includes railway, monument and mill building construction. Available immediately. Apply to Box No. 780-W

DRAUGHTSMAN, experience in civil engineering, forestry engineering, land surveying and house construction. Good references. Apply to Box No. 781-W.

ELECTRICAL AND SALES ENGINEER, S.E.I.C., grad. '28. Experience includes one year test course, one year switchboard design and two years switchboard and switching equipment sales with large electrical manufacturing company. Three summers Pilot Officer with R.C.A.F. Available at once. Apply to Box No. 788-W.

SALES REPRESENTATIVE. Electrical engineer with ten years experience in power field interested in representing established firm for electrical or mechanical product in Montreal territory. Excellent connections Apply to Box No. 795-W.

CIVIL ENGINEER, S.E.I.C., graduate '30, age 23, single. Experience includes mining surveys, assistant on highway location and construction, and assistant on large construction work. Steel and concrete layout and design Apply to Box No. 809-W.

CIVIL ENGINEER, college graduate, age 27, single. Experience includes surveying, draughting concrete construction and design, street paving both asphalt and concrete. Available at once; will consider anything and go anywhere. Apply to Box No. 816-W.

CIVIL ENGINEER, B.E. (Sask. Univ. '32), S.E.I.C. Single. Experience in city street improvements; sewer and water extensions Good draughtsman. References. Available at once. Location immaterial. Apply to Box No. 818-W

CIVIL ENGINEER, S.E.I.C., B.Sc. (Queen's '32), age 21. Three summers surveying in northern Quebec. Interested in hydraulics and reinforced concrete. Available at once. Location immaterial. Apply to Box No. 822-W.

CIVIL ENGINEER, B.Sc., A.M.E.I.C., with fifteen years experience mostly in pulp and paper mill work. reinforced concrete and structural steel design, field surveys, layout of mechanical equipment, piping. Available at once. Apply to Box No. 825-W.

ELECTRICAL ENGINEER. S.E.I.C., grad. '29, age 24, married; experience includes one year Students Test Course, sixteen months in distribution transformer design and eight months as assistant foreman in charge of industrial control and switchgear tests. Location immaterial. Available at once. Apply to Box No 828-W

SALES ENGINEER, M.E.I.C., graduate civil engineer with twenty years experience in the structural. sales. and municipal engineering fields, and as manager of engineering sales office Available at once. Apply to Box No. 830-W

CIVIL ENGINEER, B.A.Sc., D.L.S., O.L.S., A.M.E.I.C., age 46, married. Twelve years experience in charge of legal field surveys. Owns own surveying equipment. Eight years on technical, administrative, and editorial office work. Experienced in writing. Desires position on survey work, assisting in or in charge of preparation of house organ, on staff of technical or semi-technical magazine, or on publicity, editorial or administrative office work. Available at once. Will consider any salary, and any location. Apply to Box No. 831-W

CIVIL ENGINEER, M.Sc., R.P.E. (Sask). Age 27. Experience in location and drainage surveys, highways and paving, bridge design and construction city and municipal developments, power and telephone construction work. Available on short notice. Apply to Box No. 839-W.

CIVIL ENGINEER, S.E.I.C., B.Sc. '32 (Univ. of N.B.) Age 25, married. Two years experience in power line construction and maintenance; one year of highway construction; one summer surveying for power plant site, location and spur railway line construction. Available at once. Location immaterial. Apply to Box No. 840-W.

Situations Wanted

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.

CIVIL ENGINEER, B.Sc. (Alta. '31), S.E.I.C., age 24. Experience, three summers on railroad maintenance, and seven months on highway location as instrumentman. Willing to do anything, anywhere, but would prefer connection with designing or construction firm on structural works. Available immediately. Apply to Box No. 846-W.

MECHANICAL ENGINEER, JR.E.I.C., technical graduate, bilingual, age 30. Two years as designing heating draughtsman with one of the largest firms of its kind on this continent handling heating materials; three years designing draughtsman in consulting engineers' office, mechanical equipment of buildings, heating. ventilation, sanitation, power plant equipment, writing of specifications, etc. Present location Montreal. Available at once. Apply to Box No. 850-W.

BRIDGE AND STRUCTURAL ENGINEER, A.M.E.I.C., McGill. Twenty-five years' experience on bridge and structural staffs. Until recently employed. Familiar with all late designs, construction, and practices in all Canadian fabricating plants. Desirous of employment in any responsible position, sales, fabrication or construction. Apply to Box No. 851-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.

MECHANICAL ENGINEER, B.Sc. '32, S.E.I.C. Good draughtsman. Undergraduate experience:—One year moulding shop practice; two years pipe fitting and sheet metal work; one year draughting and tracing on paper mill layout; six months machine shop practice; and eight months fuel investigation and power heating plant testing. Desires position offering experience in steam power plants or heating and ventilating design. Will go anywhere. Apply to Box No. 858-W.

MECHANICAL ENGINEER, age 31, graduate Sheffield (England) 1921; apprenticeship with firm manufacturing steam turbine generators and auxiliaries and subsequent experience in design, erection, operation and inspection of same. Marine experience B.O.T. certificate thoroughly conversant with Canadian plants and equipment. Available on short notice. Any location. Box No. 860-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.

ENGINEER, McGill Sci. '21-'25, S.E.I.C., aerial mapping, stereoscopic contour work; lumber classification; highway, railway and transmission line locations; estimates; water storage investigations, etc. Five years ground surveys; three years aerial mapping. Bilingual. Available on short notice. Apply to Box No. 872-W.

CONSTRUCTION ENGINEER (Toronto Univ. of '07). Experience includes hydro-electric, municipal and railroad work. Available immediately. Location immaterial. Apply to Box No. 886-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.Sc., Montreal 1930, age 26, single, French and English, desires position technical or non-technical in engineering, industrial or commercial fields, sales or promotion work. Experience includes three years in municipal engineering on paving, sewage, waterworks, filter plant equipment, layout of buildings etc. Available immediately. Apply to Box No. 891-W.

ELECTRICAL ENGINEER, grad. Univ. of N.B. '31. Experienced in surveying and draughting, requires position. Available at once Will go anywhere. Apply to Box No. 893-W.

CIVIL ENGINEER, B.A.Sc., JR.E.I.C., age 29. single Experience includes two years in pulp mill as draughtsman and designer on additions, maintenance and plant layout. Three and a half years in the Toronto Buildings Department checking steel, reinforced concrete, and architectural plans. Available at once. Location immaterial. At present in Toronto. Apply to Box No. 899-W.

ENGINEER, JR.E.I.C., specializing in reconnaissance and preliminary surveys in connection with hydro-electric and storage projects. Expert on location and construction of transmission lines, railways and highways. Capable of taking charge. Location immaterial. Apply to Box No. 901-W.

MECHANICAL ENGINEER, Canadian, age 25, B.Sc. (Queen's '32). Since graduation on supervision of large building construction. Undergraduate experience in electrical, plumbing and heating, and locomotive trades. Available at once. Apply to Box No. 903-W

Situations Wanted

DESIGNING ENGINEER, A.M.E.I.C. Permanent and executive position preferred but not essential. Fifteen years experience in designing power plants, engine and fan rooms, kitchens and laundries. Thoroughly familiar with plumbing and ventilating work, pneumatic tubes, and refrigeration, also heating, electrical work, and specifications Apply to Box No. 913-W

INDUSTRIAL ENGINEER, B.Sc. in M.E., age 25, married, is open for a position of a permanent nature with an industrial concern. Experience includes three years in various divisions of a paper mill and two years in an electrical company. Apply to Box No. 917-W.

ENGINEER, B.Sc., A.M.E.I.C., R.P.E. (N.B.), age 35, married. Seven years' mining experience as sampler, assayer, surveyor, field work, and foreman in charge of underground development; two years as assistant engineer on highway construction and maintenance. Available on short notice. Apply to Box No. 932-W.

CIVIL ENGINEER, B.Sc., '25, McGill Univ., JR.E.I.C., P.E.Q., age 32, married. Experience as rodman and instrumentman on track maintenance. Seven and one-half years with Canadian paper company, as assistant office engineer handling all classes of engineering problems in connection with woods operations, i.e., road buildings, piers, booms, timber bridges, depots, dams, etc. Apply to Box No. 933-W.

ELECTRICAL ENGINEER, Dipl. of Eng., B.Sc. (Dalhousie Univ.), S.B. and S.M. in E.E. (Mass. Inst. of Tech.), Canadian. Married. Seven and a half years' experience in design. construction and operation of hydro, steam and industrial plants. For past sixteen months field office electrical engineer on 510,000 h.p. hydro-electric project. Available at once. Apply to Box No. 936-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.

ELECTRICAL ENGINEER, twenty years experience, desires position, either temporary or permanent. Experienced in design, construction, and operation of power and industrial plants, and supt. of construction. Apply to Box No. 974-W.

INDUSTRIAL ENGINEER, B.Sc., in C.E. (McGill Univ. '30), graduate student in industrial engineering '33 session, age 27, single, available for a position of temporary or permanent nature with industrial concern. Has theoretical knowledge of latest methods of market analysis, production control, management and cost accounting. Also experience in the design and construction of industrial buildings. Location immaterial. Apply to Box No. 981-W.

CIVIL ENGINEER, B.Sc. (Univ. of Sask. '33), S.E.I.C., age 28, single. Experience in testing hydro-electric equipment, draughting, surveying, city street, improvements, technical photography. Available at once. Location immaterial. Apply to Box No. 986-W.

ELECTRICAL ENGINEER, B.A.Sc., '27, JR.E.I.C., A.A.I.E.E. Married. Age 31. One and a half years G. E. Test Course, Schenectady; four and a half years motor and generator design including induction motors, D.C. and A.C. motors and generators. Willing to do anything, design or sales preferred. Available at once. Present location Toronto. Apply to Box No. 993-W.

MECHANICAL ENGINEER, S.E.I.C., B.Sc., Queen's University '33. Age 24, desires position on power plant and power distribution problems, factory maintenance, heating and ventilation or refrigeration design. Willing to work for living expenses in order to gain experience. Apply to Box No. 999-W.

ELECTRICAL ENGINEER, S.E.I.C., B.Sc., (N.S. Tech. Coll., '33), desires work. Experience in transmission line construction. Location or class of work immaterial. Apply to Box No. 1010-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.

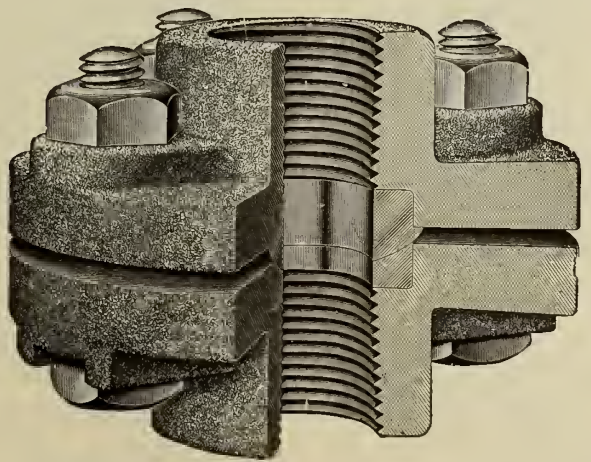
CIVIL ENGINEER, B.Sc. (Queen's 14), A.M.E.I.C., Dominion Land Surveyor, 5 months' special course at the University of London, England, in municipal hygiene and reinforced concrete construction. Experience covers legal and topographic surveys, plane tabling and stadia surveying, railway and highway construction, drainage and excavation work. Available at once. Apply Box No. 1035-W.

MECHANICAL ENGINEER, S.E.I.C., B.Sc. (Queen's Univ. '33). Will work for living expenses anywhere to gain experience. Maintenance, operation, sales, or design of machinery preferred. Apply to Box No. 1042-W.

ELECTRICAL ENGINEER AND GEOPHYSICIST. Age 36. Married. Seven years experience in geophysical exploration using seismic, magnetic and electrical methods. Two years experience with the Western Electric Company of Chicago, working on equipment and magnetic materials research. Experienced in radio and telephone work, also specializing in precise electrical measurements, resistance determinations, ground potentials and similar problems of ground current distribution. Apply to Box No. 1063-W.

For Sale

ENGINEERING NEWS RECORD—Complete file 1916-1933 with five years' indices, bound leather back and covers in half yearly volumes. Selling price just sufficient to cover binding. Apply to Box No. 20-S.



Purchasers' Classified Directory

A Selected List of Equipment, Apparatus and Supplies

For Alphabetical List of Advertisers see page 22.

Valuable suggestions appear in the advertising pages.

Purchasers' Classified Directory

I

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Indicator Posts:
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J

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L

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Northern Electric Co. Ltd.
Locomotives, Electric:
Can. General Elec. Co. Ltd.
Can. Westinghouse Co. Ltd.

M

Machinery, Hydraulic:
Dominion Engineering Works Limited.
Machinery, Metal Working:
The Can Fairbanks-Morse Co. Ltd.
Dominion Engineering Works Limited.
Machinery, Woodworking:
The Can. Fairbanks-Morse Co. Ltd.
Dominion Engineering Works Limited.
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Can. Westinghouse Co. Ltd.
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Northern Electric Co. Ltd.
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Neptune Meter Co. Ltd.
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Neptune Meter Co. Ltd.
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O

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R

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S

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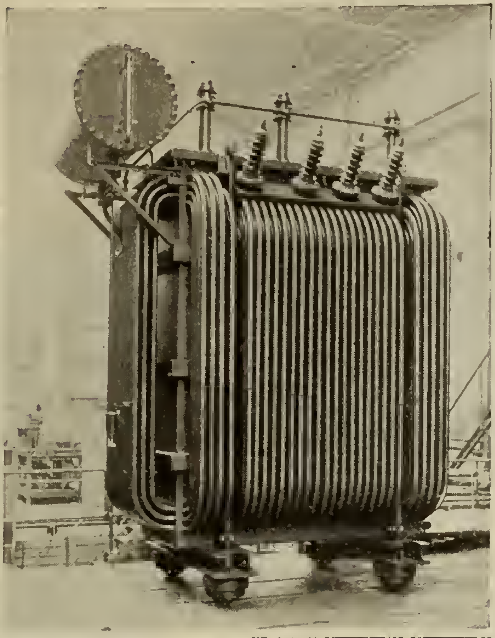

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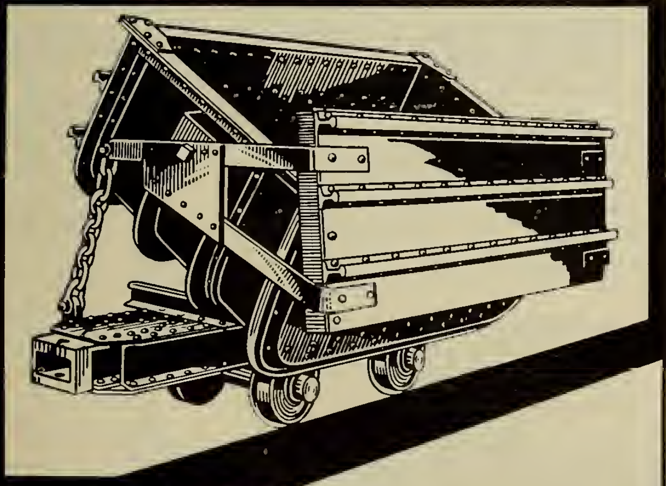

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T

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U

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V

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W

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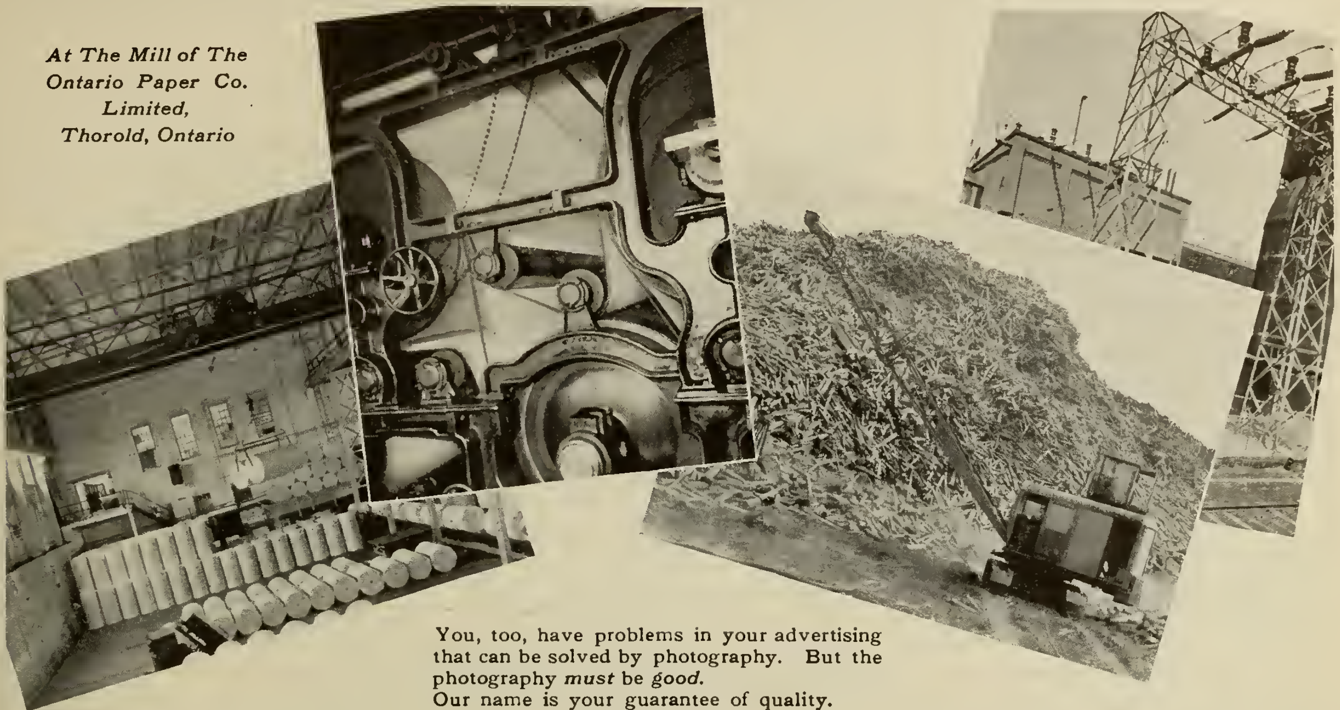

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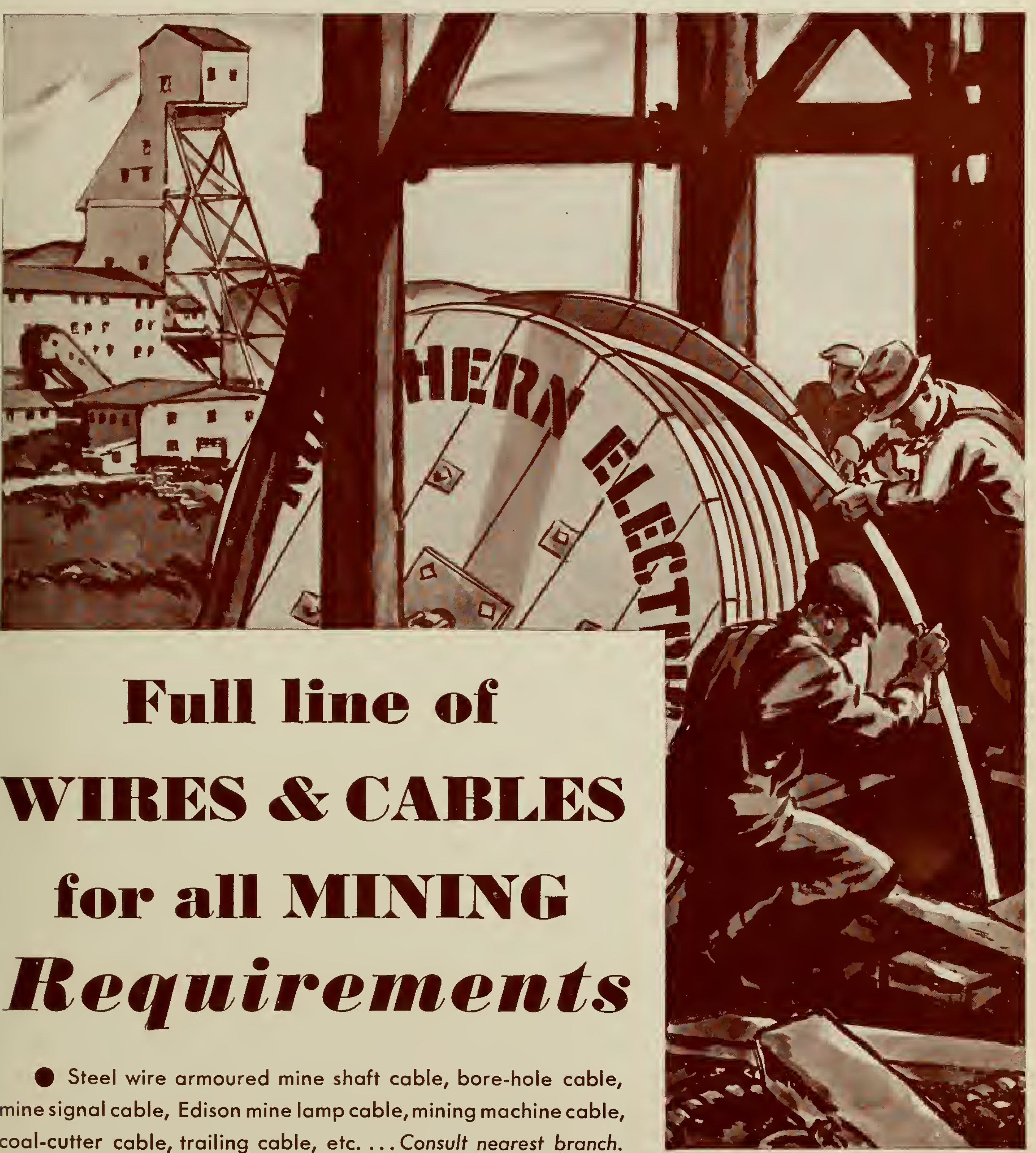

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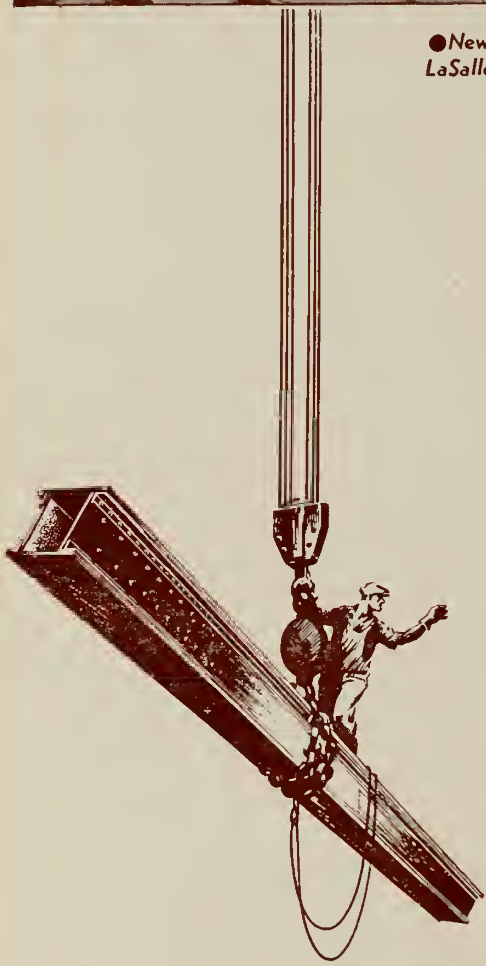

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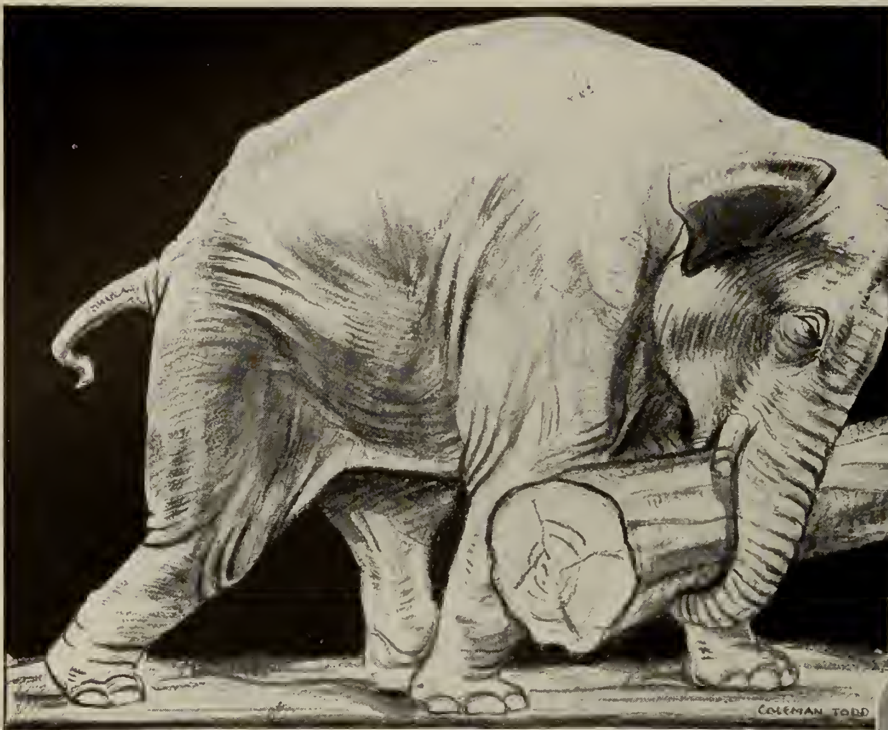

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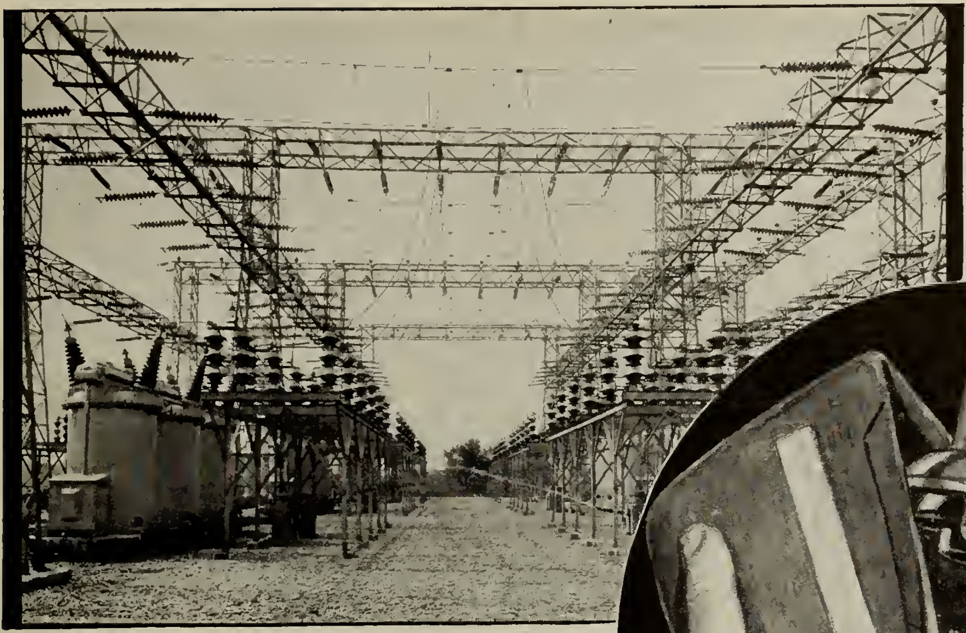

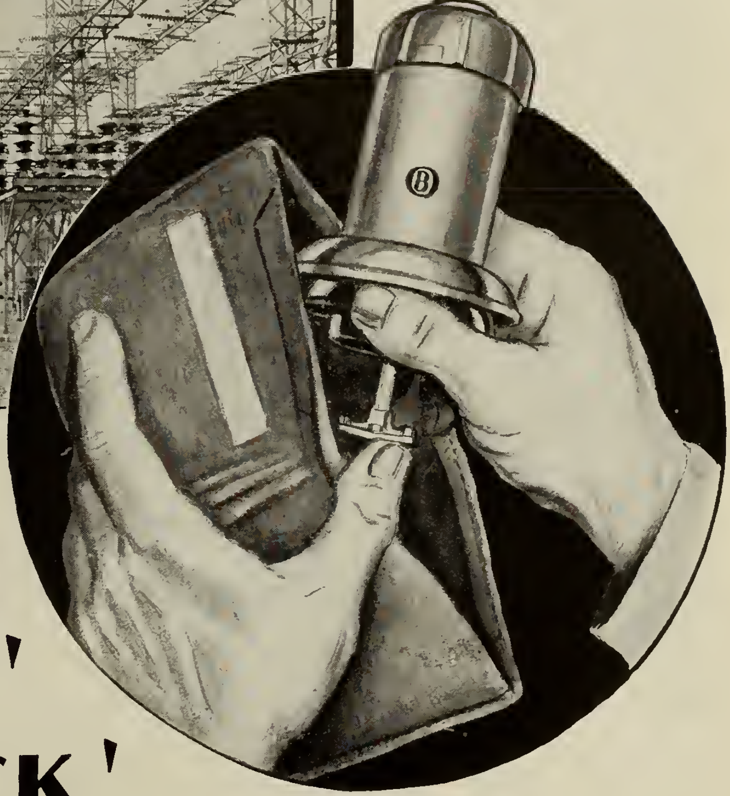

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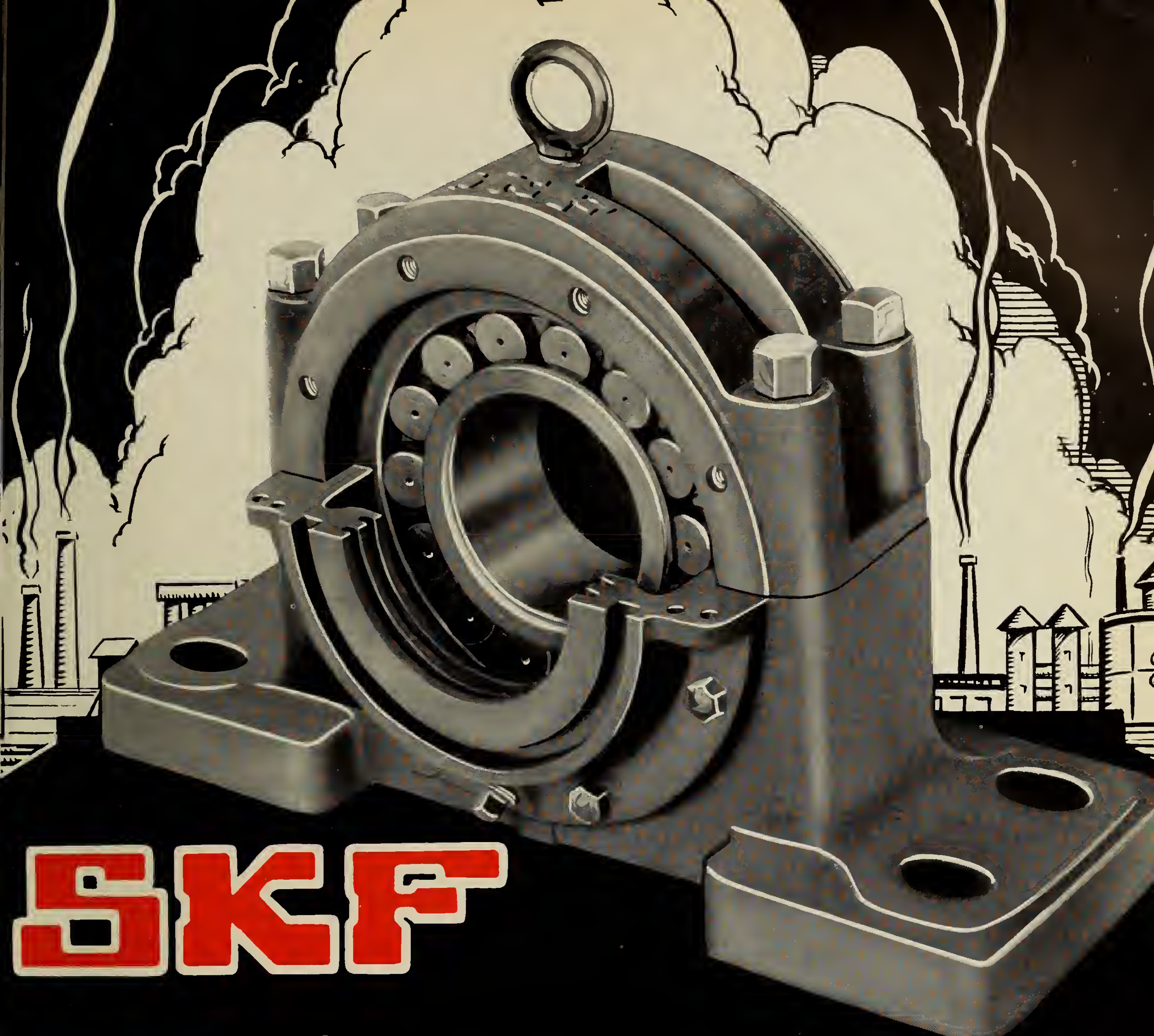

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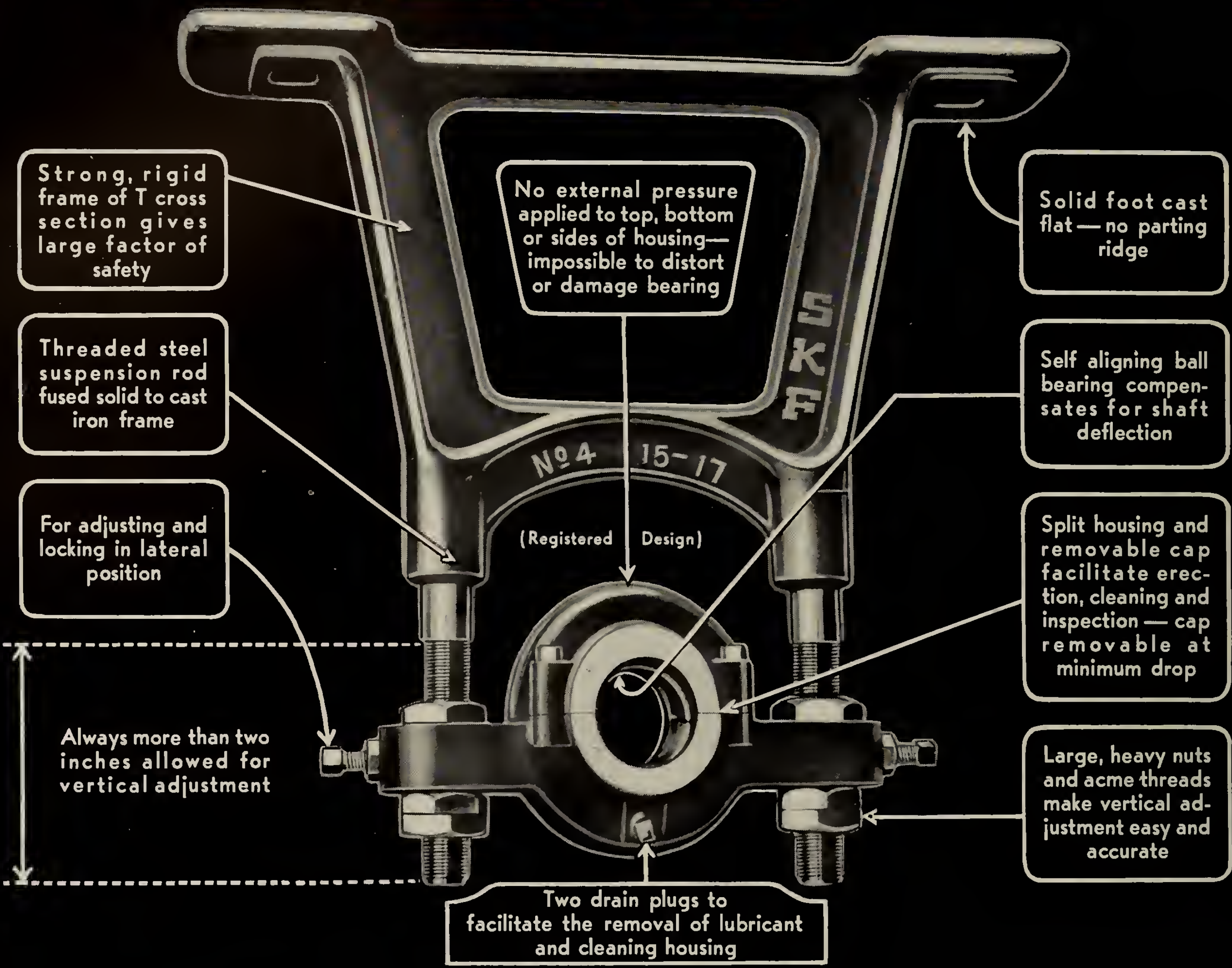

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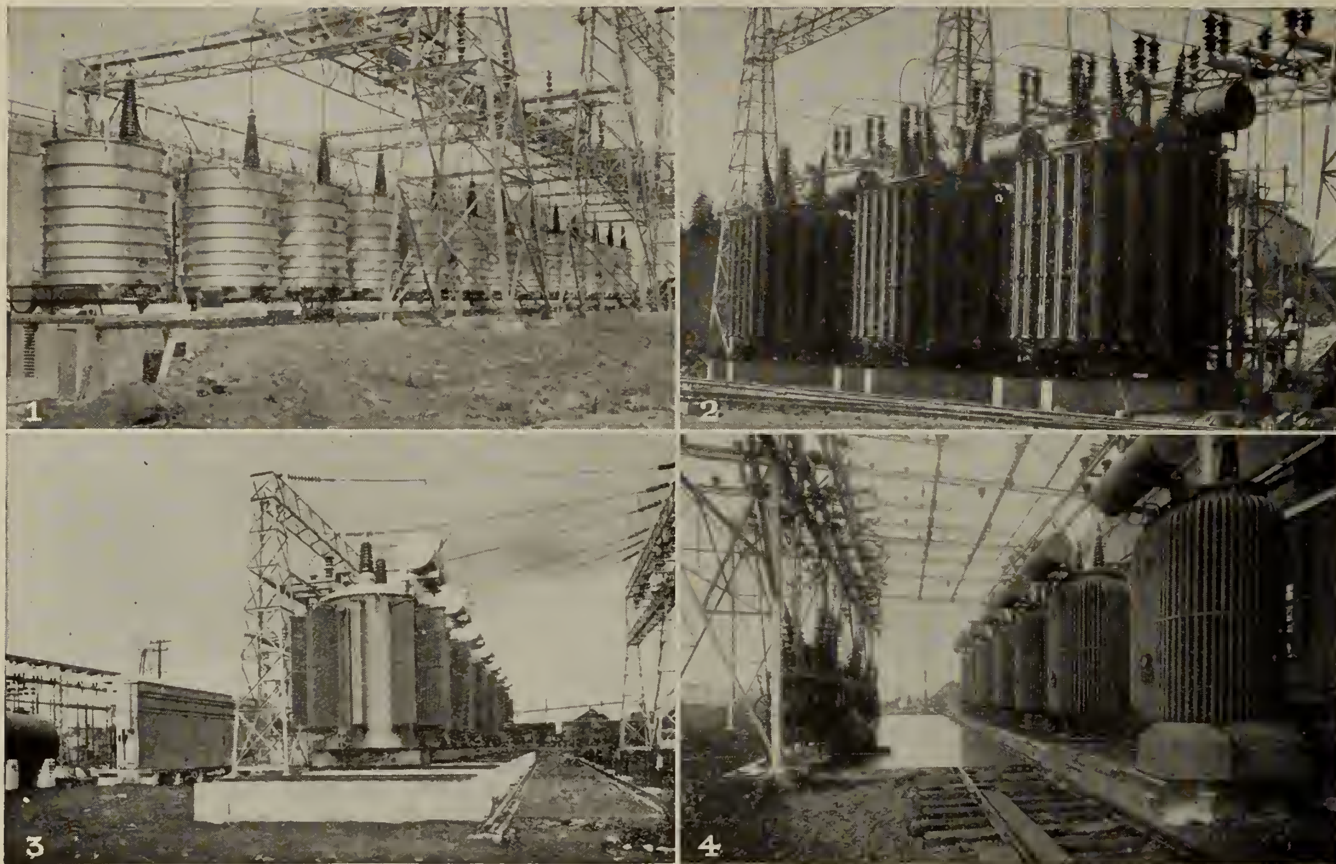

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Supervisory Control and Automatic Protection in Hydro-Electric Developments

With particular application to the Maritime Provinces

Howard Fellows, A.M.E.I.C.,
Assistant Chief Engineer, The Nova Scotia Power Commission, Halifax, N.S.

Paper presented at the Maritime Professional Meeting of The Engineering Institute of Canada, July 13th, 1933.

SUMMARY.—The author sketches briefly the history of the development of supervisory control and automatic protection as applied to electric generating stations and enumerates the various systems which have been used. He describes the operation of the synchronous selector supervisory system which has been adopted in the Mersey system in Nova Scotia. The paper outlines the requirements of this system as regards control and protection, explains how these have been met, and points out the suitability of this type of control for the conditions applying to hydro-electric stations in the Maritime Provinces.

It is not the writer's intention to go into the details of the technical features of supervisory control and automatic protection in this paper, but rather to give a brief outline of their growth, together with a general description, paying particular attention to the application and benefits to be derived from their use. These points will be presented with special reference to their value in the Maritime Provinces.

History

As in most cases where the development of a device or even a science is not a distinctly new departure but rather an application in a small way, at the beginning, of devices already in operation, it is rather difficult to give a definite date for the first application of supervisory control to electric power stations.

Lichtenberg and Zogbaum in a paper presented at the World Engineering Congress in Tokio in 1929, are authorities for the statement that "In 1898 the first system operators' equipment was installed in New York city." This installation was apparently for the purpose of connecting rotary converters inverted to steam driven direct current generators to help out during peak loads.

Lichtenberg and Wensley presented a paper at the World Power Conference at Berlin in 1930, which states that "Automatic stations and substations in their present form are about fifteen years old." The text accompanying this statement would lead to the belief that it refers to stations which were unattended and hence are the forerunners of the system which is so prevalent today, and particularly applicable to the Maritimes. The report further states that the station mentioned went into operation December 25th, 1914, and was so successful that in 1915 other stations were converted to automatic operation.

The initial application of automatic features was used in electric railway substations and the machines were so arranged that extra d.c. generators were brought on the line either by low voltage on the feeders, or by an excessive current (which are both produced by overloading), or by time switches installed in the substations. The function of the automatic devices usually was to start a rotary converter, bring it up to speed and successfully tie it in on both the a.c. and d.c. sides, which is a much more complicated operation than that required in the ordinary generating station, and hence many of the relays and other devices were brought to a high state of perfection early in the game. Initially this work was carried out in stations which were manually attended because sudden loads would be imposed and human agencies could not get additional units on the line fast enough to give satisfactory service. The increase of even the lighting load when a heavy cloud blankets a congested city area is often such as to require additional generating capacity, and since the power house attendants cannot always foretell this, difficulty was experienced in being prepared to carry this unexpected load demand. In one case on record we find that a power company stationed a man on the roof of the building during the daylight hours to warn the attendants of the approach of such a cloud.

The interrelation between the a.c. and d.c. energy of apparatus which is connected either mechanically or electrically, or both, in different types of a.c.-d.c. machines made them very difficult to take care of on account of the entirely different characteristics of the two systems being brought together, but the success of the stations was phenomenal and it was logical that the application would spread. When the growth of generating stations made them too large to be under the direct eye of the operator, the dispatcher's room was located separate from the engine room and the cable supervisory came into being. The expansion of transmission line and distribution systems, and the tying together of different generating stations then created the necessity for a central load dispatcher who performed his work through telephone communication with the operators of the various stations. This naturally became slow and cumbersome, with many uncertainties, and the present supervisory in its various forms was initiated, giving the dispatching office control of the generating units and switching stations entirely. Following the supervisory, and the consequent elimination of attendants at the distribution points, telemetering was developed whereby the units of electrical measurements at the remote stations were made available in the dispatcher's office. The benefits of supervisory are greatly enhanced by and sometimes wholly dependent on the automatic protection of the units supervised, in that the cost of manual labour can be reduced and these automatic devices had

Fig. 1—Lower Lake Falls Generating Station, Mersey System.

already been well advanced in the operation of the railway substation.

The earliest supervisory systems made use of at least one wire between the controlling point and the device to be controlled, which naturally limited the application on account of the number of wires and the size of control board required for any comprehensive supervision. The step which simplified the control and increased the field of application was the accomplishment of a large number of operations and indications on a maximum of four wires. No attempt will be made in this article to describe the various steps in the growth of supervisory, although some mention would probably be of interest. Reliable authority would seem to bear out the following progressive steps in the development:

A Step by Step system which was complicated and cumbersome was installed in 1912 in New York City for the purpose of indicating circuit breaker operation.

The Selector supervisory system which was originally designed for use with automatic stations, and which required three circuits for its operation.

The Key Visual supervisory system using two pairs of telephone wires, which has been in satisfactory operation for a long time.

The Distributor supervisory system which was developed about the same time as the selector supervisory system previously mentioned and was favoured because fifty operations and fifty indications could be carried on in five seconds.

The Code Visual supervisory system which was an attempt to simplify the key visual supervisory system, and which required two wires more than the number of stations to be controlled. This system was limited to the remote control and operation of thirty functions at a distance of about 10 miles.

The Synchronous Relay supervisory system which was developed to control and meter an entire station up to 30 miles distance, using modern telephone equipment and four wires.

The Synchronous Selector supervisory system which can control ninety-two remote operations over four line wires and up to a distance of 30 miles. This is the system adopted at the Mersey and consequently it will be described more in detail.

The last two mentioned systems are modern and effective and are comparable in accomplishment although a different scheme is used in the two cases.

In addition Carrier Current supervisory systems are in operation which make joint use of the transmission line wires or ground wires and which employ moderate frequencies of the order of 500 cycles.

Type Adopted on Mersey System

The Synchronous Selector supervisory system requires four wires for its operation, which are designated as the control, indication and synchronizing circuits, all of which utilize a common return. For the operation of the equipment at the dispatcher's panel the following apparatus is required for each unit to be supervised.

A select key, a control key, and various coloured lamps closely grouped around the select key. In addition there is a synchronizing key which is used for the operation of the selector, a start key to put the selector in motion and an operate key all of which are common to the entire layout. A bell and a lamp are also located on the panel to call the operator's attention in the case of an operation being performed in an outlying station. These also are common to the entire equipment. In addition also, there are the necessary relays for the performing of the various functions, and four continuous ungrounded wires between stations.

The operation of the system is then as follows:—

Suppose for example that an increase in load on one unit is required. The operator assures himself that the selectors are in step by noting the associated lights. If these are in step the select key for the particular control to be operated is pulled out and the start key depressed to start the selector which will then stop at the point selected by the select key and light an amber lamp to show that everything is in order. The line wires are now connected to the piece of apparatus in the remote station, which is to be operated, and the control key is turned to the position which will increase the gate opening on the unit connected to the supervisory. The operate key is then depressed and held in till the load is the required amount as noted on the instruments associated with the incoming feeder. The selector is then turned to the zero position by depressing the select key. In this case red and green lamps are unnecessary and are not included, but in the case of a circuit breaker, and many other operations, a red lamp would light for the closed position of the breaker and a green light for the open position showing when the operation had been performed as required. The equipment is so arranged that several operations can be performed very speedily and accurately, especially when it is considered that the indication from the unit supervised is in plain view to the operator as he works his supervisory control.

In case an operation should take place in a remote station such as the tripping of a breaker, pilot switches which are auxiliary to the breaker itself will put the selector in operation and the white light associated with that piece of apparatus will come on at the control board and at the same time the bell or gong will ring, calling the dispatcher's attention to the fact that something unexpected has taken place. The indicating lights also show just what piece of equipment has been affected so that the dispatcher knows at a glance what sections of the system are in trouble. If a series of unexpected operations take place instantaneously in an outlying station they will be stored up and the indications sent to the dispatcher in turn. This mechanism operates so speedily that the indication of all units which are controlled will be given at the dispatcher's desk in five seconds, that being the time required for the selector to travel over its entire range and give indications on the way around of all operations which have taken place.

Hydro-Electric Possibilities in Nova Scotia

The Maritime Provinces of Canada present a problem in power development that is more or less peculiar to the topography of the country as well as its geographic location. This probably applies more particularly to Nova Scotia in that the province is long and narrow and the mainland is divided by a near mountain range extending northeasterly and dividing it into two watersheds, one of which discharges generally into the Atlantic ocean, while the other discharges into the Bay of Fundy, or the Northumberland strait. Each of these watersheds is broken up into numerous small areas so that a large number of rivers discharge into the ocean with a considerable drop in level in comparatively short distances, but with very few pronounced water falls and with comparatively small watersheds to feed them. This means that speaking in terms of modern generating station practice there are numerous water power sites where substantial blocks of power can be developed for a reasonable amount of capital expenditure, and a low generating cost per kilowatt hour secured, providing the operation can be kept within reasonable limits. For the accomplishment of this much desired condition the modern supervisory control with protected generating and transmission equipment is ideal. A typical example is embodied in the Mersey system which is Nova Scotia's largest hydro power possibility and which is now described in some detail.

The Mersey System

The Mersey system developments are situated on the Mersey river which meets the salt water about two miles above the town of Liverpool and which has as its head water Lake Rossignol, the largest body of fresh water in the province. The storage basin as now increased and in a normal water year is good for a sustained flow of 1,400 second feet. The total drop between Rossignol at spillway and mean tide level is 274 feet in about 14 miles which may be developed in nine power sites, or in five sites if the load demand justifies the larger installations. The initial installation which is owned and operated by the Nova Scotia Power Commission was made to supply the power and energy required under a contract with the Mersey Paper Company for 20,000 h.p. and 105,000,000 kw. hrs. per year and is constituted as follows:—

The uppermost development known as Upper Lake falls, or No. 1, is situated at the foot of Lake Rossignol with Lower Lake falls, or No. 2, about one mile below and Big Falls, or No. 3, about three miles further down. The head of No. 1 varies from 21.5 to 41.5 feet depending on the height of the lake. The head of No. 2 is 48.5 feet and that at No. 3 is 58 feet, giving a total drop in a little over four miles of 148 feet theoretically, and under the best conditions. The economical development of this stretch of river indicated the building of the three developments as noted above and in order to obtain a better diversity factor and water balance under varying load conditions it was considered expedient to install two units in each power house. No. 1 station contains two units of 3,000 kv.-a. each, No. 2 station has two units of 4,100 kv.-a. each, and No. 3 station contains two units of 5,000 kv.-a. each. From No. 3 station, a 66-kv., 3-phase transmission line carries the power and energy to the Mersey Paper Company's mill about 16 miles distant. The stretch of river indicated above was located in the forest and ten miles from a village so that any and all housing accommodation which would be necessary for the operating staff had to be provided and that at considerable expense because of the remoteness, roughness and rocky nature of the country. The situation that had to be faced was, therefore, three generating stations which would require a staff of trained operators in each, together with all the necessary housing for each member of the staff. Under the circumstances it was only natural that consideration would be given to the operation of all the stations from a dispatcher's board, and the layout was such as to lend itself to, at that time, the most up-to-date installation in the country. The application of supervisory control alone would not have been of any benefit since it was not so much a case of load dispatching and circuit manipulation as of reducing the operating cost by eliminating the attendants so that the whole question of automatic operation of all the units together with their effective protection in case of troubles developing had to be considered. The importance of the satisfactory performance of all units in these stations was further enhanced by the fact that the system supplies the entire requirements of the Mersey Paper Company's mill with its high load factor which practically means that while the mill is operating all units must operate continuously. It was, therefore, realized that if supervisory operation was to be of any benefit at all it had to go the whole way, with the result that a scheme was applied whereby the two upper stations could be operated unattended except for inspection and cleaning, and the third station would be virtually the same although on account of the switchboard being located in No. 3 station it did not require the same degree of protection.

The requirements of the system were therefore—

1. To start and stop two waterwheel driven generators in each of the two remotely located stations, and two similar units remotely located in the same station;
2. To raise and lower the voltage on all the above machines;
3. To open and close the governors of all the above units for division of load;
4. To operate a by-pass gate in the No. 1 dam in order to balance the water below in the event of a unit being out of service for any reason;
5. To tie in the units automatically;
6. To get a satisfactory number of readings of the water elevation at No. 2 dam so that efficient and continuous operation of that power house as well as No. 3 power house would be assured;

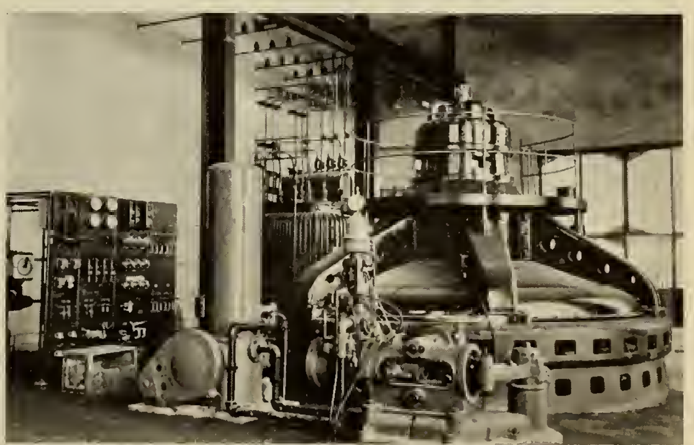

Fig. 2—3,000 kv.-a. Generating Unit in Upper Lake Falls Generating Station.

7. To so equip the units that they would automatically take care of themselves in the event of the following irregularities:—

(*a*) Lock out the units if they have stopped for any cause which would be dangerous to them and which would persist, such as short circuit, harmful overload, overheated bearings, failure of the generator field, excessive voltage, failure of the water on the lignum vitae bearings, auto transformer trouble or anything which would cause the differential relays to operate.

(*b*) Temporarily stop the unit if the system overspeeds, if moderate overloads are imposed which cause excessive heating, operation on unbalanced phases, or if failure of the governor oil pressure occurs. Water failure on the lignum vitae bearing also will allow the machine to restart if waterflow re-establishes itself.

8. To give indication at the dispatcher's board of the position of any piece of equipment which is under the control of the supervisory, as for example as to whether a breaker is open or closed, or the position of the by-pass gate at the No. 1 dam as well as the water elevation at the No. 2 dam, or other like indication.

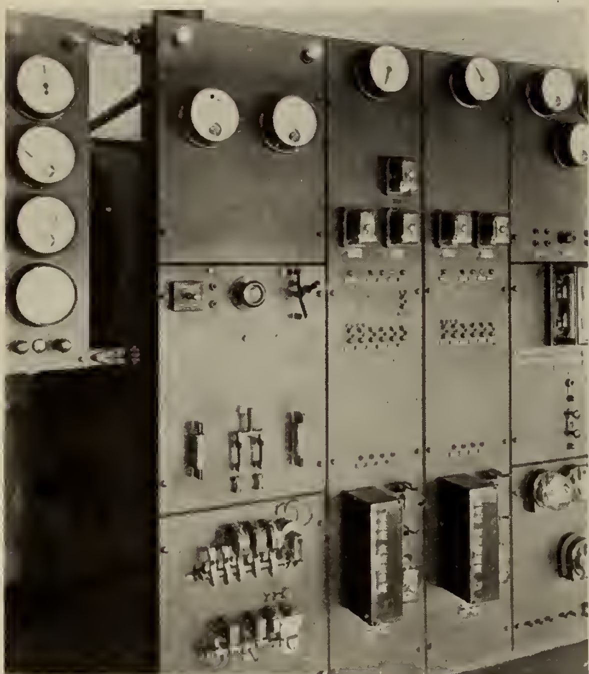

Fig. 3—M.G. Set Panel and Supervisory Control Panels at Big Falls Generating Station.

The physical layout of the three developments with the amounts of power to be developed in each, was peculiarly adaptable in that it was more economical to carry a separate feeder from each generator in the outlying stations to a switching structure at the No. 3 station. This simple scheme permitted the indication and measuring completely at the dispatcher's board of the voltage, load, power factor and kilowatt hours, so that remote metering was not even attempted. It also eliminated the necessity of tying the units together in each station on a bus in that station and thus eliminated many operations which were possible of accomplishment but which would greatly complicate the operation especially in time of trouble. No indication was necessary of the gate opening of each wheel either, since (unless the unit is in trouble) that is given by the kilowatt meter at the dispatcher's office, and if the unit is in trouble, the automatic devices will remove the machine from the line and notify the dispatcher, if he has not already noticed the trouble from his meters.

The matter of power factor between the different units required consideration and this was taken care of by installing an individual regulator on each generator which stays in the circuit at all times and the operating point of which is adjustable by supervisory from Big Falls until the proper power factor is obtained as indicated on the incoming instruments from that unit. The individual regulators also save complications in that in case of a trip out under a heavy load, high voltages which would lock out the units are avoided and the operator does not need to worry about that condition in case of such a happening. Virtually, therefore, it will be seen that the layout is such that each generator is an individual station in itself except that they are housed two in a building and the batteries for the supervisory control are therefore common to the two units.

Due to the physical layout of the stations the supervisory cable as provided was steel armoured and placed under water in the flowage of each station, thus eliminating the effect of inductive and other influences which would exist in the air and more particularly when paralleling a high tension line. Some difficulties have been experienced with this cable from mechanical causes, but these are well ironed out at the present time and excellent service is being given.

The matter of tying in the generators also received much consideration and in view of the relative size of the units it was deemed satisfactory to allow both No. 1 station generators to synchronize themselves by the pull-in method. That is, the indication being given the governor starts the turbine and as soon as its speed reaches 95 per cent of its synchronous speed, the circuit breaker closes bringing the generator on the line as an induction motor, immediately after which the field switch closes, causing the machine to pull in step. The decision to use this method has justified itself in that no disturbance from that source has caused inconvenience to the customers of the system, and in fact the operation is usually not even noticeable on the lines. It is interesting at this point to recall an incident in connection with the operation of the system and the synchronizing of these machines. Trouble occurred at one time which caused the entire Mersey system proper to go off the line and the paper mill to drop its load. The Guzzle generating station (a manual plant acquired for construction purposes which has been kept in operation) stayed on the system and thus maintained voltage and frequency even though only 600 kv.-a. was available in the station. This, however, was sufficient to allow the automatic stations to function properly with the result that No. 1 automatic unit restarted and pulled in, thus stabilizing the system and holding the same until other units had time to come in. It is also worthy of note that amortisseur windings are not needed on these units since they have sufficient pull-in torque inherent in their design to pull-in to step unaided.

In the case of the four remaining generators, it was considered that self synchronizing would cause too severe a disturbance on the system so that automatic synchronizing by speed matching method was adopted. That is, the units are brought up to speed in the ordinary manner with the field applied and the breaker automatically closed when the units are in synchronism and all other conditions are correct.

The whole development scheme on the river has been laid out in such a manner that if it is economic to do so, future developments not only on the same river but also on the Medway river can be controlled from this point and as a continuance of the existing equipment. The success of the Mersey system to date may be considered as phenomenal and has fully justified the installation. In fact there is no doubt that a considerable amount of machine hours and money have already been saved by the automatic features as against manual attendance because of certain difficulties with the oil circulating pumps.

As a point of general interest some mention should be made of braking the units when they are coming to rest. Much consideration was given to this item since considerable trouble has always been experienced with the stopping of manually attended units using airbrakes. With a full realization of the probable weakness of oil braking, it was finally adopted as the most satisfactory with the oil from the governor system being used. After the gates have been closed for a certain length of time, the brakes are automatically applied and will stay on for a predetermined time, after which they will automatically release. This is necessary because the immediate release of the brakes would probably allow the generator to creep, unless sufficient time is allowed for the oil to squeeze out from between the faces of the thrust bearing. On the other hand if the pressure is kept on and the brakes applied during the entire time when the unit is down, excessive oil leakage will logically take place. If it is necessary to restart a generator before the set time expires the indication from the supervisory to open the gates will automatically release the brakes so that the unit may start. The braking system adopted has proved entirely satisfactory.

General Application

As previously noted in this paper, supervisory control is intimately connected with automatic protection and in small installations practically its sole value is, in the writer's opinion, tied up with automatic operation. In the design of larger stations automatic protection is applied because it is justified in the better protection given to the equipment, often saving thousands of dollars in loss when accidents occur, sometimes due to human failures but often due to machine failures which cannot be detected by the attendant until after the permanent damage has been done. In the application of supervisory, therefore, to a larger installation, or to switching operations only, the benefits may be chiefly speed in and ease of control of a complicated system which in themselves are extremely important in a large system and easily justify the outlay. In the smaller systems, however, the supervisory cannot be economically applied unless the cost of station attendance is reduced thereby. Following this train of thought it can readily be seen that applications will present themselves where the automatic protection is justified but where supervisory control is too expensive.

The case just cited in fair detail in the description of the Mersey system can be considered as typical of a major installation in Nova Scotia and as applicable to the largest installation which can be made due to the capacity of the various sites as mentioned earlier. In this particular case the extra capital cost involved was actually less than would have been required to provide the extra housing accommodation for the staff, so that a direct saving in operating labour of at least $12,000 a year was made, while to date the maintenance costs have not exceeded those of manual stations for the same period of time and under the same condition. In addition the protection afforded the equipment is, it is believed, superior and certainly the ease and speed with which service can be re-established following trouble is vastly better than that which would obtain under manual operation.

There is another possible application in the province which would apply to very small stations where, as mentioned above, it would not be justifiable to install supervisory control but where automatic protection of the units could eliminate the attendants entirely and thus greatly reduce the cost. By doing this many small power sites can be used which could not be economically developed by other means. There are many cases in the province where small tributary streams can be made available as supplementary supply to the main station either on a peak supply basis, a run of the river basis, or a straight energy basis. These small stations will usually be in comparatively inaccessible places and the design of the building need only be such as to make a fire proof, rugged structure which will be correspondingly cheap. The value of many of these small developments can be better realized when it is considered that a 100-kw. generator operated continuously will deliver at its own switchboard probably 800,000 kw. hrs. a year after allowing for some time out of service. At the same time the loss of that 100-kw. unit at any time will not affect the peak carrying capacity of the system. In a case of this kind supervisory control would certainly be a needless expense but a very satisfactory scheme would be to simplify the generating stations to the utmost, even to the elimination of a voltage regulator with the excitation system so designed that even at runaway speed, dangerous voltages would not exist. In this case governing could also be eliminated, provision being made only to close and open the gates. Automatic devices in this case would only be required for oil temperatures, field failures and one or two other such contingencies.

It is rather difficult to deal in costs without using specific cases, but an attempt will be made to show that a small installation as just described would be economic. As an overall cost it can be fairly assumed that $200 a kv.-a. would cover the installation so that the total would be $20,000. Taking fixed charges and maintenance at 10 per cent the annual cost would be $2,000 which would cover all costs. This gives a cost per kilowatt hour of 0.25 cents which is certainly very cheap energy. If this station was attempted on a manual basis the cost of operation alone, even with attendance of a type comparable with the importance of the station, would be probably $1,500 a year to which must be added the cost of housing for its staff which would likely bring the cost to $2,000 for operation only. In other words, the addition of a few automatic features would cut

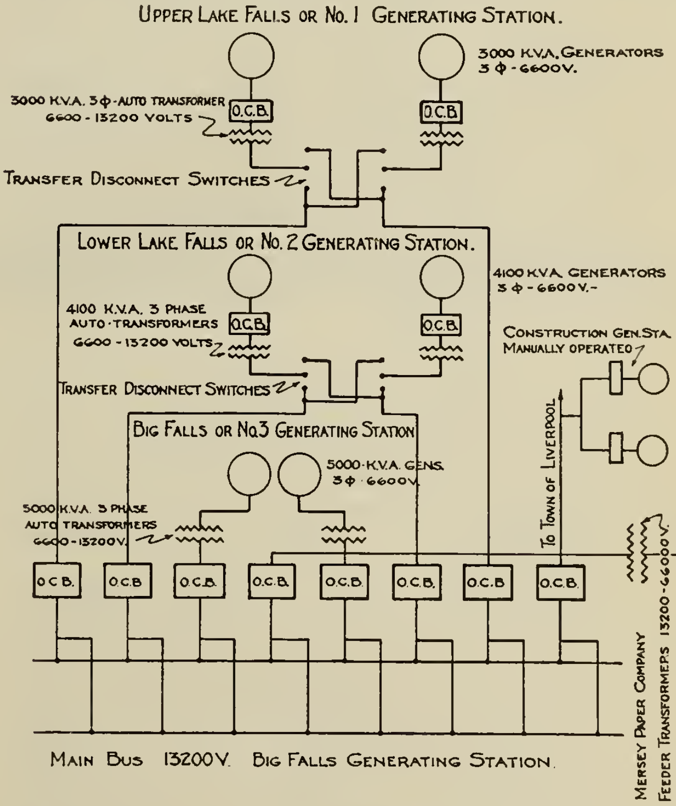

Fig. 4—Diagram of Electrical Arrangement of Mersey System.

the cost of energy at this station by 50 per cent and give adequate protection to the installed plant. It might fairly be argued that an installation as small as this could be operated unattended and unprotected and take the risk, but that cannot be considered as comparable to the condition of operation that would exist under the protected conditions with the risk eliminated.

Another method for the development of this site also dependent on the application of these features (provided a fair sized headpond is cheaply available), would be the installation of a much larger unit to operate on a peak load basis only. Generally speaking, a 400-kw. unit could operate six hours per day on the same water as a 100-kw.

would require for all day. In this case, however, the very assumption necessitates the provision of a more elaborate scheme because the 400 kw. on peaks might be essential to the supply of the load. Supervisory control would hardly be justified in this case, however, since the unit could be controlled in a satisfactory manner by a time clock, supplemented by high and low water gauge switches so that the unit would come on the system at a predetermined time and shut down in the same manner, always checked, however, by the water level switch. This unit would be considerably more expensive and would, therefore, require more adequate protection, but the percentage cost of the protection would be less than that in the other case and the addition of 400 kw. at peak, of reliable power would likely be worth much more than the kilowatt hours only.

The possibility of the application of supervisory control to switching stations, together with the metering of energy at the base station by telemetering is an accomplished fact and is in use in Halifax, but its application in the Maritimes is rarely justified. The field for this equipment is more generally in connection with interconnected networks of large power systems.

In the foregoing no attempt has been made to describe the intricate details of the operation of automatic protective devices and supervisory control since the same is beyond the scope of this article, but rather an effort has been made to show the application of the operation generally in this province, considering in particular a case where it has been applied to an entire system and also setting forth the possibilities where the system is applied to auxiliary power and/or energy supply, or to both, for an existing generating system.

Conclusions

Supervisory control has been in the course of development and has been in satisfactory use in various forms for over thirty years, and can adequately and safely handle the transfer of different functions in connection with the complete operation of a generating station without the aid of regular attendance at the controlled station.

Automatic control of the unit supervised can be applied in such a manner as to give more reliable and satisfactory operation than that obtained with human attendance.

The application of these two systems in varying degrees is adaptable to the Maritime Provinces where many small hydro power developments exist which cannot be economically used if an operating staff has to be maintained, but which will provide satisfactory service at a reasonable cost either alone or as auxiliary to base stations. It is also applicable to the largest installations and by its application lessened costs can often be secured with more reliable service and better protection for the equipment involved.

Pulverized Coal for Steam Boilers

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Paper presented at the Maritime Professional Meeting of The Engineering Institute of Canada, July 14th, 1933

SUMMARY.—The paper deals with the development of equipment to burn Nova Scotia coals as pulverized fuel, commencing with the installation of the very progressively designed Bettington boilers by the Dominion Coal Company in 1912. Subsequent progress in Canada and the United States is discussed, involving the successive development of the slag screen, hollow air-cooled side walls and finally water-cooled side walls. Reference is made to the various methods of introducing air and pulverized fuel, and to the means adopted for coal storage and drying. Figures are given as to the performance of a number of typical powdered fuel installations.

The coal industry of Nova Scotia is a matter of vital concern to the prosperity of eastern Canada. With the exception of agriculture, it is the largest employer of labour in the province, and thus provides a goodly portion of the purchasing power so essential to our prosperity. Nova Scotia coals are ideal for use in pulverized form, and it will be interesting to trace progress in the art of burning this fuel under boilers.

One of the great modern engineering romances is the story of development in the art of burning pulverized coal under stationary steam boilers, and it is the purpose of this paper to point out some interesting features of these developments which have been adopted in eastern Canada.

It should be a source of considerable pride to Maritime engineers that the first pit-mouth public service power station on the American continent was built in 1906 at Chignecto Mines, N.S., and operated successfully for twenty years. That Maritime industrialists are progressive is proved by the fact that the first pulverized coal fired boilers in North America were installed by the Dominion Coal Company in 1912, and operated practically continuously until late in 1932.

It is said that the first commercial application of pulverized coal firing was made to a cement kiln in 1895, at a plant of the Atlas Portland Cement in Pennsylvania, and that ten years later it was applied to metallurgical furnaces in the same district. As early as 1876 various attempts were made to burn pulverized coal under boilers, but it was not, however, until about 1909 that any degree of substantial success was attained. At that time several independent efforts were under way in the United States, while very substantial progress was being made in England.

In August, 1910, the engineering firm Fraser and Chalmers Ltd., of London, issued a 24-page bulletin illustrating in detail and describing with accuracy the construction and operation of a pulverizer, with classifier, supplying powdered coal and pre-heated air to a water tube boiler complete with superheater, air pre-heater and economizer. The burner and furnace were water-cooled; coal was dried in the mill and furnace ash discharged to the bottom of the furnace in a fluid condition conveniently removed therefrom. This was the Bettington pulverized fuel boiler plant, which had been developed as a result of extensive experiments begun in South Africa, continued and first patented in the United States, and finally completed and commercially exploited in Great Britain. The bulletin contains a summary of tests on a Bettington boiler plant which had then been successfully and regularly operated in Fraser and Chalmers Ltd., Erith (Kent) shops for over a year. Test results are given for three kinds of English coal, three kinds of South African coal, and Welsh anthracite duff. Boiler efficiencies varying from 66 to 80.3 per cent were shown.

Three of these Bettington boilers were installed in the Waterford Lake Power plant of Dominion Coal Company in 1912; a fourth boiler was added in 1913 (see Fig. 1) and a similar boiler was installed in Moncton. Over 25,000 h.p. of Bettington boilers were installed in England and South Africa.

Let us now turn to the very active but less progressive development in the United States. In 1910 a 300-h.p.

water tube boiler was fired with powdered coal in the Henry Phipps power plant in Pittsburgh. Owing to limited furnace volume this boiler did not develop its full rated capacity; an efficiency of approximately 79 per cent was reported. The low rating and ultimate failure of this installation is said to be due to the lack of furnace volume.

In 1913 two separate installations were made in New York State, and both later abandoned due to slagging,

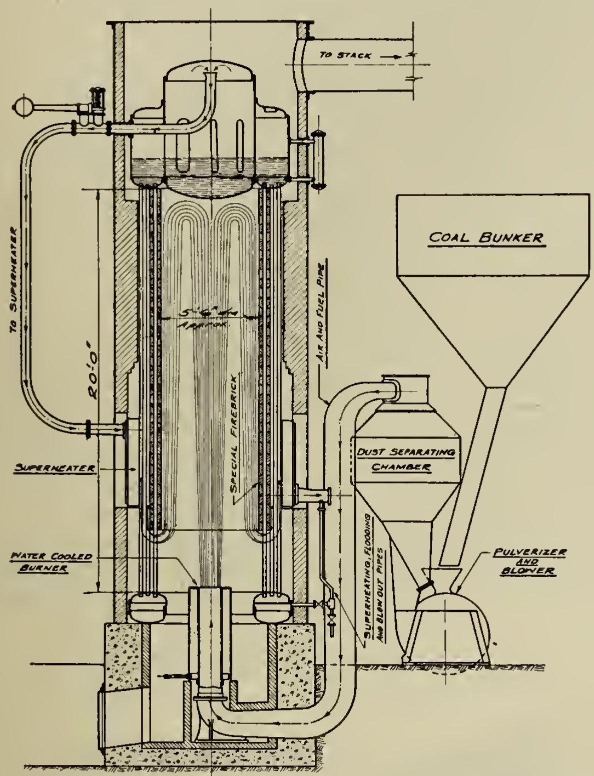

Fig. 1—Sectional View of Bettington Boiler, Waterford Lake Power Plant, 1912.

short life of furnace linings and inability to develop full boiler capacity—again a lack of furnace volume.

About this time a pulverized fuel installation was made in the Parsons, Kansas, plant of the M. K. & T. Railway. Bituminous coal was used and this plant operated with what was then considered remarkable success. In fact results were so encouraging that additional boilers were equipped in 1917. Solid refractory furnaces of rather large proportions were used.

About 1917 the Milwaukee Electric Railway and Light Company installed a rather large refractory furnace under a water tube boiler. Powdered coal was fired vertically downward inside the front wall where secondary air for combustion was admitted—the idea being to obtain a soft lazy flame. But high furnace temperatures resulted in the accumulation of slag in the furnace bottom, the erosion of side walls, and caused many shutdowns.

In the course of experiments to determine the best method of freeing this furnace of slag, a water screen was installed near the furnace bottom. The chilling effect of these bare water pipes solidified the floating particles of molten ash into a granular dry substance that settled beneath the screen where it could readily be removed at intervals while the furnace was in operation. At first this water screen had a water supply independent of the boiler, but later the screen circulation was tied into the boiler circulation. And this change in furnace design, more than any other single item, contributed to the ultimate and permanent success of the modern pulverized coal fired furnace.

Next was developed a furnace with a water screened bottom and hollow air-cooled side walls. The principle upon which the air-cooled wall is based is that furnace wall temperature, due to the thin furnace lining, is lowered by the air sweeping at the back of it, and this permits the slag to build up in thickness until the cooling effect of the air diminishes to a point where further deposits of molten ash run off the slag skin formed on the refractory. The heated air is used for combustion. This hollow wall type of construction made a very efficient furnace that was fairly reasonable in maintenance cost, when the heat liberation was increased over that allowable in a solid brick wall furnace. These furnaces were generally fired vertically downward through the arch, so that long flame travel would permit fairly complete combustion with a minimum of flame impingement on refractory surfaces. The fuel was "fogged" into the furnace, so to speak; the fuel and combustion air were in layers. However, for furnaces of greater dimensions required with the larger and more efficient steam generating units rapidly coming into demand, the hollow wall construction had quite definite structural limitations, and the method of building furnace walls with water cooled metallic surfaces came into vogue. Both structural and economic necessities, in fact, forced the adoption of a furnace construction very similar to that which Bettington had adopted fifteen years previously. Experience had proved that large refractory furnaces were too costly to build, unreliable and costly to maintain at rapid rates of combustion, and required much too expensive structures to house them.

Furthermore, during this intensive development period about ten years back, the manufacturer of mechanical stoker equipment, alarmed by the increased competition from pulverized coal, very considerably improved the design and flexibility of stokers. Stoker fired furnaces were designed with air-cooled or water-cooled furnaces and very high rates of heat release could be continuously employed, and pre-heated air often used for combustion.

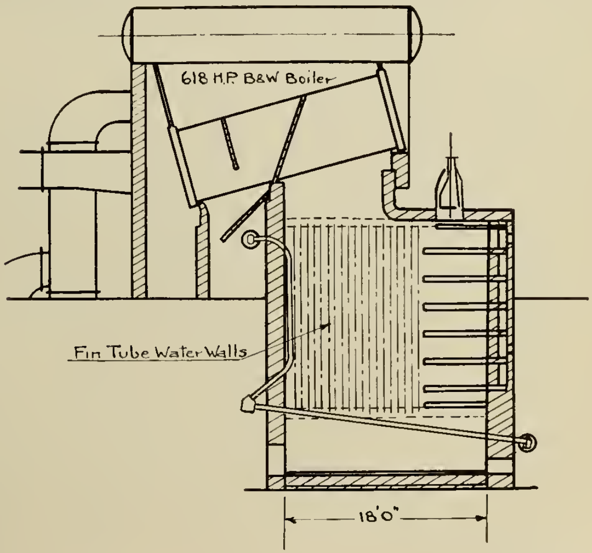

Fig. 2—Installation with Slag Screen and Furnace Walls Partially Water Cooled.

Thus, during the ten years past, the battle between stoker firing and pulverized coal firing for steam boilers has raged continuously, and the principal effort has been directed to increase combustion rates while keeping the furnace walls and furnace bottom at a temperature below the fusing point of the ash in the coal being burned.

By the use of water walls the chief heat absorbing portion of the boiler has, in fact, been built around the furnace to withstand not only high temperature but also the scouring action of violent mixing. It is the radiant heat absorbing surfaces of water walls and lower rows of boiler tubes that transfer heat most rapidly. And it is the violent mixing of pulverized coal and pre-heated air in "turbulent" burners that permits that high rate of heat release essential to justify the cost involved. Turbulent combustion with a minimum of excess air produces high temperatures, and high temperatures facilitate rapid combustion, therefore completing it in a minimum of space.

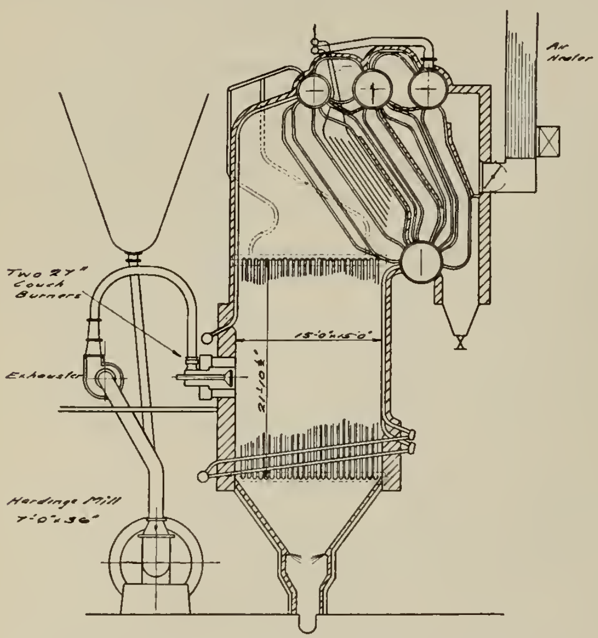

Fig. 3—900-h.p. Stirling Boiler, Seaboard Power Plant.

These improvements to boiler and furnace design have been aimed to produce more steam per dollar of investment. Gradual improvements in the design of air pre-heaters, coal drying and pulverizing equipment, etc., have also been similarly aimed.

A large proportion of the earlier pulverized coal installations for large boilers employed the storage system, where crushed coal was separately dried then pulverized and stored in a bin adjacent to the burners. This system requires considerable space and is quite costly to install, but it does permit uniform and fine grinding and almost perfect control of the coal and air mixture to the furnace. But the unit, or direct, system of pulverizing, employing one pulverizer per boiler, or one pulverizer per burner has rapidly come into favour—because it is more compact, less costly and sufficiently efficient and flexible for most cases. In these unit systems the pulverization is accomplished by impact mills, attrition mills, roller mills, or ball mills, and the coal drying is accomplished by the pre-heated primary air which sweeps the fine coal from mill to burner. Here again is a well developed tendency to adopt a principle embodied in the Bettington patents over twenty years ago.

It should be pointed out, however, that a certain combination of the storage system with the direct or unit system is sometimes desirable. For one very large boiler equipped with one large pulverizer and with several burners to efficiently carry a wide range of load, it is desirable to interpose a bin and feeders between the mill and burners. With such a bin of, say, four or five hours capacity there is insurance of continued boiler operation during a temporary stoppage of the pulverizing equipment.

There is one feature of the drying of coal inside the pulverizing mill that apparently produces results contrary to expectations. What actually takes place is that the heated particles of coal in the mill give up their moisture to the surrounding envelope of heated "primary" combustion air. Furthermore, this moisture in the heated air for combustion undoubtedly has the effect of reducing the flame temperature in the furnace. But the efficiency of the boiler and furnace is apparently reduced but little, if any, by the liberation of this considerable water vapour from the coal. And a reasonable explanation of this phenomenon lies in the fact that of all the gases making up the ordinary products of combustion, carbon dioxide and water vapour alone are capable of absorbing and emitting heat by radiation, and these can radiate heat to a colder surface even when non-luminous. Thus with water walls facing the turbulent flame of combustion, it seems reasonable to assume that much of the heat radiated from water vapour in the products of combustion is absorbed by the radiant heat absorbing surfaces and transferred to the steam.

The amount of pulverized coal that can be efficiently burned, per cubic foot of boiler furnace volume, for long uninterrupted periods, depends on many factors; the fineness of grinding, the coal analysis, the fusing point of the coal ash, the temperature of pre-heated combustion air, the rate of radiant absorption into the boiler water, the turbulence of the coal-air mixture, the formation of slag on furnace walls and boiler tubes, the removal of ash, etc. With solid refractory furnaces a satisfactory heat release will depend, to a considerable extent, on the fusing point of ash and amount of excess air employed, but over 12,000 B.t.u. per cubic foot has not been very successful with Nova Scotia coals and troublesome maintenance

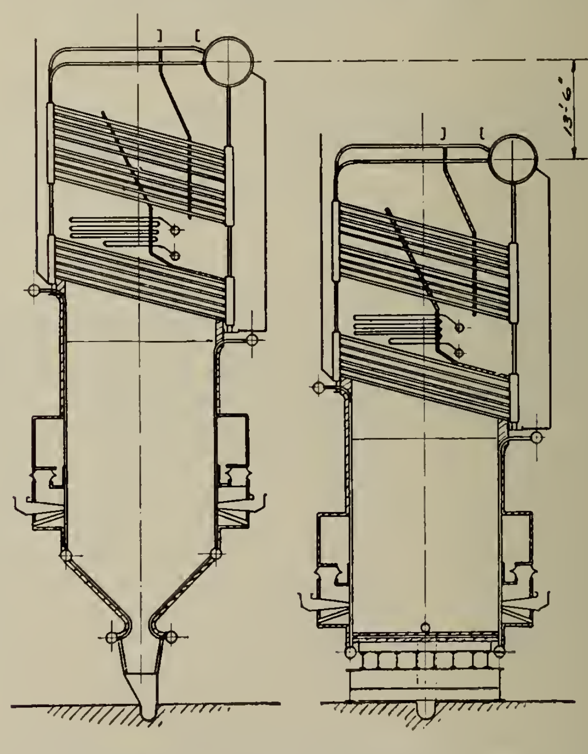

Fig. 4—Comparison of Space Required for Hopper Bottom Furnace and Slag Tap Furnace.

sometimes accompanies even slower rates of combustion. But the solid refractory furnace is seldom considered now-a-days. A leading Canadian authority with wide and successful experience in the application of boilers and furnaces to pulverized coal firing states that:—

"Nova Scotia coals are ideal as pulverized fuel; they are easily pulverized and the rate of flame propagation exceedingly high, affording easy primary air control over a wide range of load conditions. The carbon is free burning, uniting readily with oxygen under ordinary flame temperatures. Its free burning characteristics and high volatile content result in very high furnace temperatures; its comparatively short flame travel affords a high heat release per cubic foot of furnace volume. This high heat release tends to cause high furnace maintenance unless water cooling is resorted to. It is rather interesting to note that the first units installed to burn this coal in powdered form were the Bettington boilers. . . It is also very interesting that these boilers, I understand, are still giving a good account of themselves, and that their design, although probably twenty-five years in advance of their time, is still the basis for the modern powdered fuel installation, involving a completely water-cooled furnace, pulverized fuel and pre-heated air."

Thus, it may be helpful to compare some characteristics of the Bettington unit with similar characteristics of more modern installations using pulverized Nova Scotia and New Brunswick coals. This has been done in the table below.

This incomplete list of boilers using Nova Scotia coal in powdered form plainly shows the tendency toward more water cooled surface in the furnace, and slightly increased heat release per cubic foot of furnace volume. But the tabulation does not show the greatly increased reliability and decreased maintenance costs which have resulted from improved design made possible by operating experience. The tendency is definitely toward turbulent combustion.

In order to obtain higher rates of heat release when using coals having ash fusion temperatures under 2,500 degrees F., a number of the larger power plants in the United States have boilers arranged with slag-tap furnaces—the ash is removed in liquid form. This development was started in 1928, at the Huntley station in Buffalo, and has since been applied to about seventy large boilers in twenty-five different stations. Heat liberated in these slag-tap furnaces ranges from 25,000 to 40,000 B.t.u. per cubic foot per hour. Another advantage of the slag-tap furnace is its ability to burn the coal completely.

In thus briefly reviewing the trend of powdered coal developments during a period of unparalleled engineering and industrial activity, one must conclude that Bettington lived twenty-five years in advance of his time.

Boiler Plant	Boilers				Date	Furnace				Fuel	Temp. Air to Fce.	Exit Flue Gas Temp.		Efficiency Boiler Furnace & Preheater	Boiler H.P.		Cu. Ft. Furnace Vol. per B.H.P.			B.T.U. Heat Release per Cu. Ft. Fce. Vol.	
	No.	Type	Sq. Ft. Heat. Surface per boiler	Steam Press. lbs.		Volume Cu. Ft.	Cooling Surface: Walls	Cooling Surface: Water Screen	Cooling Surface: Total Sq. Ft. per boiler			Boiler	Heater		Max. Guarantee	Normal Operation	100% Boiler Rating	Max. Guarantee	Norm'l Operation	Max. Guarantee	Normal Operation
A	4	Bettington	1,966	175	1912	475	300	—	300	Dom. Slk.	Cold	560	—	73.3*	300%	288%	2.4	.80	.85	60,000	55,000
B	2	Robb	3,500	240	1926	2100	88	255	343	9600 B.T.U. Duff	Cold	?	—	?	275%	185%	6.0	2.2	3.25		14,000
C	2	Burroughs	7,650	300	1926	3700	970	—	970	Dom. Slk.	560	700	410	83.0	400%	325%	4.83	1.2	1.5	33,500	27,500
D	7	B. & W.	10,163	135	1926	8200	955	246	1201	Dom. Slk.	320	450	360	86.0	300%	175%	8.07	2.7	4.6	15,000	8,500
E	1	B. & W.	6,180	200	1927	4000	503	165	668	Dom. Slk.	?	?	?	83.0	300%	275%	6.4	2.15	2.4	18,500	17,000
F	2	Kidwell	6,200	250	1927	4400	970	344	1266	Sp'hill Slk.	Cold										
G	4	B. & W. Stirling	13,000	450	1929	7380	1508	336	1844	Dom. Slk.	?	?	?	82.6	275%	225%	5.65	2.05	2.5	19,500	16,000
H	2	B. & W. Stirling	9,219	450	1929	5800	1250	360	1610	Splint Coal	310	590	450	83.5	300%	275%	6.3	2.1	2.3	20,000	18,000
I	2	Kidwell	6,029	450	1930	4070	990	340	1230	Minto Coal	400	595	331	82.3	300%	275%	6.7	2.2	2.4	18,000	15,000
J	1	Kidwell	7,550	450	1931	7650	1285	—	1285	Duff 9600	?	?	?	Over 80%	350%	175%	10.0	2.5	5.0	17,000	8,500
K	1	C. E. Generator	15,671	785	1930	7917	yes	yes	2832	12,895 B.T.U.	510	682	385	85.8	350%	330%	5.0	1.4	1.5	27,250	25,550
L	1	C. E. Generator	12,280	445	1931	8000	yes	yes	2880	B.F. Gas	425	762	458	82.5	475%	440%	6.5	1.37	1.5	31,285	27,410

*Boiler only.

The Effect of the Development of the Electronic Valve Upon Electrical Engineering and Industry

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Abridged from an essay submitted for the Past-Presidents' Prize 1932 which received Honourable Mention.

The growth of modern electrical engineering is largely due to the development of two distinct types of apparatus, electro-magnetic machinery and electronic valves. Faraday's discovery, in 1831, of the fundamental law of electromagnetism paved the way for the development of the dynamo by such men as Gramme, Brush, Edison, and Hopkinson, while to Fleming, De Forest, Richardson and Langmuir we owe the tremendous advance that has resulted from the more sensitive and intimate control of electric currents made possible by the electronic tube.

I. The Electric Current

Atoms and Electrons

The popular conception of the structure of an atom is that of a solar system in miniature, in which minute particles called electrons move in definite orbits about a central nucleus consisting of electrons and protons. A neutral atom is one which has equal numbers of protons and electrons, and has no net electric charge, while an "ionized" atom, or simply an "ion," is one which has a greater or less number of electrons than of protons, and so has a negative or a positive charge. Such a picture of particles obeying the laws of classical dynamics is beautiful in its simplicity, but the new wave-mechanics which the physicists have developed to explain natural phenomena which were unexplainable before, has robbed the uninitiated of the solace of this picture. In the words of W. L. Bragg: "The former idea of a series of electron orbits has been replaced by a wave mechanical distribution which cannot be visualized." Einstein's space-time continuum has ousted the luminiferous ether of Maxwell and Faraday, and if there is an ether we are told by Jeans: "Each of us must carry his own ether about with him, extending through all space and all time, much as in a shower of rain each observer carries his own rainbow about with him." The electron, today, is no particle, but a kink or strain in space, and can be likened to nothing more concrete than the solution of a differential equation of wave motion.

It is this strange abstraction, then, that does us service in all the devices to be described in this essay; in the language of the engineer it has a negative charge of 1.6×10^{-19} coulomb and a mass of 9×10^{-28} gramme. The proton, equally mysterious, has a positive charge of like amount and a mass 1,846 times as great. In a neutral atom the nucleus consists of protons and a smaller number of electrons, intimately associated with one another, while the balance of the electrons move around it with high velocity.

Free electrons, having an enormous charge in comparison with their mass, acquire high velocities when free to move in an electric field, and we usually define the velocity of an electron by the potential (equivalent volts) required to produce this velocity when the electron is free to move.

When a free electron hits an atom one of several things may happen. If its velocity is below a certain value (the *resonance potential*) it will bounce off with a change of direction but no loss of energy or effect on the atom. If the speed is greater than this value, however, the impact will change the orbit of one of the atomic electrons. This necessitates an absorption of energy by the atom and a corresponding decrease in the energy of the rebounding electron. If the velocity is still higher, the impact will result in the removal of one or more electrons from the atom itself, which then becomes a positive ion. The potential necessary to give an electron, moving over its mean free path, sufficient velocity to remove one electron from an atom is termed the *ionization potential.*

A positive ion will attract any free electron in its vicinity and this attraction may result in the permanent adoption of the electron, which takes the place of the missing one and so balances the charge. When the visiting electron falls into place in its new orbit it radiates electro-magnetic waves, the wave-length of these radiations being smaller the greater the depth of penetration of the electron. For instance, if the electron enters the orbit closest to the nucleus extremely short X-rays will be produced, while an arrival in the outer orbits gives rise to ultra-violet or visible radiation.

Emission of Electrons from Solid Bodies

The free electrons near the surface of solid bodies will escape if their velocity is great enough. To wrest themselves free they must give up a certain amount of energy, and if they do not possess this energy they cannot escape. The amount varies with the atomic structure, i.e., with the material of the solid body. For example, a free electron cannot escape from a tungsten filament unless its velocity is greater than 1.28×10^8 cm. per second, corresponding to a potential difference of 4.52 volts (the latter figure is called the *electron affinity* of the material). The behaviour of the free electrons in the solid may be deduced from the kinetic theory of gases, and this tells us that among the multitude of electrons to be considered, almost any velocity is possible, though the probability of any given electron having one of the extreme speeds is very low. This means that, even at ordinary temperatures, a few electrons will have sufficient energy to escape from the filament, and are ready to be drawn off by any positively charged body in the neighbourhood.

Thermionic Emission

The number of free electrons near the surface of the filament having velocities above the critical value may be enormously increased by raising the temperature. The theory of this effect is largely due to O. W. Richardson, and the law now generally accepted is given by the formula $I = AT^2e^{-b/T}$, where I is the emission current per unit area of the filament, and T is the absolute temperature. A and b are constants, A being theoretically (but not actually) constant and equal to 60.2 for all materials, while it can be shown that b is equal to $\frac{\phi \times 10^5}{8.6}$ where ϕ is the electron affinity of the material in equivalent volts.

The above formula assumes that all the emitted electrons are immediately removed and are not allowed to be pulled back into the filament. The variation of the emission with temperature is illustrated in Fig. 1, which shows curves for tungsten, thorium, and a mixture of strontium and barium oxides.

It is clear from the form of Richardson's equation that for an efficient filament (i.e., one in which we obtain a high emission per watt expended in heating it) we must have a low value of ϕ. The exact value of this quantity is not easy to determine, and the limits of some representative measurements are as follows: (1)*

Tungsten	from 4.46 to 4.57
Thorium	from 2.94 to 3.27
Calcium Oxide	from 1.77 to 2.5
Strontium Oxide	from 1.27 to 2.15
Barium Oxide	from 0.99 to 1.85
Mixture of Barium and Strontium Oxides, 1.04	

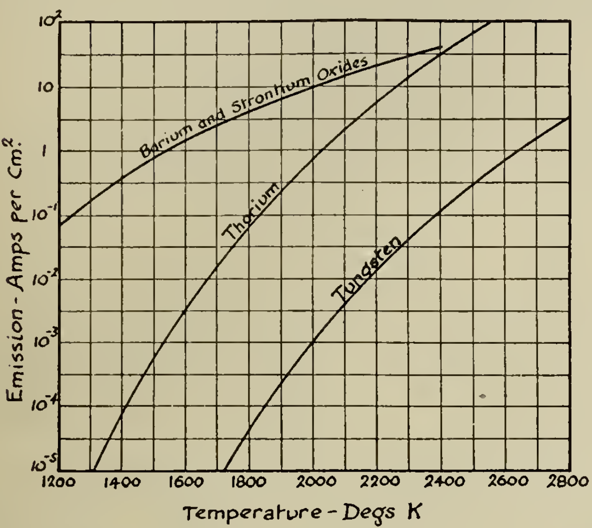

Fig. 1—Comparison of Thermionic Emission from Different Materials.

The emission of electrons from a hot filament forms the source of current in the majority of electronic tubes, and if the circuit is completed through a second electrode which is kept cool we have a thermionic valve in which the only possible direction of the current in the conventional sense (opposite to the actual electron flow) is from the cold electrode (anode) to the hot filament (cathode). As we shall see later, this simple valve was the forerunner of the multitudinous types of tube in use today.

Photo-Emission

The atomic structure of certain elements is distinguished by the presence of one or two outer electrons much more loosely attached to the atomic family than the remainder of the constituents, which form a symmetrical system tied together by considerable forces. The alkali group—lithium, sodium, potassium, rubidium, and caesium—have atoms which contain one such lone electron, and the atoms of the alkaline earths—beryllium, magnesium, calcium, strontium, and barium—have two. It requires but little energy to detach such electrons from their atoms, and under certain conditions this energy can be provided by electro-magnetic radiation.

The old classical mechanics failed to account for this release of electrons from solid substances by the action of light. Einstein, however, by adopting Planck's quantum theory (2) developed a fundamental equation for such action that has been experimentally verified by Millikan (3) and others. According to Planck's theory, an electro-magnetic radiation of frequency f contains energy which is made up of an integral number of energy quanta of value hf, where h is Planck's Universal Constant of Action and has the value 6.55×10^{-27} erg-second. If the charge of an electron is e, and the electron affinity is ϕ, then the energy necessary to free the electron from its parent atom is ϕe (the *work-function*), and if this is less than the value of the energy quantum of the radiation which is given up when the radiation impinges on the atom then the electron will be released and will leave the atom with kinetic energy equal to the difference between hf and ϕe, or, in the terms of Einstein's equation, $\frac{1}{2} mv^2 = hf - \phi e$, where m is the mass of the electron, and v its velocity of release.

It is seen from this equation that if the frequency f of the radiation be less than $\frac{\phi e}{h}$ the electron cannot be released, no matter how great the intensity of the radiation; a high intensity simply means a large number of energy quanta given up, but it is necessary for the release of electrons that the value of one energy quantum be greater than the work function ϕe. The minimum value of the frequency that will produce photo-emission is therefore equal to $\frac{\phi e}{h}$ and is called the *threshold frequency.*

If the frequency of the incident radiation is greater than the threshold value, then the number of electrons released per second will be proportional to the intensity of the radiation, and will also depend on the temperature. The velocity of emission is independent both of the intensity and the temperature.

Values of the Electron Affinity ϕ (in equivalent volts) for various Photo-emissive Substances (4)

Lithium	2.36	Caesium	1.36
Sodium	1.82	Calcium	2.4
Potassium	1.55	Strontium	2.0
Rubidium	1.45	Barium	1.7

The number of electrons emitted per second varies with the frequency of the radiation. The relative response of a photo-emissive substance for different frequencies of radiation gives a measure of its *colour-sensitivity,* which usually has a maximum value at some particular frequency, although if the latter is very much increased the response is again found to grow. In Fig. 2 are shown relative colour-sensitivity curves for the alkali metals, in which the wave-lengths are given in Ångstrom units (10^{-8} cm.); the visible spectrum lies between about 3,900 Å. and 7,600 Å.

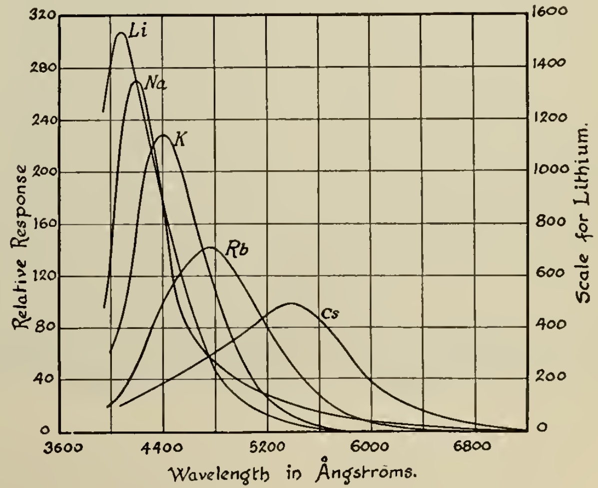

Fig. 2—Colour-Sensitivity Curves for Alkali Metals.

Caesium is seen to have its maximum sensitivity nearer the red end of the spectrum than the other metals, and due to this property it is extensively used in photo-cells whose function it is to respond to natural and artificial light.

A two-electrode tube with a photo-emissive cathode, whether evacuated or gas-filled, constitutes a true electronic valve and is of ever-increasing importance in its practical applications.

*Figures in brackets refer to the Bibliography at the end of the essay.

The Electric Current in Gas-Filled Tubes

Let us consider a tube with two cold electrodes, containing an inert gas such as mercury vapour at a low pressure of, let us say, about 1 mm. of mercury. Some of the atoms of the vapour will be ionized by the action of cosmic rays (electro-magnetic radiations of extremely short wave-length, from about 8×10^{-5} to 5.25×10^{-4} Ångstrom units) and the application of a small potential difference between the electrodes will cause a very small current due

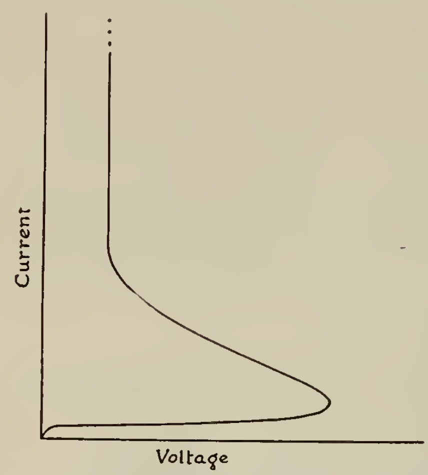

Fig. 3—Voltage-Current Characteristic of a Gas-Filled Tube with Cold Electrodes.

to the movement of the free electrons to the anode and of the positive ions to the cathode. If the potential is increased there will be no appreciable increase of current until the potential drop along the mean free path of the molecules approaches the ionization potential of the gas, at which point atoms will be ionized by collision, the resulting free electrons and positive ions joining the initial wanderers to augment the current.

When no potential is applied to the tube, and consequently no current is flowing, the free electrons and ions due to cosmic radiation are distributed uniformly throughout the tube, and if we consider any small volume of this space there will be no resultant charge therein, since the charges of the free electrons will be exactly counterbalanced by those of the positive ions. Now when the current begins to flow due to the applied potential, the electrons, being much lighter than the ions, will move away toward the anode more quickly than the ions will move toward the cathode. There will thus be a dearth of electrons near the cathode, and consequently any small volume of the space in this region will have a positive charge, called the *space charge.* This has the effect of increasing the potential gradient near the cathode, and it follows that so long as this is greater than the ionization potential of the gas the augmented current flow will continue, although the total potential difference between the electrodes may be less than before.

This condition is known as the *glow discharge,* since the ionization and collisions of the atoms set up radiations of visible frequency. If, after ionization has commenced, the current is allowed to increase it will be found that the potential across the electrodes will at first decrease and will then attain a constant value, so that the voltage-current characteristic of the tube appears as in Fig. 3.

If the current is not limited by external resistances in the circuit it may grow excessively. A point will be reached when the cathode begins to emit electrons, due to its heating by bombardment of positive ions and consequent thermionic emission, and also possibly due to the intense potential gradient in the vicinity. The discharge then takes the form of an arc and a still larger current will tend to flow.

The potential necessary to start the glow discharge in a given gas depends on the pressure of the latter, the form and constitution of the electrodes, and their distance apart. Such a tube, unless the electrodes have different surface areas, has no valve action, the direction of current-flow depending solely on the polarity of the applied potential.

Gas-Filled Tube with Electron-Emitting Cathode

If now one of the electrodes is one whose normal function it is to emit electrons (such as a hot filament or plate of a photo-emissive substance), the tube will function as a valve. The main current stream, or arc, will consist of free electrons and ions produced by collision of the atoms and the emitted electrons, and so long as the anode is kept cool and the voltage is not excessive this current can only flow in one direction, so that valve action takes place and the tube may be used as a rectifier of alternating current.

II. The Two-Electrode Thermionic Vacuum Tube

The fact that an exhausted bulb with a hot filament and another cold electrode will only pass current in one direction was first noticed by Edison while working on his incandescent lamp. This effect was thought for a time to be due to the emission of negatively charged carbon atoms from the hot filament, but in 1899 J. J. Thomson showed that the particles were unit negative charges, or electrons.

The actual development of the valve is due to J. A. Fleming, who constructed a number of experimental diodes in order to examine the various aspects of the phenomena. Fleming used his valve for the audible detection of high-frequency radiations in wireless telegraphy, and the circuit used for this purpose is shown in Fig. 4. High-frequency radiations induce a small alternating e.m.f. of like frequency in the aerial, and if this is allowed to produce currents in a circuit containing a telephone receiver no audible response is obtained, since the frequency of the currents is too high. If now a diode is included in the receiver circuit, the current will consist of

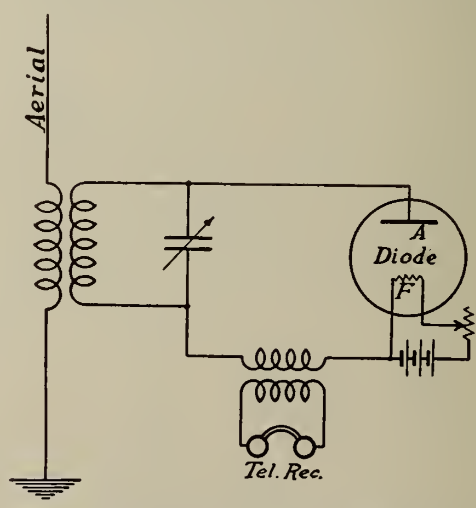

Fig. 4—Elementary Circuit Showing Original Use of Fleming Valve for Detection of Wireless Signals.

unidirectional pulses of the same frequency as the audio-frequency variations of the amplitude of the radiations which are produced by the transmitting apparatus. In Fig. 4 the receiver is shown coupled to the valve circuit by means of a transformer, so that the telephone current will be alternating at audio-frequency, and the signal will be heard.

The addition of the third electrode, or grid, by De Forest in 1907 made available a much more powerful method for the rectification of radio-frequency currents, and the present sphere of the two-electrode tube, or simple valve, lies chiefly in its use in converting alternating current to continuous current.

Use of Diode as Rectifier

There are two chief spheres of use for two-electrode vacuum tubes, or diodes, at the present day. Firstly, for the supply of low-power direct current at moderate voltages where a commercial a.c. supply is available, and secondly for the supply of high-potential direct current.

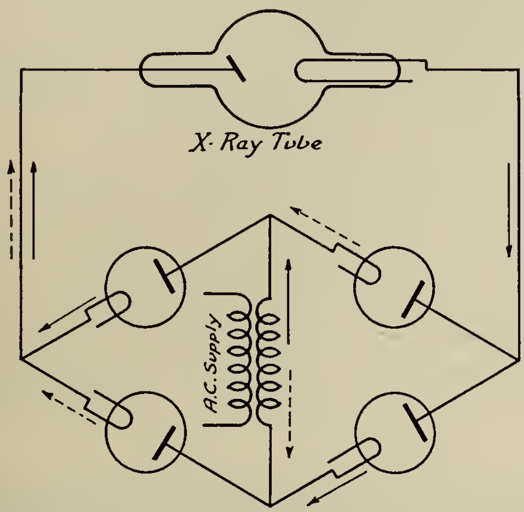

Fig. 5—Full-Wave Rectification with Bridge, or Graetz, Connection of Four Diodes, or Kenotrons.

An important example of the first case is in the supply of direct current for the tubes of radio receiving sets. The clumsy and heavy "B" batteries, with their charging problems, have now been relegated to the shades of history.

The use of diodes for the provision of high-tension direct current has by no means reached the limit of its development, and interesting advances for some time to come may be expected. Important examples of their use at the present time are to be seen in the supply of high-tension d.c. to radio power valves, X-ray apparatus, and high-potential cable testing equipment. (5 and 6.)

Four tubes can be arranged to give full-wave rectification and double the voltage of one tube by means of the bridge, or Graetz, connection shown in Fig. 5 which has the advantage of using the transformer in such a way as to give its full current at its full voltage. Such an equipment to give 200,000 volts and 0.5 ampere is illustrated in Fig. 6.

In the tubes shown the heat generated in the anode by the bombardment of the electrons is dissipated by radiation, and this naturally limits the current-carrying capacity. To obtain larger currents tubes are constructed with tubular copper anodes which are water-cooled. (7.)

III. The Two-Electrode Thermionic Gas-Filled Tube

In a gas-filled tube the gas molecules are ionized by collision with the electrons emitted from the cathode, and these positive ions, continually travelling to the cathode, produce two important effects. Firstly, they reduce the negative space-charge due to the travelling electrons and hence reduce the potential drop in the tube for a given current; and secondly, they may strike the filament with such energy that the temperature is considerably increased, with increased electronic emission and possible disintegration of its material. Gas-filled tubes have been successfully developed which pass large currents, while deleterious effects on the cathode are prevented by proper adjustment of the gas pressure and voltage.

The Tungar Rectifier

This hot-filament two-electrode tube was developed, after many years of experiment, by the General Electric Company, for the purpose of supplying rectified current at low voltages, for such duties as battery charging. It contains the inert gas argon at a comparatively high pressure of from 3 to 8 mm. of mercury; at such pressures the molecules of gas are close enough together to prevent the positive ions from attaining velocities high enough to harm the cathode, which nevertheless is heated sufficiently by this bombardment to maintain the operation of the tube when the filament current is cut off. To enable the device to be self-starting, however, the filament current is usually maintained.

Hot-Cathode Mercury-Vapour Rectifier

Rectifiers in which the cathode takes the form of a pool of mercury from which electrons are emitted due to the maintenance of a "hot-spot," or area of very high temperature, by positive ion bombardment have been used for many years. Mercury-arc rectifiers, to use their common name, are true electronic valves and have now attained to such a position of importance in the supply of d.c. power that it is thought best to reserve an account of their uses for a separate section of this essay. It suffices to say, for the present, that the establishment of the arc necessitates auxiliary arc-striking anodes and that it is

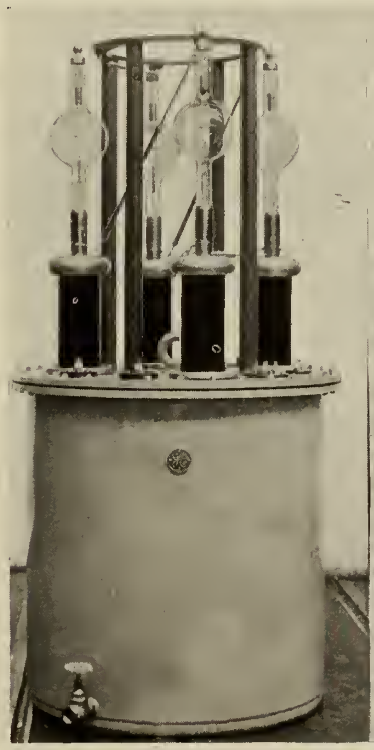

Fig. 6—100,000-Volt Bridge-Connected Rectifier, with Four Kenotrons.

Fig. 7—Rectifier Unit (Transformer and Eight Tubes) using Mercury-Vapour Diodes (Phanotrons).*

necessary to arrange for full-wave rectification since once the arc goes out the cathode loses its emitting temperature. The substitution of an electrically heated metal filament

**Tube Data:*

Maximum anode current: instantaneous	40 amps.
average	10 amps.
Maximum peak inverse voltage	20,000 volts.
Maximum tube voltage drop	24 volts.
Filament current	25 amps.
Filament volts	5.0
Type of filament	Indirectly heated.
Height of tube, inches	19.5

for the mercury cathode removes both these disabilities and makes possible a simple rectifier that can be used for either half- or full-wave rectification of moderate currents with a wide range of anode voltages.

The mercury-vapour diode as developed by the General Electric Company is commonly known as a "Phanotron." The cathode is usually oxide or thorium coated and in some types is indirectly heated, which method allows a large emitting surface, shaped in such a way that heat radiation is a minimum, to be kept at a uniform potential. It is to be noted that in vacuum tubes an electron must be provided with a straight path to the anode, while in a gas-filled tube the molecules deflect the electrons in all directions so that the emitting surface can be shaped with a view to minimum heat radiation, and hence higher efficiency. A small drop of liquid mercury is placed in the tube and provides the mercury vapour; the vapour pressure is hence directly proportional to the absolute temperature, which in most cases corresponds to from 20 to 50 degrees C.

Such tubes are applicable wherever rectification of a.c., within certain limits of current and voltage, is necessary. Tubes can be obtained to take a maximum instantaneous current of 600 amperes (100 amperes average), or to withstand a negative anode potential of 15,000 volts. These figures will no doubt be greatly extended in the future, and the great strides that are being made in rectifier development will probably lead to some very interesting changes in general electrical practice, a possible example being the adoption of high-tension d.c. power transmission. (See Fig. 7.)

IV. The Three-Electrode Thermionic Vacuum Tube

The introduction of the control electrode, or grid, into the Fleming diode by De Forest in 1907 resulted in the development of a device of extraordinary value. The successful growth of radio communication is due chiefly to the remarkable properties of this three-electrode vacuum tube, or triode. De Forest's valve, which he called the "audion," is shown at *A*, Fig. 8. The control electrode, consisting of a metal wire bent into the form of a grid, is visible between the two plates forming the anode and the small tungsten filament. About the same time, Lieben and Reisz, working in Vienna, developed a similar device for the amplification of audio-frequency currents, and their "relay" is shown in Fig. 8, *B*. The cathode consists of an oxide-coated, or Wehnelt, filament of platinum strip situated at the centre of the lower bulb; the grid is a circular plate perforated with holes, which can be seen at the junction of the upper and lower bulbs, while the anode is a short helix of aluminum wire at the top of the tube. The valve contained mercury-vapour at a low pressure, provided by a small piece of mercury amalgam which can be seen in the small tube at the side.

The presence of gas in these early tubes made their operation very uncertain, and it was not until 1915 that Langmuir succeeded in producing vacuum tubes with a gas pressure as low as 0.01 micron,* in which the action was independent of any ionization of gas molecules. Langmuir called his diode a "kenotron," which has already been described, while to the triode he gave the name "pliotron" and it is this tube that is seen in Fig. 8, *C*. The filament is of tungsten, the grid and anode of nickel wire, and the tube was intended for the amplification of radio signals.

Triode as Detector, or Rectifier, of Radio Signals

In the action of a vacuum tube the effect takes place, for all practical purposes, instantaneously with the cause; it is therefore particularly well suited for use in circuits of extremely high frequency, such as are involved in radio transmission and reception. In its application as a detector of the radio frequency e.m.f.'s which are induced in an aerial, a steady current is maintained from anode to cathode by means of a source of direct voltage, while the signal e.m.f., usually of extremely small magnitude, is impressed between the grid and the filament. The mean value of the grid potential must be kept at such a value that the operation of the tube is confined to the initial curved portion *AB* (Fig. 9) of the characteristic. If the signal e.m.f. has a steady amplitude, the grid potential will alternate in the same way, and due to the curvature of the characteristic the increase of anode current during that part of the cycle when the grid is made more positive will be greater than the decrease when the grid is made more negative. The result, therefore, of the steady signal e.m.f. will be an increase in the mean value of the anode current.

If now the amplitude of the radio-frequency signal e.m.f. is modulated in its transmission, i.e. if the amplitude varies with audio-frequency, the result will be that the anode current will vary with audio-frequency, so that the signal may be heard by putting a telephone in the anode circuit.

Triode as Amplifier of Small Alternating E.M.F.'s

If the tube is operated on the straight portion of the characteristic, a small alternating voltage applied to the grid will result in pulsations in the anode current of the same frequency. If a resistance is now put in the anode circuit the potential drop across it will be proportional to the anode current, and will contain an alternating component which is an amplification of the signal e.m.f. The "no-signal" current in the resistance may be balanced out to leave only the amplified alternating e.m.f.

If the tube operates on portions of the characteristic which are not straight, the amplification will be "distorted"; that is, the wave-form of the amplified e.m.f. will not be exactly similar to that of the signal.

A B C

Fig. 8—Three Historic Triodes.
A—De Forest's Audion.
B—The Lieben-Reisz "Relay."
C—Langmuir's Pliotron.

*One micron = one thousandth of a millimetre.

Triode as Generator of Alternating Currents

If an inductance of L henries is connected in parallel with a condenser of capacity C farads, an electrical disturbance in the circuit will result in an oscillatory current of frequency $n = \frac{1}{2\pi\sqrt{LC}}$ cycles per second. Due to the inevitable presence of some resistance in the circuit this alternating current dies away, in just the same way as the oscillation of a pendulum dies away if it is not maintained by suitable forces applied at the right moment. The function of a triode in a valve generator is simply to apply forces (electro-motive) at the right moments to maintain the oscillatory current in a circuit containing inductance and capacity.

The wave-form of the current flowing in the inductance branch is relatively free from harmonics, and valve generators are extensively used to produce currents of good wave-form over a great range of frequency, which is practically determined by the constants L and C of the oscillatory circuit.

Extremely high frequency currents can be generated by giving the grid a high positive potential, while the anode is made slightly negative, with respect to the filament (8). The frequencies obtained by such an arrangement are comparable with the time taken for the electrons to travel between the two electrodes.

V. Practical Applications of the Three-Electrode Thermionic Vacuum Tube

Radio

The phenomenal progress and perfection of radio communication are due almost entirely to the triode. Radio signals consist of electro-magnetic waves of high frequency (from about 2×10^4 to about 2×10^8 cycles per second), and their amplitude is made to follow the oscillations of the sound waves that are to be transmitted. The small currents controlled by the voice, or other sounds, in the microphone are amplified by means of triode amplifiers before they are used to modulate radio-frequency currents generated by a triode oscillator. The modulated currents are then passed through further amplifiers and are finally passed into the transmitting aerial with a power of perhaps several kilowatts. The tubes used in these last stages of amplification are capable of handling large currents. The "Cooled Anode Triode 10" (C.A.T. 10) of Marconi's Wireless Telegraph Company has a total filament emission of 40 amperes, the filament being heated by 225 amperes at 30 volts, while the anode can dissipate 50 kw. continuously at a potential of 12,000 volts. A demountable continuously evacuated valve rated at 500 kw. is also in operation.

At the receiving end, if telegraphic signals are involved, the dots and dashes are made audible by superposing a locally produced oscillation, differing in frequency by an amount which will produce an audible beat note, onto the incoming signal. This is known as heterodyne reception. In radio telephony, the incoming signal is passed through several stages of radio-frequency amplifiers, which are so arranged by tuned circuits to pass only that particular frequency-band which is to be received, the amplified signal then being rectified to reproduce the transmitted sounds in telephone or loud speaker. In super-heterodyne reception, the frequency of the incoming signal is reduced by producing a "beat" by means of a local valve oscillator, the resultant current, which is still of super-audio frequency, then being amplified and rectified by the use of other tubes.

The present trend of radio communication is in the development of short and ultra-short waves. Wavelengths of the order of 15 to 50 meters are found to be particularly suitable for long-distance communication, and a broadcasting station has been built at Daventry, in England, for the short-wave transmission of programmes to all parts of the empire. Ultra-short waves, of a meter or less, are being developed for short-distance directional communication.

Measurements

The applications of the triode in the measurement field make use of its properties as rectifier, as high-frequency generator, and as an amplifier to extend the sensitivity of instruments. Even as the triode has been the chief factor in the development of radio communication, so has it proved to be indispensable in the difficult field of radio measurements.

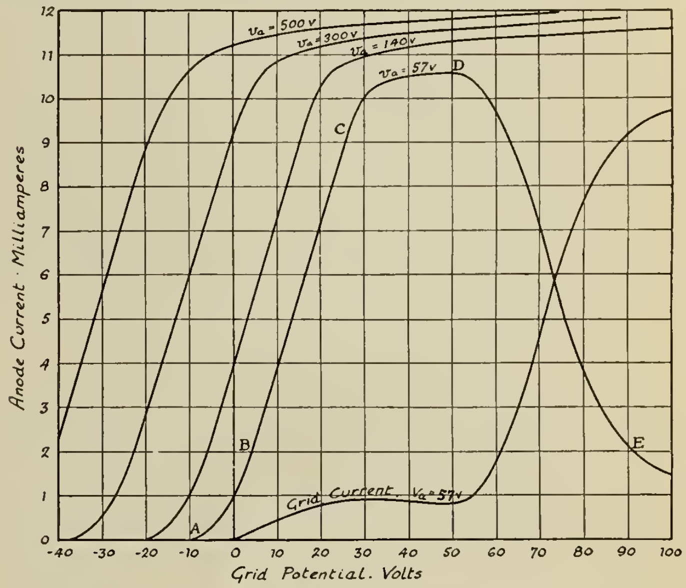

Fig. 9—Characteristic Curves of Typical High-Vacuum Triode.

Use of Triode in Control of Electrical Apparatus

The possibilities of using triodes in the control of electrical machinery and industrial apparatus are now being realized. Although vacuum tubes do not appear to be of such universal value in this respect as gas-filled tubes, they have nevertheless been successfully adopted in a variety of applications, of which it is proposed to mention two.

Vacuum tube amplifiers have been used to supply driving power of proper phase to rotating synchroscopes. This method obviates the use of expensive high-voltage transformers, the alternating voltage of the line to be synchronized being applied to the grid of a triode by means of a cheap capacitance transformer (9).

The vacuum tube oscillator has been adapted to give automatic levelling of elevators. An oscillator on the car has inductive coupling between the grid and anode circuits, and is so arranged that when the car is at the proper floor-level a metal plate comes between the coupled coils and stops the oscillation, this resulting in the operation of a relay which stops the car within one eighth of an inch of the proper position (10).

VI. The Three-Electrode Thermionic Gas-Filled Tube

Triodes filled with mercury vapour at pressures of from one to fifty microns have been successfully developed by the General Electric Company who use the name "thyratron" for the device (11). The function of the grid, which intercepts every possible path from filament to plate, differs from that in the vacuum tube in that its potential governs the starting of the arc only: it has practically no effect on the anode current once this is established, and the arc can only be stopped by removing the positive potential of the anode.

The thyratron is therefore a valve which is either fully closed or fully open: if the grid potential is below a certain critical value (depending somewhat on the anode voltage) the potential gradient in the tube is insufficient to cause ionization and the emitted electrons are drawn back into the filament. An increase in grid potential above this value will increase the potential gradient near the cathode sufficiently to start the arc, but if the grid potential is now lowered a sheath of positive mercury ions will collect around it and so shield the rest of the tube from the effects of its potential.

If a direct voltage is applied to the anode such a tube can be used as a simple switch which can be closed by a slight increase in grid potential. In this respect it has great value as a quiet, reliable "contactor" without moving parts which can be very simply operated. When used with alternating voltages, however, its potentialities are much greater, due to the fact that the grid re-establishes its control every time the anode potential becomes negative.

VII. The Mercury Cathode Mercury-Vapour Rectifier

The mercury-arc rectifier which has, as its electron-emitting cathode, a pool of mercury a spot of which is kept at an emissive temperature by ionic bombardment is, for high power purposes, the most important of all electronic valves. It is usually provided with a large number of anodes (six, twelve, or more), enclosed in a steel tank which is continuously evacuated by high-vacuum pumps, and hence gives a d.c. voltage wave comparatively free from ripples. The anodes, of graphite or steel, are situated in a ring at the top of the tank and sealed into it by means of mycalex or mercury seals. Careful research during the last few years has resulted in much higher current capacities and the proper use of anode screens has diminished the danger of arc-backs. (An arc-back is the establishment of an arc between two or more anodes.) (12, 13.)

The mercury-arc rectifier has practically superseded the rotary converter for the power supply of d.c. traction systems. At voltages higher than about 600 its superior efficiency is recognized, while for high-voltage d.c. supply it has marked advantages over rotating machinery whose voltage is limited by commutation difficulties. Overload currents of several hundred percent can be carried for short periods, operation is noiseless, economic considerations are favourable, and automatic control is more readily accomplished. (14, 15.)

VIII. The Photo-Electric Cell

If we replace the hot filament of a diode by a cathode whose surface is covered with some photo-emissive material, and arrange this surface so that it may be illuminated by light passing through the glass wall of the tube, we have an electronic valve whose action is controlled by light intensity.

One of the earliest photocells, due to Hallwachs, had as cathode a plate covered with copper oxide which responded chiefly to ultra-violet radiations, but the introduction of the alkali metals was due to Elster and Geitel and as early as 1906 cells sensitive to visible light were in use. A potassium cathode, "sensitized" by passing a glow-discharge through hydrogen, was common in these early cells, but at the present day caesium, due to its higher sensitivity at the red end of the spectrum (see Fig. 2), is widely, though not universally, used.

The High-Vacuum Photocell

If the tube is highly evacuated the current is due entirely to the passage of the photo-electrons from cathode to anode under the action of the applied potential, which should be high enough to ensure the passage of all the emitted electrons. The current will then be independent of moderate voltage changes, and will vary linearly with the intensity of the incident light.

The currents produced in vacuum cells are very small; as an example, the SR-50 cell of the Westinghouse Company gives only 6 microamperes per lumen of light flux.

The Gas-Filled Photocell

The presence of an inert gas at low pressure has the usual effect of augmenting the current flow due to ionization and consequent increased cathode emission caused by positive ion bombardment. Gas-filled tubes are made to give up to 100 microamperes per lumen, but the current is no longer exactly proportional to the intensity of radiation. Argon is the gas most used for this purpose.

IX. Applications of the Photo-Electric Cell (16, 17)

The photocell is proving an extremely useful tool of unlimited possibilities. Its present uses may be roughly divided into three main groups.

(a) Electrical Reproduction of Variations in Light Intensity

The synchronized sound accompaniment of cinematograph films ("talkies") is effected by first producing a photographic record of the sound vibrations at the side of the picture film. This is done by the microphonic control of electric currents which produce light variations by means of a glow-discharge tube, Kerr cell, or vibrating mirror or shutter. The photographic record is then reproduced as sound by means of a photocell and amplifier unit, which must be carefully designed to give linear amplification and necessitates the use of high-vacuum cells.

The telegraphic reproduction of pictures is now a standard aid to journalism. The picture is "scanned" by a spot of light the scattered reflections of which are caught and focussed on a photocell which reproduces the variations electrically. These are then transmitted by the usual methods of telegraphy and photographically reproduced at the receiver by means of light modulated by the incoming signals.

"Television," or the instantaneous transmission of animated scenes, is a problem of great complexity, but with the help of the photocell has already been developed to a fair degree of success (18). For instance, the Derby, run on Epsom Downs on June 1st, 1932, was seen by television in London on a screen nine feet by seven.

In order to produce the effect of continuous vision the whole scene must be transmitted not less than about twelve times per second, and since the definition of the picture depends on having as large a number as possible of constituent "points," it is evident that the range of frequency of the modulations of the carrier wave will be very high. With a 15,000-point picture, to be reproduced 12.5 times per second, this frequency-band is 93,750 cycles per second. Without the instantaneous response of the photocell, television would be quite impossible.

(b) Light Measurement and Analysis

The photocell is eminently suitable for photometric purposes, the intensity of illumination being directly measured, or recorded (19), by the photo-current, either with a micro-ammeter or after amplification (16, 17, 20), and portable light-intensity meters are now available. Ultra-violet photometry can be performed with cells having cathodes sensitive to these high frequencies, such as cadmium and uranium (21), while sensitivity to the infra-red is obtained with a selenium-tellurium alloy or with thallium sulphide.

Combined with a spectroscope, the photocell provides simple and accurate methods of spectrophotometry, or the quantitative analysis of light into its component wavelengths. The accurate matching of colours can also be readily performed, and these photo-electric methods will undoubtedly supersede, for these purposes, the use of the unreliable human eye.

(c) Control of Apparatus by Light

Under this heading come an enormous number of ingenious applications. In the majority of cases a change of the intensity of the light incident on the cell is made to operate a relay which actuates the controlled mechanism. Commercial units, containing photocell and relay, are now obtainable in several forms. The only apparent limit to the uses of such a piece of equipment is that of man's ingenuity and imagination. It is only possible to mention a few of the applications already in use, such as automatic switching of office and factory lighting when daylight fails, rapid and accurate counting of people and articles, control of street crossing signals by demand, automatic switching of conveyor trucks, opening of doors for heavily loaded waiters, control of chemical processes by the light transmitted through solutions, smoke-density recording, etc. It would be impossible to enumerate all the useful acts that are accomplished with the aid of the human eye: it is equally impossible to give a full account of the uses, actual and possible, of the eye that is electrical.

Conclusion

It is not pretended that this account of electronic valve action is in any way complete, either in the number of devices discussed or in the uses to which they may be put. Limitations of space prevent discussion of many rectifiers which may properly be included in the term "electronic valve."

The development of vacuum and gas-filled tubes has been extremely rapid since the days of Fleming's early diodes, and the tendency of the present day is for higher and higher capacities, with the replacement of the fragile glass envelopes by demountable steel containers, efficient pumps maintaining the necessary vacuum. Thus we see that the device whose use was confined so long to radio and comparatively low-power applications is undoubtedly becoming of primary importance in power engineering.

In the electric current man has at his disposal one of the most amenable of natural phenomena. With it he can produce heat, light, sound, and mechanical power. He can send it with little loss to do his bidding at great distances, and by its aid he can transmit his thoughts and wishes to the ends of the earth. The electronic valve is essentially a device which gives great and sensitive control over this current, such control as one would have if Niagara could be stopped by putting a finger in the stream; this control has been obtained by freeing the current of material obstacles and using it under circumstances where it is free to obey those forces which are its true masters.

Acknowledgment for the use of figures accompanying this paper is made as follows: L. B. Turner's "Wireless" by courtesy of the Cambridge University Press for Fig. 1; Miss Seiler, by courtesy of the Astrophysical Journal for Fig. 2; the General Electric Company for Figs. 6 and 7; and the director of the Science Museum, London, Marconi's Wireless Telegraph Co. Ltd., and the Rt. Hon. Sir Henry Norman, Bart., for Fig. 8.

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The Rapide Blanc Development

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Paper presented before the Junior Section of the Montreal Branch of The Engineering Institute of Canada, November 16th, 1932.

SUMMARY.—After mentioning the preliminary studies made on the Upper St. Maurice, the author discusses conditions affecting the design of the Rapide Blanc development on that river, particularly with reference to the sluiceways and gates, the efforts made to reduce construction costs, the difficulties as to transportation, and the arrangements made for concrete mixing and placing and for cement storage and weighing. The design of the intake sections of the development is followed up in more detail as regards the preliminary layout, conditions for stability and the precautions required during construction.

The Rapide Blanc development is the first step of a series of hydro-electric developments contemplated by the Shawinigan Water and Power Company on the upper stretch of the St. Maurice river, from a point six miles above the town of La Tuque and extending a distance of 78 miles upstream. Between these points the river is a succession of rapids with a total drop of 630 feet.

Much time has been spent in studying this part of the river and the various sites and schemes made possible by the many rapids. Excellent control of the river is obtained by means of the immense storage reservoir created by the Gouin dam, one of the largest in the world. It has a drainage area of 3,650 square miles and a capacity of over 160 billion cubic feet. In addition, three dams on the Manouan river, known as A, B, and C dams, store 21 billion cubic feet.

The geological, engineering and economical features of each proposed site were considered and compared. The effect of one development upon another, construction facilities, transportation of materials and the delivery of electrical energy were taken into account for the purpose of developing the river by stages and finally forming a harmonious group.

When solid rock was not found near the surface, an electrical survey was made and revealed the existence of a pre-glacial river bed. It soon became apparent that the present river does not always follow its primitive course. When it does, as in the case of Rapide Sans Nom, the level of solid rock is found to be 110 feet below the actual bed, which fact eliminates the possibility of building a gravity-type structure economically.

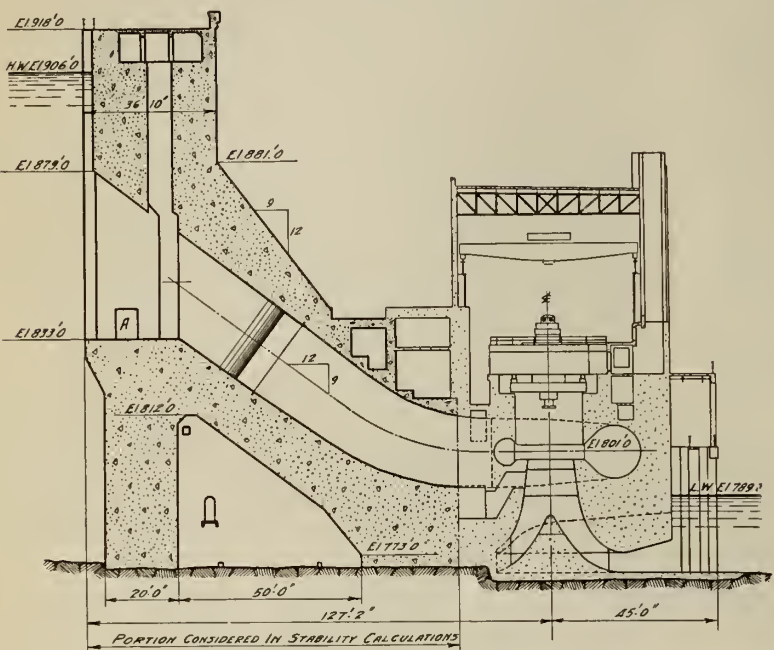

Fig. 1—Section through Intake and Power House.

Finally, after many careful investigations, six sites were chosen as giving the most economical arrangement and best harmonizing the development of the Upper St. Maurice river. The studies leading to this result have been fully described by C. R. Lindsey, A.M.E.I.C., in a paper published in The Engineering Journal for July 1933.

Choice of Site and Layout

It was decided to develop Rapide Blanc first. This location offered the exceptional advantage of providing the largest pond of all proposed sites and insured the maximum regulation of the river in this region. The area of the pond created is over 30 square miles. One foot draw-down will supply 10,000 cubic feet per second continuously for twenty-four hours. This is four times as great as the pond at the Grand'Mere development. Also, the geological survey showed that, at this point, the present river had departed from its original course, and solid rock appeared almost at ground level.

It is to be noted that the rapids known as "Rapide Blanc," having a total drop of about 275 feet, will be developed in two stages. At their foot, where the Trenche river flows into the St. Maurice, a development known as "Trenche river development" is to be created with a head of 160 feet. Rapide Blanc development is situated above the middle of the rapids, 100 miles below Gouin dam, with a head of approximately 113 feet.

With solid rock out-cropping and river banks suitably close and steep, the most economical design for the dam was a gravity-type structure in a straight line. The history of the river shows that the maximum flood recorded at this point has never been over 65,000 cubic feet per second, but it was decided to provide for a possible flood of 150,000 cubic feet per second. Accordingly, the following structures were built:

1. Three sluice-ways 50 feet wide, with sills 36 feet below head race level, giving a capacity of approximately 43,000 cubic feet per second each.

2. One sluice-way 50 feet wide, with sill 16 feet below head race level, giving a capacity of approximately 12,000 cubic feet per second.

3. Two regulating gates, for winter operation, with a capacity of about 6,000 cubic feet per second. They are of the pressure-gate type, with hoisting machinery totally enclosed and intake below the lowest head race, and therefore below the ice cap. The outlet is also kept constantly below water level by means of a weir built downstream.

Four passages, 21 feet wide by 28 feet high, were built through Nos. 1 and 2 sluices to provide for by-passing the river during construction. Such large openings were necessary to take care of spring and fall floods and to avoid flooding out the coffer-dams, and they were equipped with gates that could be shut when the river level had to be raised. Provision was made for filling the by-passes with concrete when no longer required.

The mean flow of the river at Rapide Blanc being 14,400 cubic feet per second, it was decided to install at present four units, each of 3,600 cubic feet per second capacity, and provide for an additional two units of the same size to be put in later to take care of peak loads, when excess water can be used or the pondage drawn from.

An elaborate log chute is to be built. A tapered steel floating flume collects the logs that are delivered by means of a hinged flume, rising and falling with the water level, to the main chute.

There is to be no high tension switching at Rapide Blanc; high voltage power is to be delivered at 200,000 volts direct to the La Tuque sub-station. The transformers of 36,000 kv.-a. capacity (one for each unit) are placed out of doors. The low-voltage switching is done by metal-clad oil circuit breakers in the powerhouse.

Great care was taken in studying the architectural aspects of the powerhouse and it will compare favourably with existing structures of a similar nature.

Features of Interest in Construction

The unit costs at Rapide Blanc were very low due principally to the following reasons:

1. There was sufficient time for a thorough office study of the development as a whole, thus permitting co-ordination of the designs on permanent structures and construction plant layout.

2. The purchase, installation and co-ordination of the various units of construction plant were based on an economic study of conditions at Rapide Blanc, and in addition with some thought for future construction work on the Upper St. Maurice river. For example—many temporary structures ordinarily built of wood were, in this case, built of steel in units that could be removed and re-used elsewhere.

3. Detailed plans were made covering all temporary construction plant, thus placing the method of doing this work in the field on the same basis as for the permanent structures.

4. The work at Rapide Blanc was done on an efficient basis, the output per man-shift having been fairly high.

The savings effected by a thorough office study of conditions in the field can be demonstrated by the following example:

The supply of sand was to be obtained from a nearby gravel pit, giving 35 per cent rejections. Men in the field later found a pit farther away giving only 20 per cent rejections. According to the old methods, the latter would probably have been used on the merits of lower rejection percentage. However, office study proved it to be less economical for the following reasons:

1. The road to the second pit would have been longer and more difficult to build.

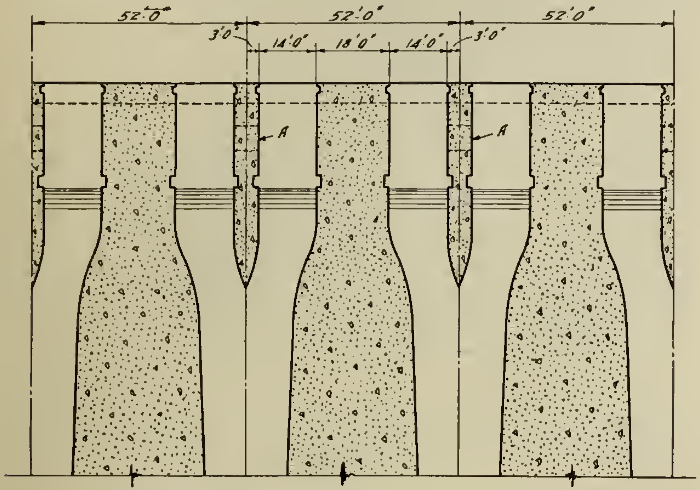

Fig. 2—Plan of Intake Passages.

2. A supplementary transmission line and transformers were necessary, while in the first instance the source of electric power was nearby.

3. Stripping proved to be more costly.

4. A more elaborate layout of conveyors would have been necessary, the second pit being shallower than the first.

Three different schemes were possible for transportation of materials and machinery from the main railway line to the job, a distance of ten miles.

1. A railroad branch line from the C.N.R. transcontinental line.

2. The water route from Flamand, a C.N.R. station on the St. Maurice river, about 18 miles above Rapide Blanc. Scows hauled by diesel tugs.

3. By road.

Each scheme was studied in the light of tonnage to be transported and also schedule to be maintained. The road gave the lowest unit cost, but important considerations in its choice were the facts that passenger transportation by automobile and trucking is becoming generalized, and that about seventy-five per cent of the road can be used for the future Trenche river development.

The largest single load to be carried was found to be approximately 100 tons. To convey this will require the construction of a trailer with a capacity far in excess of anything yet seen in this country. Its weight will be about 35 tons.

The roadway was built in two portions, concrete and gravel; the concrete strip, 10 feet wide, to be used by loaded vehicles and the gravel strip, 12 feet wide, to be used by returning unloaded traffic. There are 4-foot shoulders, giving a total width of 30 feet.

Naturally, for such heavy and expensive loads as transformers, the specifications for the road had to be very rigid. The maximum grades permissible were of the order of 5 per cent and the curves a minimum of 300-foot radius. An accident, while hauling important and expensive machinery, would not only mean damage to the apparatus itself but delay and consequent interruption of the construction schedule.

All crushed stone necessary for concrete production was obtained from useful excavation for the powerhouse and other permanent structures. By placing these structures suitably a balance between excavation and rock needed for construction was arrived at. The blasted rock loaded by derricks on to dump cars was hauled by rail to the crusher plant, a short distance off. From there on, not a single foot of track was used. Belt conveyors were employed throughout—to a storage pile and then to the mixing plant, as required.

Sand obtained at a nearby pit was trucked to a storage pile and then belt-conveyed to the mixers.

Bulk cement was unloaded at Rapide Blanc station into two bins, each containing thirteen carloads. Two semi-trailers with special tank bodies of 10-ton capacity hauled the cement to the special bins over the mixers. Each cement truck hauled an average of 200 tons per day, equalling about five carloads. It took from three to five minutes to load these trucks and about one minute to unload them.

The mixing was done by two 2-yard mixers, which arrangement was found more efficient than a battery of four one-yard mixers, resulting in less labour required and in a more simple layout. All the aggregates were fed by gravity into the mixers and were weighed. The water was also weighed, this method being more accurate than the capacity measurement, where a few extra gallons mean a considerable excess in weight.

It is also interesting to note the manner in which the cement was weighed. A weighing bin fed by a screw conveyor of special pitch was used. The screw was driven by an electric motor with characteristics of high starting torque but low kinetic energy (small rotor), meaning instant stoppage as soon as the current was cut off. An extension arm was attached to the weighing lever. When this arm passed the capacity point, a hole in a disc, it shut off a ray of light which in turn affected a photo-electric cell, which immediately interrupted the current. This method was very efficient in controlling the quantity of cement; the difficulty of doing so by hand being aggravated by the tendency of the cement to arch in the hopper and to collapse at the last moment, adding an excess amount into the batch.

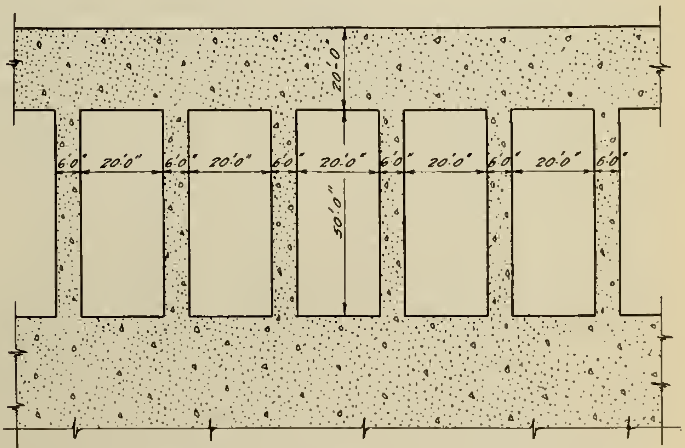

Fig. 3—Foundation Plan of Intake showing Voids.

The mixed concrete was delivered by belt conveyors to the pouring operations, thus obviating disintegration and permitting a dryer mix than with long chutes. It was then tripped into elephants' trunks or into hoppers, which fed 2-yard buckets lifted into place by stationary or travelling derricks with very high hoisting speeds but with ability to effect a slow pick-up.

A uniform 3,000-pound concrete was used throughout the job, although it had been attempted to use a leaner mix in the interior of the masses. This was found impracticable on account of extra formwork, labour required and time lost.

The water-cement ratio method of proportioning was used, the proportions of aggregates varying greatly with

Fig. 9—Rapide Blanc Development under Construction.

conditions of fineness and humidity. Tests were conducted continually throughout the pouring operations.

Design of Intake Section

An engineer learns in his first years of professional experience that the most difficult part of a problem is not always its mere mathematical solution, but rather, the proper choice of assumptions, the collection and checking of data, the intelligent co-ordination of practical facts and, generally speaking, the building of the body of the problem itself.

As an illustration of this it will be of interest to go briefly through the entire design of the intake section of the development and give an idea of the considerations that led to the final layout.

When the development of a waterfall is contemplated, as was the case at Shawinigan falls, La Gabelle and Paugan falls, a ledge is ordinarily available at the site of the intake. Rapide Blanc being in the centre of rapids, a dam must be built to give the hydrostatic head and then it can be modified to serve as intake to the powerhouse.

Conditions being suitable, a dam of simple gravity bulkhead section, resisting full hydrostatic pressure, ice pressure and uplift, was designed and placed upstream from the powerhouse substructure. Suppose that the design of the latter has been fixed after due consideration of the turbine sizes, spacing and elevation, tailrace excavation, river by-passing facilities during construction, etc. The proposed head being 113 feet, penstocks are necessary to convey the water to the turbines. Accordingly, they are brought up the downstream face of the bulkhead.

The next step is to determine the number, size and shape of openings to each penstock. The following limitations have to be taken into account:

1. The total width, including piers, is limited by the spacing of the penstocks which, for symmetry, are kept on the same centres as the turbines, i.e. 52 feet.

2. The tops of the intake openings have to be kept far enough below the lowest headrace level to avoid turbulence in the pond and suction of debris and frazil into the units. Five feet is considered the minimum permissible.

3. The sill of the gates must not be so low as to unduly increase the size of hoisting machinery and add to the difficulty of lowering them against a high head.

On a river like the St. Maurice, where logging operations are done on a large scale, trash racks are always used. The speed of the water passing through them has to be kept as low as possible, from 2 to 3 feet per second. Each turbine taking 3,600 cubic feet per second, the area of the racks is easily found.

There are three possible alternatives as to the number of openings to the penstocks:

1. A single opening.
2. Two openings.
3. Three openings.

It is obvious that if a single opening were used the width of racks, emergency gates and head gates would be prohibitive. When three openings were tried, it was found difficult to bring them into a single circular section to join up with the penstock without considerably increasing the breadth of the intake. It was also hard to balance the flows in each opening and avoid eddies. Two openings were therefore adopted.

The dimensions of each trash rack opening were finally fixed at 14 feet wide by 46 feet high, giving an area of 1,288 square feet and a speed of 2.8 feet per second for the water, before deducting the area of the racks themselves.

It may be stated that the latter are designed to withstand full hydrostatic pressure when totally clogged with debris, but the unit stress is taken at 25,000 pounds per square inch. Six-foot piers were provided between each two openings, leaving 18 feet between adjacent sets of intakes.

It was decided not to use a regular gatehouse. A gantry crane is used for manipulation of racks and gates, but the hoisting machinery for the operation of the headgates is enclosed in a low room provided in the concrete. This permits placing of the rack grooves at the extreme face of the intake. The emergency gates (stop logs) are to use the same grooves, not being necessary at the same time as the racks.

The headgate openings were determined by the same method as the trash racks. Their size was fixed at 14 feet by 30 feet, giving a speed of 4.3 feet per second. The transition from two rectangular passages to a single circular one was made by gradually rounding the corners of the extreme sides (as two letters "D" facing each other), and bringing the central pier to a point. This is done in such a manner as to give a uniform rate of increase of the velocity of the water.

Vent pipes are provided downstream from the headgates, in case of a quick shut-down of the turbine gates, thus preventing the creation of a vacuum in the penstocks and their tendency to collapse.

After the general shape of the intake was found, stability calculations by the ordinary method of moments were made at intervals of 10 feet downwards, considering the width of 52 feet between centres of penstocks as a unit. Naturally each portion surrounding the voids in the structure is properly reinforced to transfer pressures to the mass.

The following data were assumed:

Concrete: weighing 150 pounds per cubic foot (actually the mean weight was 156 pounds).

Ice Pressure: 10,000 pounds per linear foot of dam.

Uplift: Full head at heel, to zero at toe, except when the section considered is low enough to use full tailrace head at toe of powerhouse to zero at heel of intake.

In regard to this assumption for uplift, reference may be made to a study of hydrostatic pressures, both within and under the base of dams, which is being made by a committee of the American Society of Civil Engineers. A recent article also says: "Provisions for such observations were made in the Gibson dam on the Sun river, Colorado, which was completed in 1929, and two years of uplift pressure measurements show that appreciable water pressures from the reservoir do not penetrate into the interior of the concrete; that only nominal upward pressures occur at the contact surfaces between the masonry and the rock, and that the foundation grouting near the upstream edge of the base, together with installation of drains, is effective in preventing the transfer of dangerous water pressures from the reservoir to the rock foundations." Nevertheless at Rapide Blanc full uplift was considered at the construction joints. At the base special precautions against infiltration in the rock were taken. At least ten feet of decayed rock was removed and in spite of that, deep and wide seams (about one inch) filled with decayed rock appeared. Much drilling and grouting under pressure of 80 to 100 pounds per square inch were done, this being a greater pressure than the total hydrostatic. head.

All cases of stability were considered, the worst case governing:

1. Emergency gates closed.
2. Headgates closed with emergency gates opened.
3. Water in the penstock.

When necessary, bulk was added to the downstream side.

After the complete and stable design was arrived at, it became evident that economy could be effected by bringing the intake and powerhouse closer together, thus saving concrete and shortening the penstocks. The powerhouse substructure, although helping to a certain extent to the stability of the intake and acting against sliding, cannot be assumed as doing so in the calculations. The reason is that it might prove dangerous to add stresses to the already heavy loads the honeycomb draught-tube structures withstand (weight of turbines and generators).

Reduction of the uplift factor is the only means left for shortening the base of the intake. This was obtained by the introduction of a drain twenty feet from the upstream face, running the full length and discharging by gravity into a sump. Uplift was then considered as full head at heel to zero 20 feet downstream. A similar drain was placed near the toe to take care of the uplift due to the tailrace head.

It was later decided to make the upstream drain large enough to act as an inspection tunnel, but as the quantity of concrete per horse-power developed was still very high compared to the existing plants mentioned before, further saving was contemplated by creating a regular void in the lower portion of the intake. Six-foot piers were placed in the void at intervals of 26 feet on centres to tie in the heel and the toe.

About 10,000 cubic feet of concrete were saved in this manner. Of course the extra form work and reinforcing required reduced the actual savings in money.

All portions of the structure acting as beams and walls resisting water pressure were reinforced by the ordinary methods, to transmit their loads into the main masses and produce a homogeneous structure. For example, it was found that the small 6-foot pier in the intake proper was not stable by itself. Therefore, it had to be tied into the large piers. Also to avoid excessive reinforcement, an equalizing hole was provided in it to take care of the different heads if one emergency gate were shut and the other open. (See hole A.)

A large amount of reinforcing was used to counteract shear between the drain void piers and the mass. The calculations for the exact amount required were rather involved and subject to discussion, but French law covering such design was referred to and an excess of steel provided for safety sake.

Discussion on "Hydraulic Stability"

Paper by A. W. F. McQueen, A.M.E.I.C.[1]

A. Aeberli, M.E.I.C.[2]

In Mr. Aeberli's opinion the regulation problems dealt with in this paper involved the control apparatus of the hydraulic turbine, that is the automatic turbine governor. It seemed, therefore, advisable to give a few notes on his experience in the actual operation of power plants.

Surge problems, when viewed by the power plant designer offered more or less difficulty because the called-for assumptions were not always in accord with operating conditions. The governor designer however is in a position to obtain stabilization even under very difficult conditions, such as long pipe lines with high water velocities and absence of surge tanks, and this could be accomplished by means of adjustments and selection of proper mechanical details.

In pipe lines where the ratio $\frac{L}{H}$ has values from 10 to 15, and up to 20, it is quite possible to obtain hydraulic stability by suitable selection of flyball characteristics, flywheel effect, time movement of control apparatus, and correctly designed governor compensation.

Mr. Aeberli had observed in a number of power plants with long and short pipe lines, even when equipped with surge tanks, that gate swings or oscillations occurred on turbines for no apparent reason, the load being constant. Through careful and persistent investigations, it was possible to trace the oscillations down to faulty governor equipment.

In this respect it seemed that even the Heimbach plant, to which the author had referred, was no exception. It was designed at a time when very few governor manufacturers had solved the regulation problem correctly. This was by no means a reflection on the designer or manufacturer; it was simply a question of not having sufficient experience in the art.

In some power stations which Mr. Aeberli had occasion to supervise, instability was so severe that locking of units, either electrically or mechanically, was necessary to obtain stability. In these instances there was sufficient flywheel effect, comparatively slow governor time, and ideal hydraulic conditions (low water velocities, etc.), so that the source of the trouble had to be sought elsewhere. Governors were overhauled and readjusted, and finally, as a last resource, the compensation in the governors had to be reconstructed, and thus stability was obtained. This was true for any type and make of governor, and indicated that the manufacturers, in general, were not aware of the importance of delicate compensating devices. It seemed strange that even in technical literature very little information is obtainable on the subject. After all, generally speaking,

(1) This paper was presented at the General Professional Meeting of The Engineering Institute of Canada, Ottawa, Ont., February 7th and 8th, 1933, and published in the January, 1933, issue of The Journal.

(2) Mechanical engineer, Hydro-Electric Power Commission of Ontario, Toronto.

instability in an hydraulic system was caused by quick load changes, and such instability could be corrected, or dampened out, by proper timing of gate movement.

The question of permanent speed adjustment was one which caused considerable confusion in power plant operation. He noted that the author suggests that turbines with flat efficiency curves require a small inherent speed change in the governor, while turbines with peaked efficiency curves (such as propeller turbines) require a large inherent speed change. This statement was not quite clear to Mr. Aeberli. Generators, direct connected to water wheels, when delivering energy into a central system, must always run at the same synchronous speed to assure uniform frequency. The inherent speed change was therefore only of temporary duration, and came into action only after load change at any load. A large inherent speed variation (up to about 4 per cent) would assure quick adjustment with less oscillation, while a small inherent speed change, or an isochronous governor, could be very unstable.

In some recently built plants of low and medium head, equipped with propeller turbines and Francis turbines, instability had been experienced, which so far had been traced to turbulent flow in the draught tubes, caused by cavitation. Even in these cases it was possible to obtain good speed regulation with modern governors, but load swings were hard to eliminate even when injecting air into the draught tubes. These load swings, or surges, might be very violent, and did not seem to be in synchronism with draught tube action, or any other condition in the water passage.

These conditions were causing considerable controversy amongst the various interested parties, and required a great deal of study and investigation in the near future.

R. D. Johnson[(3)]

Mr. Johnson remarked that the author had evidently taken the time to study previous work on this interesting subject and thereby had been enabled to make a creditable presentation of general mathematical conclusions which as far as they go are well known to students of the subject. There was, however, one omission which should be mentioned.

The paper contained little to indicate that the arguments and conclusions are not applicable to finite initial load changes affecting a differential surge tank properly designed.

For example, the author made the statement that a harmonic wave has an increasing amplitude when $a < 0$ and a constant amplitude when $a = 0$. This is practically true with simple surge tanks for finite initial load changes, but is not true by any means in general for the differential surge tank, which is quite capable of maintaining a wave of constant amplitude when $a < 0$. As this fact is one of the distinguishing features of a differential surge tank, and as the simple tank has practically been discarded, it would have been more interesting to have brought the work up to date.

Mr. Johnson desired to point out that it may happen even with $a < 0$ that the constant wave developed in a differential surge tank is of such small dimensions as not to interfere in any practical way with plant operation, although with a simple tank of the same dimensions operation would be impossible.*

The history of the development of the subject might be simply stated.

Mr. Johnson was well versed in this matter some twenty-seven years ago and in 1908 had published a complete surge diagram illustrating an augmenting wave due to governor action.†

(3) Hydraulic engineer, 67 Wall Street, New York, N.Y.
*See Transactions A.S.C.E. 1915, Vol. 78, page 764.
†See Transactions A.S.M.E. 1908, Vol. 30, page 467.

The critical size of surge tank was there particularly described but at that time he had not yet developed what might be called a formula, and he was compelled to adopt the more tedious methods there indicated, which were, however, sufficiently accurate.

This work constituted the first information of this character to be presented to the public and it awakened such interest that, amongst others, Professor Deiter Thoma, in Germany, made a remarkable contribution to the subject and developed a large part of the mathematical information contained in the author's paper. This work was published in 1910 under the title of "Zur Theorie des Wasserschlosses bei selbsttätig geregelten Turbinenanlagen." Mr. Johnson had himself developed, quite independently of Professor Thoma, the fundamental formula for critical area at constant efficiency as well as the interesting multiplier $1 + \frac{3}{2} \cdot \frac{P}{E}\frac{dE}{dP}$ which indicates closely the increase in the critical area due to a drooping efficiency curve.

He did not publish this, because Professor Thoma's work came to his attention, but he did, nevertheless, present part of his own derivation in the Transactions A.S.C.E.,* with relation to air surge tanks. It may be noted that this derivation is fundamentally and radically different from that of Professor Thoma.

Long before this also, Mr. Johnson had discovered the beneficial damping effect on such surges of increasing the conduit velocity at the point where the surge tank is attached.

Many years later he was asked by the authors Calame and Gaden to comment upon their valuable book entitled "Théorie des Chambres d'Equilibre" and thus he discovered that they had entirely omitted the effect of a drooping efficiency curve upon the critical area and also that they had no knowledge of the damping effect due to increasing velocities passing the surge tank.

He had called the authors' attention to these vital omissions, referring them to Professor Thoma's work and also to his own work above cited, and urged them to write a supplement to their book setting forth this subject more fully, taking into account in particular the velocity effect passing the tank, known as "Venturi action."

The authors were very grateful for this suggestion and went seriously to work upon their paper "De la Stabilité des Installations Hydrauliques Munies de Chambres d'Equilibre," afterwards published in the "Schweizerische Bauzeitung" under dates of July 30th and August 6th, 1927, in which they were thoughtful enough to give him credit for his participation.

These authors not only re-derived the previous mathematical conclusions which served to confirm them but they also added the interesting study of generating stations operating in parallel as affecting the critical size of surge tank.

This constituted a brief history of the matter which had now culminated in the further transcription by the present author, taken, it would appear, entirely from the work of Calame and Gaden.

Mr. Johnson also wished to contribute the following note on the Surge Instability of the Differential Surge Tank as compared to that of the simple tank.

The author's paper presented this question very well as related to the Simple Surge Tank, leading up to the value of F according to his equation (7a) which here will be designated as F_o.

It was, however, very important to draw a sharp distinction with respect to the Differential Surge Tank.

When the area of a differential tank is less then F_o a wave of moderate magnitude does not necessarily augment

*See Transactions A.S.C.E. 1918, pp. 267-269.

upon successive subsequent swings as it does in a simple tank, but usually goes the other way until it reaches a constant amplitude, frequently of such small proportions as to have no practical harmful effect upon plant operation, and the writer is able to state a very simple equation determining the amplitude of this small perpetual oscillation of the water level in the tank. If its semi-amplitude plus or minus as measured from the steady or mean level is not greater than 1.5 or possibly 2 per cent of the total net head it will be impossible to detect its presence on a surge chart when compounded and confounded with the swings due to ordinary load changes, and some such tolerance is quite permissible if other considerations do not call for the design of a larger tank which would, incidentally, be almost sure to damp out entirely any perpetual vibration.

The simple formula referred to is as follows:

$$y_o \overline{<} \frac{8\phi cbV_o}{\pi\theta}$$

where

$\pm\ y_o$ = semi-amplitude of the perpetual wave
a = effective area of port
A = conduit area = penstock area
L = conduit length
F_o = critical area of surge tank
F = actual area ($<F_o$) of surge tank under consideration with inside riser area assumed = 0
$\phi = \frac{F_o}{F} - 1$
V_o = steady mean velocity corresponding to mean quiescent water level in tank
$b = \sqrt{\frac{AL}{Fg}}$
cV_o^2 = Difference in water level between forebay and surge tank (including velocity head in conduit as indicated at the tank connection.)
(δv) = difference between conduit and penstock velocities at any time t
(ΔV) = maximum value of (δv)
$\theta\,(\delta v)^2$ = head acting on the port at any time
$\theta = A^2 \div 2ga^2$

The unquestionable practical accuracy of this equation has been demonstrated by the tedious but accurate process of arithmetic integration and this fact must provide sufficient excuse for certain approximate assumptions which appear in the following demonstration.

Furthermore, by means of the same tedious processes, far too long and too complicated to be introduced into the subject matter of this discussion, it has been found where the surge tank contains an inside riser of area = A_1 the value of F may be safely assumed to be $\left(F - \frac{A_1}{2}\right)$ in computing the value of y_o.

The theory is based upon the fact that for small values of (ΔV) the negative impulse giving rise to the critical area F_o equals.

$$\int_o^T 2\,cV_o\,(\delta v)\,dt \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where T is the interval between values of (δv) equal to zero and V_o is the steady mean velocity corresponding to quiescent level. Now it is evident that a smaller tank than F_o would maintain a wave of constant amplitude if the negative impulse were to be increased in the ratio of F_o/F and this may be done merely by adding in the negative impulse due to the choking at the port which varies as $(\delta v)^2$.

The total impulse due to this cause is therefore

$$\theta\int_o^T (\delta v)^2\,dt \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Now if we assume (δv) to vary with t along a sine curve (sufficiently near) we may write the above two impulses as follows:

$$\text{Impulse due to friction} = 4\,cV_o\,(\Delta V)\left(\frac{T}{\pi}\right) \ldots\ldots\ldots (3)$$

Impulse due to the choking at the port

$$= \theta\,(\Delta V)^2\,\frac{\pi}{2}\left(\frac{T}{\pi}\right) \ldots\ldots\ldots\ldots (4)$$

We may now write the simple equation bringing out the proper value of (ΔV) which we are seeking, omitting the constant $\left(\frac{T}{\pi}\right)$ in all terms.

$$4\,cV_o\,(\Delta V) + \theta\,(\Delta V)^2\frac{\pi}{2} = \frac{F_o}{F}\,4\,cV_o\,(\Delta V) \ldots\ldots (5)$$

or

$$(\Delta V) = \frac{8\,\phi cV_o}{\pi\theta} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

Now the relation between (ΔV) and y_o is nearly as follows as derived from fundamental considerations.

$$y_o = (\Delta V) \times b \ldots\ldots\ldots\ldots\ldots\ldots (7)$$

and substituting this value of (ΔV) we have

$$y_o = \frac{8\,\phi cV_ob}{\pi\theta} \ldots\ldots\ldots\ldots\ldots\ldots\ldots (8)$$

This phase of the stability question becomes of great importance for large smooth conduits, when the port is designed for maximum load changes of 25 per cent or less and in some easily conceivable cases it will be found by trial that F may be cut down to 0.5 F_o without danger.

Hence the great superiority of the Differential Surge Tank with respect to "Hydraulic Stability."

J. B. Macphail, A.M.E.I.C[4].

Mr. Macphail desired to compliment the author on his ingenuity in getting his equations into manageable form. There was occasion for comment only on details which did not affect the general argument.

Fig. 3 shows a differential surge tank, but none of the special characteristics of such a tank had been introduced in the analysis. Hence equation (5) must be considered as being precisely applicable only to the case of a simple surge tank, connected to the penstock by a riser, and subject to the important condition that the oscillations of the water shall be small. The final result in equation (7) therefore applied only to this simple tank, and its interpretation in terms of the differential tank still remained for investigation. Two forms of interpretation are possible. First, since the oscillations are assumed to be very small, the loss of head through the riser ports may be considered to be zero, and the quantity F might be taken as the gross area of the tank including the riser. Alternatively, neglecting the net area of the tank, the quantity F might be taken to be the area of the riser only, a view which certainly erred towards conservatism. Hence another current view, that F represents the net area of the differential tank excluding the riser, seemed at least to be within the proper limits. This view was approved by Messrs. Creager and Justin (Hydro-Electric Handbook, page 533), and by Messrs. Calame and Gaden (Théorie des Chambres d'Equilibre, page 208). A closer definition of F was needed for differential tanks, especially in cases when it became, after an arbitrary increase for reasons of safety, a critical factor in fixing dimensions.

The Thoma formula quoted by the author required a slight and purely algebraic substitution to bring it to the form actually given in Dr. Thoma's publication "Theorie des Wasserschlosses." This substitution would be convenient for further discussion, so put $H_r = cV_c^2$ and we get $F > \frac{LA}{2\,gcH}$. Mr. Macphail had been unable to get a copy

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[4] Power Engineering Company Limited, Montreal.

of Dr. Thoma's publication, but the Engineering Societies Library in New York had been kind enough to give the reference, also settled another point raised, namely that the coefficient c included friction, rack and entrance losses, but apparently not velocity head. It would be interesting to examine Dr. Thoma's analysis to see whether c could sometimes legitimately be used to include velocity head and whether it was not so used merely because the study was originally undertaken for cases in which friction effects were by far the more important, in a high head plant with a long conduit. Such verification would agree with Mr. R. D. Johnson's use of c, and it would be more in accordance with the author's formula (7). This inclusion had been used by Calame and Gaden (loc. cit. page 209 and page 93). The method of connecting the tank to the conduit would seem to affect the net head on the plant rather than the changing levels in the tank.

Equation (7a) appeared to have been derived in accordance with the assumption, explained on the second page of the paper, that the plant is operating at some power less than the power at full gate, say at 20,600 h.p. in Fig. 1. Hence, the second term in the bracket in the equation is properly negative. If however, the plant were operating at some power such as 21,600 h.p. in Fig. 1, this second term would then be positive; that is, a slightly larger tank would be needed for stability. Experience in the past, though not perhaps the recent past, taught us that our plants may be built too large for the immediate market, and that nevertheless these plants will more than probably be forced to maximum output for considerable periods before very long. Hence a reduction in tank area based on advantageous plant loads and turbine characteristics should be accepted only after most careful consideration. However, another of those qualifications which made consideration of this subject so difficult must be introduced, namely the relation of head- and tail-race levels imposed by the flow characteristics of the river on which the plant is built. This relation might also affect the decision on such reduction.

Mr. Macphail considered the author's treatment of the effect of plants operating in parallel both novel and interesting. Here conditions of stability might permit a very small tank, and provision for throwing full load off if the transmission line tripped out would probably govern, together with consideration of the rate at which load was subsequently to be picked up. There would also be an opportunity of reducing the tank size by providing for occasional waste of water through a suitable overflow, a device which was not always kept in mind.

E. B. Strowger[5].

Mr. Strowger observed that as the author pointed out, the Thoma formula for a damped movement of the water in a surge tank is

$$F > \frac{V_c^2}{2g} \cdot \frac{LA}{HH_r} \quad \text{.......(8)}$$

for an installation in which the conduit and penstock are connected directly to the tank without the usual riser. Stated in the form of an equality, this might be written

$$F = \frac{V_c^2}{2g} \cdot \frac{LA}{HH_r} \quad \text{.......(9)}$$

an expression giving the value of F for *incipient instability* for the conditions stated. According to information available to Mr. Strowger equation (9) is only a special application of the Thoma formula, the general form being

$$F = \frac{LA}{2gcH} \quad \text{.......(10)}$$

where

$$c = \frac{H_v + H_r}{V_c^2} \quad \text{.......(11)}$$

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or

$$F = \frac{V_c^2}{2g} \cdot \frac{LA}{H(H_v + H_r)} \quad \text{.......(12)}$$

This equation differs only slightly from the author's equation (7). For the special case where the conduit and penstocks are connected directly to the tank, then H_v becomes zero and equation (12) reduces to equation (9).

The author had shown the effect upon the area for incipient instability of the shape of the efficiency curve of the units and of the parallel operation of units. A drooping efficiency curve beyond the point of maximum efficiency increases the size of the tank for incipient instability as may be seen from equation (7a). In this equation $\frac{dE}{dP}$ represents the slope of the efficiency curve and since the curve is drooping this slope is negative and the quantity in brackets in equation (7a) is greater than $\frac{1}{H + 2H_v}$. Consequently, with a given set of physical conditions the value of F from equation (7a) is greater than that from equation (7). This consideration of a drooping efficiency curve is an important one in determining the size of a tank.

The effect of parallel operation is to further modify the size of the tank, the modification being to reduce the size for stability. This relation is interesting but Mr. Strowger felt that emphasis should be placed on the author's general admonition as to being extremely careful in the assumptions regarding the system which might lead to unsafe practices. Even on a large system there might be many occasions when a regulating station with a surge tank is called upon to hold on to a local load after separation from the system, and when there must be no question as to stability of operation.

J. B. Goodwin[6] and E. B. Hubbard, A.M.E.I.C.[7]

A rigorous checking of the mathematics presented in the paper failed to disclose any errors to Messrs. Goodwin and Hubbard, although it brought to light one or two assumptions worthy of discussion. They desired to congratulate the author on his able and interesting presentation of this difficult subject.

In showing that the expression given by Dr. D. T. Thoma, $F > \frac{V_c^2}{2g} \cdot \frac{AL}{HH_r}$ (hereinafter referred to as expression B), is strictly applicable only to certain types of development layout, the author had called attention to a fact not generally recognized. Dr. Thoma's expression was evidently based on the assumption that the velocity head registered at the surge tank is negligible, as would be the case when the conduit enters directly into a large tank in which the velocity head would be largely recovered. The expression (7) for the minimum value of F presented by the author appeared to be more nearly correct for cases in which the tank is connected to the conduit by a riser pipe or by an orifice at a point where the velocity in the conduit registers in the tank an appreciable amount of velocity head. It would be of interest to note that in determining which of these expressions to use, the location of the tank insofar as it affects the registry of velocity head should be considered. For instance, if the tank terminated the conduit, the penstock or penstocks branching from the conduit upstream from the tank, as in the case of conduit and surge tank No. 3 of the Ontario Power Company development at Niagara Falls, the velocity head would be recovered during steady flow conditions, and largely recovered during fluctuation of water surface in the tank, in any type of tank, and the use of expression B in in-

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vestigating hydraulic stability would probably give more accurate results than expression (7).

The author had made certain assumptions of interest from a hydraulic standpoint, namely that $\frac{1 - v_t + v_p}{V_p}$, $\frac{H_v}{H}$ and $\frac{Y}{H}$ are very small quantities; it would therefore be desirable to trace the effect of discarding quantities containing them as factors, and to obtain expressions differing from those given by the author by the inclusion of Y.

In simplifying the equation

$$\frac{v_p}{V_p} = \left[1 + \frac{Y}{H} - \frac{2H_v}{H}\left(1 - \frac{v_t + v_p}{V_p}\right)\right]^{-1}$$

one obtains as one of the intermediate steps the equation

$$\frac{v_p}{V_p} = 1 - \frac{Y}{H} + \frac{2\,H_v}{H+Y}\left(1 - \frac{v_t + v_p}{V_p}\right) - \frac{Y}{H}\cdot\frac{2\,H_v}{H+Y}\left(1 - \frac{v_t + v_p}{V_p}\right) \ldots\ldots (A)$$

The assumptions made in the treatment of this equation largely determine the form of the expression giving the minimum tank diameter for hydraulic stability, given by the author as

$$F > \frac{V_c^2}{2g}\cdot\frac{LA}{(H + 2\,H_v)\,(H_v + H_r)}\ldots\ldots\ldots (7)$$

which differs from expression B by the inclusion of velocity head as a factor worthy of consideration.

In deriving expression 7, the whole of the last term of equation A is discarded on the assumption that $\frac{v_t + v_p}{V_p} = 1$, while in deriving expression B the fraction $\frac{v_t}{V_p}$ is discarded on the assumption that v_t is negligible, the last term being split into $-\frac{Y}{H}\cdot\frac{2\,H_v}{H+Y} + \frac{Y}{H}\cdot\frac{2\,H_v}{H+Y}\cdot\frac{v_p}{V_p}$, and only the latter part, i.e. $\frac{Y}{H}\cdot\frac{2\,H_v}{H+Y}\cdot\frac{v_p}{V_p}$, discarded, with the result that $\left(1 + \frac{2\,H_v}{H+Y}\right)$ is a common factor of all terms of equation A, and cancels out to give $\frac{v_p}{V_p} = 1 - \frac{Y}{H}$. This being discussed in detail in the mathematical analysis to follow, it should be noted that the assumptions regarding the importance of h_v, $\frac{h_v}{H_v}$, $\frac{H_v}{H}$, $\frac{Y}{H}$ and $\frac{v_t}{V_p}$ determine the form of the expression for F.

In all the procedures examined, some small quantities containing $\frac{v_t}{V_p}$ have been discarded because their inclusion complicates the mathematics. Messrs. Goodwin and Hubbard felt that it might be possible to complete a study retaining these quantities, given sufficient time and patience, but doubted if the degree of refinement would be worth the effort.

They pointed out that in considering the fraction $\frac{Y}{H}$ it is apparent that it might be of considerable magnitude, and found that it was not difficult to retain quantities containing it in a mathematical procedure. Treating the expression A in a manner similar to the author's, and considering $\frac{Y}{H}$ appreciable, they conducted a study giving an expression

$$F > \frac{V_c^2}{2g}\cdot\frac{H+Y}{H}\cdot\frac{AL}{(H + 2\,H_v + Y)\,(H_v + H_r)}\ldots\ldots (7c)$$

which gives values of F practically the same as expression 7 for high heads, but slightly greater values of F for low heads.

Numerical comparisons based on assumed development layouts were made, which served to show that expression B often gives values of F considerably greater than expression 7c, which again gives values slightly greater than expression 7. To give a slight idea of the different values of F derived, they would submit the following table as for one particular case, the figures being based on the assumed characteristics:

$L = 6{,}000$ $\quad H_r = 6.48$
$A = 254$ $\quad V_c = 11.8$
$Q = 3{,}000$ $\quad H_v = 2.16$

Assumed		Minimum F given by expression			Equivalent tank diameter given by expression		
H	Y	B	7c	7	B	7c	7
180	15	2,820	2,070	2,066	59.8	51.4	51.3
	25		2,072			51.4	
50	20	10,160	7,170	7,000	113.8	95.6	94.3
	30		7,220			95.8	
25	10	20,320	13,580	13,000	160.8	131.5	128.7
	15		13,750			132.4	

It seemed obvious that, if hydraulic stability were a factor to be considered, the type of tank to be installed and the layout of development should be kept in mind when choosing which of the above expressions to use, as they affect the correctness of the assumptions and procedures from which the expressions are derived. They therefore presented the following detailed mathematical analysis in the hope that it would stimulate discussion and bring forth information or ideas which would remove all doubt as to the best assumptions to be made.

In considering the equation

$$\frac{v_p}{V_p} = 1 - \frac{Y}{H} + \frac{2\,H_v}{H+Y}\left(1 - \frac{v_t + v_p}{V_p}\right) - \frac{Y}{H}\cdot\frac{2\,H_v}{H+Y}\cdot\left(1 - \frac{v_t + v_p}{V_p}\right)\ldots\ldots (A)$$

it might be observed that since $1 - \frac{v_t + v_p}{V_p}$ is small, the last two terms of this equation are very small, and tend to cancel because of opposite signs, and it would be seen at a glance that $\frac{v_p}{V_p} = 1 - \frac{Y}{H}$ approximately, as would be expected because if $v_p = V_p$, then $Y = 0$.

The last term is normally smaller than the third term, as it includes the factor $\frac{Y}{H}$, and if this last term only is discarded, then

$$\frac{v_p}{V_p} = 1 - \frac{Y}{H + 2\,H_v} \quad\text{and}\quad \frac{dv_p}{dt} = -\frac{V_p}{H + 2\,H_v}\cdot\frac{dY}{dt}$$

as given by the author. To obtain this equation it is, however, necessary to make two further assumptions; firstly, that $\frac{v_t + v_p}{V_p} = \frac{v_p}{V_p}$ in the third term, and secondly, that $\frac{Y}{H}$ is negligible.

If, however, $\frac{Y}{H}$ is not considered negligible, but is retained, then proceeding as before to discard the last term and assuming that $\frac{v_t + v_p}{V_p} = \frac{v_p}{V_p}$, it follows that

$$\frac{v_p}{V_p} = 1 - \frac{\frac{Y}{H}(H+Y)}{H + 2\,H_v + Y}$$

The differentiation of this term gives a complicated expression, but if the extremely small quantity

$$\frac{V_p}{H + 2H_v + Y} \cdot \frac{2\,YH_v}{H\,(H + 2H_v + Y)} = 0,$$

then $$\frac{dv_p}{d_t} = -\frac{V_p\,(H + Y)}{H\,(H + 2H_v + Y)} \cdot \frac{dY}{dt}$$

Again, if the last terms of equation (A) is split into $-\frac{Y}{H} \cdot \frac{2H_v}{H + Y} + \frac{Y}{H} \cdot \frac{2H_v}{(H + Y)} \cdot \frac{v_p}{V_p}$, neglecting $\frac{v_t}{V_p}$ as before, and only $\frac{Y}{H} \cdot \frac{2H_v}{(H + Y)} \cdot \frac{v_p}{V_p}$ is discarded, then equation (A) simplifies to give $\frac{v_p}{V_p} = 1 - \frac{Y}{H}$ and $\frac{dv_p}{dt} = -\frac{V_p}{H} \cdot \frac{dY}{dt}$, whether or not $\frac{Y}{H}$ is considered negligible. This method may have been followed by Dr. Thoma, as the term $1 + \frac{2H_v}{H + Y}$ cancels out.

It would be of interest also to examine a procedure giving a formula the same as that given by Dr. Thoma. Assuming that the friction losses in the conduit are proportional to the square of the velocity, then

$$\frac{h_r}{H_r} = \frac{2\,v_t\,v_p}{V_p^2} + \left(\frac{v_p}{V_p}\right)^2$$

assuming $\left(\frac{v_t}{V_p}\right)^2$ negligible, whence for $\frac{v_p}{V_p} = 1 - \frac{Y}{H}$ $v_t = \frac{dY}{dt}$ and $\frac{dv_p}{dt} = \frac{-V_p}{H} \cdot \frac{dY}{dt}$, if $\frac{Y^2}{H}$ is neglected it follows

that $$\frac{h_r}{H_r} = \frac{2}{V_p}\left(1 - \frac{Y}{H}\right)\frac{dY}{dt} + 1 - \frac{2\,Y}{H}$$

or $$h_r = H_r \,.\, 2\,\frac{dY}{dt}\,\frac{1}{V_p}\left(1 - \frac{Y}{H}\right) + H_r\left(1 - \frac{2\,Y}{H}\right)$$

Next, omitting h_v in equation (2) of the author's paper as very small in proportion to total head, there results

$$\frac{LF}{gA}\left(\frac{d^2y}{d_t^2} + \frac{dv_p}{dt}\right) + y + h_r = 0$$

Substituting for $\frac{dv_p}{dt}$ and h_r and rearranging, gives $\frac{d^2Y}{dt^2} + 2\,a\,\frac{dY}{dt} + b^2Y + C = 0$, where $C = H_r\,\frac{gA}{LF}$, which is so small that it may be considered negligible, and where $a = \frac{H_r\,gA}{V_pLF} - \frac{V_p}{2\,H}$; whence for $a > 0$

$$F > \frac{V_c^2}{2\,g} \cdot \frac{AL}{H \cdot H_r} \qquad \text{(B)}$$

In considering the first two methods of arriving at values of $\frac{v_p}{V_p}$ and $\frac{dv_p}{dt}$, the inconsistency of assuming that $1 - \frac{v_t + v_p}{V_p} = 1 - \frac{v_p}{V_p}$ in the third term of equation A, and that $1 - \frac{v_t + v_p}{V_p} = 0$ in the last term, may be observed, but it must be kept in mind that the terms are of opposite sign, and that the resulting inaccuracy is not very great. In the last method it was assumed that

$$1 - \frac{v_t + v_p}{V_p} = 1 - \frac{v_p}{V_p}$$

throughout. It will be seen that the assumptions regarding the value of $1 - \frac{v_t + v_p}{V_p}$ largely determine the form of the expression for F.

Now $\frac{v_t + v_p}{V_p} = \frac{v_c}{V_c}$ of which the instantaneous value at the commencement of a surge varies inversely as the per cent load on, and directly as the per cent load off. As the surge continues, the instantaneous values of $\frac{v_c}{V_c}$ tend to unity, the rapidity of the tendency depending on the type of tank and the amount of load change.

The first method as presented by the author is strictly accurate only for small load changes as he has explained. This is true of the second method as now submitted, but it is thought that the inclusion of $\frac{Y}{H}$ tends to make the inaccuracy negligible for larger load changes.

In the opinion of Messrs. Goodwin and Hubbard the assumption in the third method that $\frac{v_t}{V_p}$ is negligible evidently leads to no great inaccuracy when the velocity head is recovered at the tank, although in the case of a layout similar to the O. P. conduit and surge tank No. 3 referred to above it would be possible to have recovery of velocity head, but values of $\frac{v_t}{V_p}$ of considerable magnitude.

Thus there are three values of $\frac{dv_p}{dt}$ for consideration:—

(1) $\frac{dv_p}{dt} = -\frac{V_p}{H + 2H_v} \cdot \frac{dY}{dt}$ ....as given by the author

(2) $\frac{dv_p}{dt} = -\frac{(H + Y)\,V_p}{H\,(H + 2H_v + Y)} \cdot \frac{dY}{dt}$ ...as now submitted

(3) $\frac{dv_p}{dt} = -\frac{V_p}{H} \cdot \frac{dY}{dt}$ ...following Dr. Thoma's procedure.

It will be seen by examining the submitted value of $\frac{dv_p}{dt}$ (2) that the coefficient of $\frac{dY}{dt}$ in the differential equation (5) is a function of Y. This is equally true in the case of the coefficient given by the author (1), where $\frac{Y}{H}$ was eliminated to attain simplicity.

Considering cases 1 and 2, the fact that the coefficient of $\frac{dy}{dt}$ in the differential equation is a function of Y makes its solution as a differential equation of the second degree in Y slightly inaccurate. (Note also the discarding of a small constant $\frac{gA}{LF}$ $(H_v + H_r)$ as negligible.) The effect, however, is small, as, while Y may vary greatly, the coefficient function $2\,a$ varies only slightly, and as the period of the harmonic wave depends on $\sqrt{a^2 - b^2}$ and the amplitude on r_1 and r_2, where both a and b^2 are affected by the inclusion of Y, the resulting inaccuracy is negligible. However, as the solution of the equation as a linear differential depends in either case on the assumption that $2\,a$ and b^2 are constants, it is submitted that it is more accurate to assume that

$$\frac{dv_p}{dt} = -\frac{(H + Y)\,V_p}{H\,(H + 2H_v + Y)} \cdot \frac{dY}{dt} = \text{a constant} \times \frac{dY}{dt}$$

than to reduce $2\,a$ to a constant by the elimination of $\frac{Y}{H}$, for it finally shows F to be a function of Y, thus

$$2\,a = \frac{gA}{LF}\,(H_v + H_r) \cdot \frac{2}{V_p} - \frac{V_p}{H}\,\frac{(H + Y)}{(H + 2H_v + Y)}$$

and ultimately for $a > c$

$$F > \frac{V_c^2}{2g} \cdot \frac{H+Y}{H} \cdot \frac{AL}{(H+2H_v+Y)(H_v+H_r)} \quad \ldots (7c)$$

Thus $\frac{H+Y}{H} \cdot \frac{1}{H+2H_v+Y}$ should be substituted for $\frac{1}{H+2H_v}$ in the expressions 7a and 7b given by the author. To use these expressions a value of Y must be assumed, except perhaps when studying the behaviour of a tank already installed, but this may be done easily with sufficient accuracy as may be seen by comparing the values of F given by expression 7c for the assumed values of Y in the above table. It is recognized that the expressions presented by the author are accurate enough for use in the study of layouts to which they are particularly applicable, but the inclusion of $\frac{Y}{H}$ which led to the expression 7c might give more accurate results in studies in which hydraulic stability is a controlling factor, especially if the water way system is to be affected by comparatively large load changes.

O. Holden, A.M.E.I.C.[8]

Mr. Holden remarked that the term "hydraulic stability" did not appear to be clearly defined by the author, but was apparently used to cover only the case of a surge tank which would have a wave of decreasing amplitude as compared with one of a constant or increasing amplitude. This requirement must be met in all tanks, but it would be found in many cases that the size of the tank is determined by consideration of the speed regulation and pressure rise, rather than by the critical area for "stability." These are points for which no general rule could be given, except as determined by a study of the particular conditions, and all tank designs should be investigated for these features.

The author had included in his paper a mathematical procedure showing the effect of the change in efficiency, particularly where the efficiency is on the falling side of the efficiency-power relation, the effect being to increase the critical area. It had been suggested, as an alternative to the enlargement of the tank, that consideration might be given to the installation of oversize units that would operate only a limited amount beyond the point of maximum efficiency. This would not increase the size of the water passages, but merely the size of the speed ring, gates and runners, and might prove to be less expensive in a large development than an increase in the size of the tank.

Dr. Thoma in his analysis had not included any velocity head past the connection to the surge tank, whereas the present investigation included this factor, resulting in a smaller diameter tank for the same conditions. This difference of course applied only where there was a restricted connection between the tank and conduit, and would not apply in cases where the conduit emptied directly into the surge tank, as considered by Dr. Thoma.

He believed that if the author would undertake the addition of a bibliography on surge tank design it would be much appreciated by all those interested in the subject.

Dr. T. H. Hogg, M.E.I.C.[9]

In reply to a question by the chairman, Dr. Hogg in the unavoidable absence of the author explained that in installing turbines with a long pipe line and a surge tank attached to it, it would be desirable to use the Norris shape of curve with a Francis speed runner having a maximum point of efficiency from 65 to 75 per cent, but this would be complicated by the fact that with a long pipe line and surge tank, when the level rises and the gates open, particularly at a time when the load is increasing near full load conditions, conditions may be so aggravated that instead of getting more power from the unit, the unit actually fails because the gates open but do not deliver any more power.

The chairman further inquired as to the result if there were no check valve in the pipe line to the surge tank. If the tank were larger so as to avoid a sudden drop in the opening of the gates, would there not still be the effect of the drop in the efficiency curve? In actual practice would it be satisfactory to work to the results obtained by the author's formulae, or would it be advisable to increase the size of the tank?

Dr. Hogg replied that a smaller tank might be used, but to get the efficiency rising up to full gate and back again would require a larger turbine, in which case when the gates opened for an additional supply of water, it would be at a constantly rising efficiency curve and would entail less cubic feet of water per kilowatt of delivered power. It was therefore a question of increasing the size of the tank as against the purchase of a larger turbine, and usually it would be better to purchase a larger turbine.

Anyone who would sit down to design a surge tank would certainly need to know all the technical literature on the subject, and would have to know how to figure the critical size of the tank, but that should not influence his judgment. A much larger tank would be used. It was only in extreme cases that the critical size affected the engineer's judgment in designing the tank.

Mr. Tupper

Regarding the differential surge tank, Mr. Tupper asked whether increased damping would result if a check valve was used for the water coming into the tank and another valve for the water going out.

Dr. T. H. Hogg, M.E.I.C.

In reply Dr. Hogg stated that in a number of air surge tanks there actually were check valves. The effect of which Mr. Tupper was thinking was taken care of in the automatic differential tank, in which the rise caused by full load reduction allows the water to spill over freely. Then when the load is pulled down and the water comes down the riser, the difference in elevation between the tank and the riser give sufficient velocity to deliver the additional water required to supply the draught velocity through the turbines.

Dr. Hogg further observed that his interest in the subjects covered by this paper commenced over twenty-five years ago when he was connected with the Ontario Power Company and was engaged there in surge tank investigations under Mr. R. D. Johnson, who was then hydraulic engineer of the company.

Attention should be called to Mr. Johnson's work in developing not only the differential surge tank, but the difficult mathematical analysis upon which the designs of the tank and its component parts are based. Many of these results had been presented in a series of papers before the American Society of Civil Engineers.

Since that time a considerable amount of additional study had been given to the problem by European and American investigators, but many of the studies made by them were prompted primarily by the published work referred to above.

The author was to be complimented on his concise and clear presentation of results hitherto unavailable in English.

A. W. F. McQueen[10]

The author wished first of all to rectify an important omission regarding the acknowledgment of his sources of

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(9) Hydraulic engineer, Hydro-Electric Power Commission of Ontario, Toronto, Ont.

(10) Assistant engineer, H. G. Acres and Company Limited, Niagara Falls, Ont.

material. Parts of the paper had to be rewritten when it was decided to submit it to The Institute just prior to the author's departure for India. He regretted that in the press of work and preparations this involved, a fuller or revised acknowledgment had not been prepared.

The author now desired to make it and to express his indebtedness to R. L. Hearn, M.E.I.C., chief engineer, H. G. Acres & Company, Limited, and to Mr. R. D. Johnson, consulting engineer of New York, for introducing the subject matter of the paper to him and for arousing his interest in it. The basic material for the paper was largely drawn from an interesting exposition of the subject by Messrs. Jules Calame and Daniel Gaden, engineers of the firm "Ateliers des Charmilles" and published by them under the title, "De la Stabilité des Installations Hydrauliques Munies de Chambres d'Equilibre" in the two issues of the "Schweizerische Bauzeitung" dated July 30th and August 6th, 1927. The mathematical treatment used by Messrs. Calame and Gaden, however, was, in the opinion of the author, extremely difficult to follow by non-mathematicians. This meant that it was necessary for the author practically to re-derive the essential equations of the paper, being considerably helped, of course, by the published work referred to above.

The first part of the paper was an attempt to present some of the prime introductory considerations of hydraulic stability as related to the use of surge tanks. To have attempted to discuss the application of the theory to the various types of tanks, particularly the differential surge tank, and to various possible arrangements of conduit, surge tank and penstocks would have extended the paper unduly.

R. D. Johnson, J. B. Macphail, A.M.E.I.C., and Messrs. J. B. Goodwin and E. B. Hubbard, A.M.E.I.C., in their discussions had presented some very interesting and valuable information on these topics and had therefore already given a considerable contribution to this second and more important phase of the subject matter.

The author also wished to thank Messrs. J. B. Goodwin and E. B. Hubbard for having checked his mathematical treatment. They had rightly called attention to the assumptions made to render the mathematics tractable. In the treatment followed by the author for simplifying the equation

$$\frac{v_p}{V_p} = \left[1 + \frac{Y}{H} - \frac{2\,H_v}{H}\left(1 - \frac{v_t + v_p}{V_p}\right)\right]^{-1}$$

the assumption is made that the quantity

$$\frac{Y}{H} - \frac{2\,H_v}{H}\left(1 - \frac{v_t + v_p}{V_p}\right)$$

which for convenience may be called x is always so small compared with unity that all powers of x greater than the first may be neglected. This is only true if $\frac{Y}{H}$ is very small. If $\frac{Y}{H}$ has any appreciable magnitude then

$$(h_v + h_r)/(H_v + H_r)$$

is no longer equal to $(v_e / V_c)^2$ and the analysis falls down. Under these circumstances, moreover, the features peculiar to any tank other than the simple tank, i.e., the differential action in the differential surge tank might come into action, and equation (1) would then no longer be true. Consequently in design work this aspect of the stability problem must be investigated.

Now $|x|$ is always less than unity, hence

$$\frac{v_p}{V_p} = \left[1 + x\right]^{-1}$$
$$= 1 - x\,.$$

Mr. R. D. Johnson had elsewhere shown the marked superiority of the differential surge tank over the simple tank with regard to its stability and in his present discussion gave the theory pertaining to the sustained small surge which may be expected to occur in a differential surge tank of smaller dimensions than the critical. He deduces a valuable equation by which the relation between the area of a differential surge tank and the value of the sustained small surge may be computed.

With regard to the author's statement as reproduced on page 16 of the January 1933 issue of The Engineering Journal regarding an operating condition under which it might be desirable to give different values of the inherent (permanent) speed change to the governors of different types of turbines, the idea might be expressed differently in the following fashion. It is generally considered necessary by engineers (though by some the proposition has been vigorously questioned) that hydraulic governors should be provided with a small amount of inherent (permanent) speed variation in order to assure a stable division of load changes among generators operating in parallel. Since such units are compelled to rotate in synchronism it follows, for example, that if two units of equal capacity are operating at half load, and the first of these is provided with a one per cent inherent speed change, and the second with two per cent, and a load increase occurs corresponding to one-quarter of the combined capacity of the two units, the former of these two units will take on approximately two-thirds of the load increase and the other only one-third. In the paragraph in question the author wished to call attention to the fact that the theory developed for parallel operation of units was based on the assumption of identical inherent speed changes, which in turn caused the units to divide the load changes approximately in the proportion of their capacities. Where different inherent speed changes are provided, load division will take place on another basis and the theory would have to be modified accordingly.

The author welcomed so generous a discussion on his paper, covering as it did not only the theme of the paper itself but also a number of intimately related topics. It indicated, as perhaps can be done in no other way, that the subject matter of the paper is only a phase of a large problem in hydro-electric design that has many ramifications. He desired to thank warmly each of the contributors to the discussion.

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R. S. L. Wilson, Chairman
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Zone B

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Zone C

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Institute Affairs and Members' Activities

To see ourselves as others see us is usually a very salutary experience. In The Institute, our Council and our committees naturally study our problems from within, and base their conclusions on observations taken from that standpoint. It is refreshing, therefore, to be able to present some views on The Institute's problems expressed by an engineer of long experience, who has given much thought to questions of professional organization and education, and who looks upon The Institute primarily as an organization designed for mutual aid and stimulus in matters of professional education and intellectual development.

The counsel so cordially given by Mr. James Porter of Vancouver in the article which we print in this issue of The Journal, will give much food for thought to those in charge of Institute and Branch affairs, as well as to individual members who are interested in the success of The Institute. It has frequently been pointed out that the services of The Institute to its members are in large measure the sum total of the services rendered by the Branches. Branch activity is in fact the mainspring of The Institute. The efforts of Branch officers have therefore as their principal aim the maintenance of the keenness and interest of the individual members in Branch affairs, and the development of that professional intercourse which is one of the main objects of The Institute.

In his essay, Mr. Porter points at once to that controlling feature of The Institute's work—its dependence for success on the efforts of its individual members. We are living in difficult times, and The Institute's functions are performed under conditions very different from those which held good at the time of its original incorporation.

The rapidity of advance of modern engineering, the increased specialization which is forced upon those who practise the profession, and the high pressure at which work has to be done, all lead to a tendency to crowd professional matters out of the mind after working hours and to limit the time devoted to professional associations or societies. Mr. Porter recognizes this difficulty, but emphasizes the advantage which accrues to an engineer who gives freely of his time and energy in society affairs.

Writing with the perspective of experience, he deals with The Institute's possibilities as a means of professional education, using that word in its broadest sense. To continue and supplement the young engineer's academic and practical training; to maintain his interest in branches of engineering other than that in which he has to specialize; to help him in learning how to present a technical subject clearly and discuss it intelligently; these are some of the benefits which active membership in The Institute should give and which are discussed in due order by our candid adviser.

Those responsible for our papers, meetings and discussions will find much to help them in Mr. Porter's suggestions. Every meeting, he points out, should have a definite intellectual purpose. Is this always the case, and, if not, what is the reason? To what extent should extempore addresses and lectures form part of Institute programmes? How should our members be encouraged and aided to prepare worth-while papers and to contribute to their discussions? The article is most helpful in the search for answers to those and other like questions. Many of the topics touched upon have already been dealt with in our editorial columns, but Mr. Porter brings them before us with a freshness and originality of view which makes his opinions worthy of careful study.

The Plenary Meeting of Council Postponed

In the September issue of The Journal there appeared an outline of the scope and objects of the Plenary Meeting of Council which was to meet on the twenty-fifth of that month.

Immediately after going to press, however, it became evident that if that meeting convened as intended, it would be impossible to do justice to one of its principal items of business, namely, the questions arising from the work of the Committee on Development.

The committee appointed by Council to report regarding the matter, while having reached conclusions on some important points of policy, had not yet been able to complete their findings in other respects. In view of this fact, and the importance of the issues involved, Council at its meeting on September 8th decided to postpone the Plenary Meeting to a later date, probably in November, to be fixed at the next regular Council meeting on October 6th. This delay, it is hoped, will enable the committee to present such a report as will allow of the preparation of any amendments to the present By-laws which the Plenary Meeting may desire to put forward for consideration at the 1934 Annual General Meeting, and later for ballot by the membership.

Past-Presidents' Prize 1933-1934

The subject prescribed by Council for this competition for the prize year July 1st, 1933-June 30th, 1934, is:

"The Engineering Features of City Management."

The first announcement and the rules governing the award of the prize, which consists of a cash donation of $100.00, appeared in the July, 1933, issue of The Engineering Journal.

If required, further particulars regarding the award may be obtained by application to the Secretary.

Meeting of Council

A meeting of Council was held at the Royal York Hotel, Toronto, on Friday, September 8th, 1933, at seven thirty p.m., with President O. O. Lefebvre, M.E.I.C., in the chair, and ten other members of Council present.

The Secretary reported that the consent of the Institution of Electrical Engineers had been received to the proposed change in name of the Radio Section of the Montreal Branch, and the name "Radio and Wire Communication Section" was accordingly approved for this section.

The Secretary announced that Councillor B. Russell, M.E.I.C., of the Calgary Branch, had found it necessary to resign, and that in accordance with the by-laws the Calgary Branch Executive Committee had presented two names for the consideration of Council for the appointment of his successor. Mr. R. C. Harris, M.E.I.C., was accordingly appointed councillor for the Calgary Branch to replace Mr. Russell for the remainder of his term, expiring in February 1934.

The report of the Finance Committee was considered, from which it appeared that a considerable drop was probable in the revenue for 1933 as compared with 1932, this being largely due to the extension of credit by Council to many members and the placing of some three hundred members on the Suspended List. The report of the Finance Committee was approved, and it was suggested that in sending out the accounts to members in October attention should be drawn to the considerable sum still outstanding in arrears of current fees.

The Secretary reported that the Committee re Development had found it impossible to complete its report in time to make due preparation for the Plenary Meeting of Council to be held on September 25th. After considerable discussion it was resolved that the Plenary Meeting should be postponed to some date in the near future, to be decided by Council after consultation with the chairman of the Committee re Development.

A request from the Canadian Chamber of Commerce for an expression of views in regard to the Canadian monetary and banking system was presented, and it was regretted that it was too late to comply with the suggestion, since the MacMillan Commission was already sitting in Toronto.

The Secretary presented correspondence with the Vancouver Branch suggesting the desirability of a petition to the Federal government requesting a reduction or removal of the tax on scientific and technical periodicals entering Canada. After discussion, the Secretary was directed to communicate with the Royal Architectural Institute of Canada, the Canadian Institute of Mining and Metallurgy, and other technical bodies if possible, to obtain their opinion as to the desirability of taking joint action in this matter.

Six resignations were accepted; two reinstatements were effected; forty members were placed on the Suspended List, and a number of special cases were considered.

A number of applications for admission and for transfer were considered, and the following elections and transfers were effected:

Elections		*Transfers*	
Assoc. Members	4	Junior to Assoc. Member	2
Students Admitted	6	Student to Junior	1

The Council rose at ten forty-five p.m.

Annual Meeting 1934

The invitation of the Montreal Branch of The Institute to hold the Forty-Eighth Annual General and General Professional Meeting at Montreal has been accepted with appreciation and Thursday and Friday, February 8th and 9th, 1934, have been tentatively approved as the dates for this gathering.

OBITUARIES

Robert Maitland Hannaford, M.E.I.C.

Great regret will be felt at the announcement of the death at Montreal, on August 28th, 1933, of Robert Maitland Hannaford, M.E.I.C., the eldest son of the late Edmund Phillips Hannaford, who was President of the Canadian Society of Civil Engineers in 1893.

Born at Montreal on March 22nd, 1865, Mr. Hannaford was educated at the Montreal High School, at Bishops College School, Lennoxville, and at Trinity College School, Port Hope. In 1886 he did survey work on the Montreal and Champlain Junction Railway, and in the same year was with the Phoenix Bridge Company, Phoenixville, Pa., as draughtsman. In 1887 Mr. Hannaford joined the staff of the Grand Trunk Railway, being transitman, leveller, etc., until 1889, and resident engineer on the double tracking of the railway between Montreal and Toronto until 1896. In 1897-1899 he was draughtsman and designer with the Pratt and Whitney Company at Hartford, Conn., and following that until 1902, was chief draughtsman with the James Cooper Manufacturing Company, Montreal. In 1902 Mr. Hannaford became connected with the Montreal Street Railway Company as assistant engineer, and in 1903 was appointed chief engineer. In 1924, after serving for some time as acting chief engineer of the Montreal Tramways Company, Mr. Hannaford was appointed engineer of maintenance of way and structures for the company, the office of chief engineer having been abolished.

ROBERT MAITLAND HANNAFORD, M.E.I.C.

Mr. Hannaford joined The Institute (then the Canadian Society of Civil Engineers) as an Associate Member on December 19th, 1899, and became a Member on March 12th, 1908. He took an active interest in the affairs of the Montreal Branch and served on a number of its committees.

William Dun Armstrong, A.M.E.I.C.

It is with deep regret that the death of William Dun Armstrong, A.M.E.I.C., which occurred at Calgary, Alta., on September 8th, 1933, is placed on record.

Mr. Armstrong was born at Owen Sound, Ontario, on November 2nd, 1890, and was educated at the Provincial Institute of Technology, Calgary, and the University of Toronto.

In 1910-1911 Mr. Armstrong was with the Canadian Inspection and Testing Laboratories, and from 1912 to 1914 was connected with the mechanical department of the Canadian Pacific Railway Company at Toronto. In 1914 he went overseas with the 6th Field Company, Canadian

Engineers, and in 1917 was transferred to the Royal Air Force. Returning to this country in 1919, he joined the staff of the Canada Cement Company Limited, and became assistant superintendent at Winnipeg. In 1921-1923 Mr. Armstrong was engineer for the company at Exshaw, Alta., and in 1923 was appointed plant superintendent at Exshaw, which position he held up to the time of his death.

Mr. Armstrong joined The Institute as an Associate Member on October 27th, 1925, and was an active member of the Calgary Branch before which he delivered several papers, among them one on Hydraulic Mining, which appeared in the July 1925 issue of The Journal. His loss will be keenly felt by his many friends and the members who have been associated with him in the activities of the Calgary Branch.

Herbert Tom Melling, A.M.E.I.C.

Regret is expressed in recording the death at Hammond, Indiana, on August 7th, 1933, of Herbert Tom Melling, A.M.E.I.C.

Born at Liverpool, England, on July 7th, 1874, Mr. Melling was educated at the Manchester School of Technology, where he took a course in mechanical engineering. From 1890 to 1895 he served an apprenticeship with Messrs. J. H. Wilson and Company, Liverpool, and later was engineer in the experimental and research department of Messrs. Crossley Bros. Ltd., Manchester, manufacturers of gas and oil engines. In 1904 Mr. Melling was appointed chief engineer to the Mazapel Copper Company, Mexico, and left England to superintend the erection of the plant. This work being completed, he joined the staff of the Power and Mining Machinery Company of Milwaukee, being responsible for the erection of gas engine installations. In 1908 Mr. Melling was engaged by Messrs. Crossley Bros. to supervise the installation of gas engines, producers and pumps at the Salak South Mines in the Straits Settlements. Returning to America in 1910, he was appointed superintendent of the Gas Power Producer plant of the city of Edmonton, Alta., and in 1916 became manager of the Canadian branch of Messrs. Willans and Robinson Ltd., at Regina, Sask. He was later in private practice as a construction engineer, and in 1924 was in New York, N.Y. In 1928, Mr. Melling was mechanical engineer with Thos. E. Murray, Inc., New York, and in 1931 became assistant engineer with the N.Y. Edison Company at East River Station, N.Y.

Mr. Melling was elected an Associate Member of The Engineering Institute of Canada on November 25th, 1919.

Clement E. Chase

Members of the Montreal Branch of The Institute will learn with regret of the death of Mr. Clement E. Chase on September 18th, when he fell from the Delaware River bridge at Philadelphia, Pa. Mr. Chase was well known to the members of the Branch as he came to Headquarters and gave an admirable lecture on Suspension Bridges in January 1933. Since graduating from Cornell University in 1910, Mr. Chase had been associated with Mr. Ralph Modjeski on bridge work, and at the time of his death was making an inspection preliminary to the construction of a high-speed line over the bridge from which he was swept by a strong gust of wind.

PERSONALS

R. C. Flitton, A.M.E.I.C., is now connected with the Wm. Hamilton Division of Canadian Vickers Limited, at Montreal, Que. Mr. Flitton graduated from McGill University with the degree of B.Sc. in 1914. From June 1915 to February 1916 he was with C. H. Topp and Company as assistant on waterworks and mining surveys on Vancouver Island. In March 1916 Mr. Flitton joined the staff of the British Munitions Co. Ltd., Verdun, Que., on tool designing and was later assistant to the superintendent in the blending and proofing (powder) department; in charge of laboratory proofs; and assistant to the superintendent of the 18 pr. shell forging department. In 1919 he was for three months sales engineer with the Williams Manufacturing Co. Ltd., Montreal, and in May of that year was appointed assistant to the superintendent of the William Hamilton Company, Ltd., Peterborough, Ont. He was subsequently engineer, chief engineer and works manager of the same company, having recently relinquished the latter position.

Carleton Craig, S.E.I.C., has been awarded the John Bonsall Porter scholarship, of a value of $500, tenable at McGill University. This scholarship, founded by Dr. W. W. Colpitts, M.E.I.C., a McGill engineering graduate, is open to graduate students of all universities proceeding to the degree of Master of Engineering in civil engineering. Mr. Craig is a former student at Ottawa Collegiate Institute and Ashbury College. He took a B.A. degree at McGill in 1930 with first class honours in mathematics and physics. Last spring he obtained the degree of B.Eng., and was awarded the British Association Medal and honours in civil engineering. Mr. Craig will continue his studies at McGill doing research work on stresses in welded connections.

ELECTIONS AND TRANSFERS

At the meeting of Council held on September 8th, 1933, the following elections and transfers were effected:

Associate Members

HAYMAN, Howard Lawrence, B.A.Sc., (Univ. of Toronto), supt., John Hayman and Sons Co. Ltd., R.R. No. 4, London, Ont.

LeCAPELAIN, Charles King, National Parks Engineer, National Parks Branch, Department of the Interior, Banff, Alta.

SAUNDERS, Max Gordon, B.Sc., (N.S. Tech. Coll.), mech. supt., Aluminum Company of Canada, Arvida, Que.

STEPHEN, Gordon Robert, B.Sc., (McGill Univ.), engr., Fraser Brace Engineering Company Limited, Montreal, Que.

Transferred from the class of Junior to that of Associate Member

BRADFIELD, John Ross, B.Sc., (McGill Univ.), plant engineer, Noranda Mines, Ltd., Noranda, Que.

CAREY, Cyril Joseph, private practice, 142 Military Road, St. John's, Nfld.

Transferred from the class of Student to that of Junior

STOREY, Thomas Edwards, B.Sc., (Univ. of Man.), power house operator, City of Winnipeg Hydro-Electric System, Slave Falls, Man.

Students Admitted

ANGLIN, Arthur Baker, B.Sc., (Queen's Univ.), 108 Albert St., Kingston, Ont.

GREENE, Godfrey Benning, Jr., (Queen's Univ.), 26 Russell Ave., Ottawa, Ont.

KELLAM, George Douglas, B.Sc., (Univ. of Man.), 24 Regal Court, Winnipeg, Man.

NICHOLSON, Robert Morley, B.Sc., (Queen's Univ.), 204 William St., Kingston, Ont.

OSTROM, Curzon Ross, (Grad. R.M.C.), Second St., Oakville, Ont.

WADGE. Norman Hilton, (Univ. of Man.), 149 Maryland St., Winnipeg, Man.

RECENT ADDITIONS TO THE LIBRARY

Proceedings, Transactions, etc.

National Research Council, U.S. Highway Research Board: Proceedings of twelfth annual meeting, December, 1932.

The Royal Society of Canada: List of Officers and Members and Minutes of Proceedings, 1933.

Canadian Electrical Association: Proceedings of the forty-third annual convention, 1933.

University of Toronto: Calendar, Faculty of Applied Science and Engineering, 1933-1934.

Association of Professional Engineers of British Columbia: Year Book 1933.

Reports, etc.

Department of Interior, Canada:
Forest Service, Forest Products Laboratories, Programme of Work 1933-1934.
Toronto Harbour Commission:
Annual report 1932.
Department of Mines, Canada:
Mines Branch, Gold in Canada, 1933.
Electricity Commission, England:
Report on measures which have been taken to obviate the emission of Soot, Ash, Grit and Gritty Particles from the chimneys of Electric Power Stations—by a committee appointed by the Electricity Commission.
American Society of Mechanical Engineers:
Power Test Codes Series 1929.
Institute of Makers of Explosives, U.S.A.:
Standard Storage Magazines.
Association of Ontario Land Surveyors:
Annual Report 1933.

Technical Books, etc., Received

The Technical Man Sells His Services, by E. Hurst (*Maple Press Company, York, Pa.*).
Canadian Mining Manual 1933 (*National Business Publications Ltd., Gardenvale, Que.*).

BULLETINS

Road surfacing machinery—A 106-page catalogue has been received from the Phoenix Engineering Company, Ltd., Chard, England, which comprises five sections describing and illustrating tar and pitch boilers, tar spraying and spreading machines, bitumen heating and spraying machines, bitumen mixers and pumps, asphalt heaters, mixers and cauldrons, transporters, high capacity hand and power driven pumps and municipal plant and appliances.

Drills—Canadian Ingersoll-Rand Company Ltd., Montreal, have issued three 4-page folders describing and illustrating the features of the following: Form No. K224, rock drill hose couplings and hose; Form CF-355, N-82 convertible drifter and sinker; and, Form CF-369, N-69 convertible drifter and sinker.

Joints—The American Concrete Expansion Joint Company has published a 17-page pamphlet showing the latest designs in expansion and contraction joints for the construction of concrete highways, etc. The standards and specifications shown in the pamphlet have been adopted by the Highway Department of the State of Illinois.

Transformers—A 36-page booklet has been issued by the Brush Electrical Engineering Company, Loughborough, England, which is of a rather new type, in that it illustrates the building of the complete transformer from the core up. Instead of grouping the illustrations in a special section, the method adopted was to arrange the book in completely self-contained sections, each with text and appropriate photographs: windings, tappings and leads, terminals, etc., and to deal with each section as a unit.

BOOK REVIEW

The Indian Forest Records

Interim Report on Work under Project No. 2, Strength Tests of Timbers in Structural Sizes, with Test Results up to 1932, by L. N. Seaman, M.A., B.Sc., M.E.I.C. Published by Order of the Government of India, Delhi, 1933. 39 pp. tables, 1s. 9d.

Reviewed by G. H. Rochester*

In his report Mr. Seaman makes an important addition to the data already available on the strength of commercial structural timbers resulting from tests carried out at the Forest Products Laboratories of Canada, England, South Africa, New Zealand, Australia, India and the United States.

It is difficult to present the results of tests on structural timbers in anything approaching an original manner, but Mr. Seaman has attempted to get away from the usual form of these reports by the allocation of the tables to an appendix. It is the opinion of the reviewer, however, that as the purpose of this publication is to present certain definite data for the use of architects and engineers, the data (in this case the safe allowable working stresses for Indian timbers) should be presented in the main body of the report, leaving the incidental data to the appendix.

The report itself sets out very clearly the objects of the investigation, the manner in which it was approached, and the conclusions arrived at. The data with reference to the relation between the strength of structural timbers and small clear specimens, the advisability of testing a relatively large number of specimens of a few of the more important species, and the increase in the strength of structural timbers due to air-seasoning, confirm the findings of similar investigations carried on at the Canadian Forest Products Laboratories.

The report, while perhaps giving information which will not have a very wide application for Canadian architects and engineers, adds very considerably to the technical information upon the strength of the timbers of the world.

*Chief, Division of Timber Mechanics, Forest Products Laboratories, Ottawa, Ont.

Timely Comment on Institute Affairs

Editor's Note:

The following article was originally prepared in the form of an open letter addressed to the Chairman of the Vancouver Branch, in reference to a circular sent to the Branch members by Mr. Buchan. The writer, an engineer now retired from active practice, has long taken a keen interest in questions of professional organization, and was one of the charter members of the Association of Professional Engineers of British Columbia. His service on the Board of Examiners of that body indicates his familiarity with the difficult problems of professional education. Thus the views he expresses are based on wide study and observation. Members' comments thereon will be appreciated.

In response to your kind invitation, I am giving you the impressions which a deaf man, who is to some extent out of things, has gained from your circular letter and memorandum of suggestions. I have not distinguished between the points which are contained in your own circulars and those which the reading of them has raised in my own mind, I have simply tried to look at your problem as a whole, as a person may who is intensely interested in it, but whose physical isolation provides him with a more or less detached view-point.

Responsibility for The Institute's Success

You do well to stress the fact that the primary essential for the success of The Institute is not so much detailed direction from the headquarters in Montreal as healthy activity in the branches, inspired by the idea that the success of The Institute is the affair of every member, and that every bit of disinterested work which he does for it will bring its own sufficient reward, often in curiously indirect ways, but always in the form of a definite gain in his own intellectual efficiency. Let me emphasize the importance of this last, in view of present conditions.

Changes in the Conditions of Engineering Work

Twenty years ago it was not unreasonable for a well-trained engineer who was fortunate in his opportunities, to look forward to retirement at 55, or even earlier. But the war has put an end to all that; and the question has become one of keeping intellectually and nervously sound till 65. We are living in the fourth decade of the twentieth century, with the telephone, the type-writer, and the auto in full activity. These inventions have multiplied the number of responsible decisions which engineers, no less than business executives, are called upon to make in the course of the ordinary working day. To make matters worse, many of these decisions, especially those given by telephone, are necessarily hasty ones. These are apt to leave an uneasy impression on the mind of the responsible party that he may have reached mistaken conclusions in some instances. Such an impression, when repeated day after day, has reactions both on the nerves and the intellect. We are only concerned with the latter here. A common manifestation of it is an eagerness to crowd professional matters completely out of the mind after working hours. Another and even more serious manifestation is a gradual inability to take up any matter which calls for long-sustained attention. Both these are injurious in the case of men who are engaged in a profession like modern engineering, marked as it is by an almost feverish rapidity of advance. It is true that most engineers who have reached the age of 40 have become fairly clear in their own minds as to the line of work which they can afford to neglect. Even apart, however, from the capricious workings of destiny, there is danger for the engineer in every deliberate decision to exclude a section of his profession from the sphere of his intellectual interests. He must at all costs maintain the keenness of his appreciation of engineering as an intellectual interest and an agency of lifelong education.

The Institute as a Mental Gymnasium

In every place where men have been conspicuously successful as regards intellectual achievement, they have managed to devise some means of stimulation by taking advantage of their natural interest in one another's work. Only a very few men can do their best work in anything approaching isolation. The intellectual value of a society does not depend mainly on the size of the meetings, though it is not easy to rise to the occasion with an audience of only a dozen. But it has been my good fortune to see an even smaller audience warm up to a pleasant glow of interest on a number of occasions with subjects much less interesting than engineering. Such a gratifying experience is not, however, a thing which comes at random. Every meeting must have a definite intellectual purpose. To disregard this is to leave the door open for purposeless gossip; and gossip about engineering is of no particular value to anyone. It has certainly no power of attracting an audience of engineers.

The Importance of Papers

The natural way of focussing the interest of the members is by the reading and discussion of papers. If a member is fortunate in his choice of a subject, and does the very best of which he is capable, there need be no fear of a lifeless debate upon it. The subject need not be "in the air" in order to prove a success. The point of cardinal importance is that the writer shall have a keen interest in it himself. But this interest must not be of a merely advertising nature. It is not possible to exclude the natural desire to justify one's fellow-members in forming a good opinion of one's performance; but this should be forgotten in the determination to make some return to the audience which has paid one the compliment of coming to the meeting in order to hear what one has written.

The writing of a paper which will justify its place in the programme is not an easy matter, unless in the case of a man who possesses a powerful and systematic memory. Few of the smaller societies are fortunate enough to include members equal to feats of rapid and instructive composition; and the main reliance of the programme official must be on men of ordinary ability who are willing to take pains. They may not be heaven-sent writers; but if they know enough about the subject which they have chosen to realize its intellectual interest, their honest enthusiasm will always prove infectious.

There is occasionally a tendency to dispense with papers and rely upon extempore addresses. This should not be encouraged. It is not good for most authors; and it is certainly not good for the programme. The exercise of preparing a written paper is of an altogether higher order than that of speaking from a mere list of points. The extempore speaker can only in the rarest instances secure the compactness, the freedom from irrelevance, the orderly sequence of points, the sense of proportion, and the avoidance of jarring phrases, which mark the carefully prepared paper. I cannot help believing that an engineer, whether old or young, who is determined to maintain his intellectual efficiency, should prepare a paper for The Institute once every five years, and supplement this with a paper once every two years, not necessarily for The Institute or on an engineering subject, but still of sufficient interest and importance to call out the best in him.

Turning to the audience, there is always a feeling of respect for a writer who has obviously done his best to be useful; and this will insure a spirit of friendly and instructive discussion. The rhetoric of which we hear so much as to the worthlessness of read addresses as against extempore speaking has no application to engineering societies. Useful debate depends far more upon clear, logical and full presentation of a subject by the person responsible for its introduction, than upon looking the listeners in the face, provided of course that the reading is audible and intelligent.

The Element of Unselfishness

It is occasionally asserted that to give others the benefit of what we have gained by experience or study is quixotic folly. But there can be no greater mistake than this view. The more ready a man is to give of his best for the benefit of his fellow-members, the more will his professional keenness and power of seizing the important points of a subject increase. These are things which no generosity on his part can diminish. Then, too, the effort to throw his knowledge into the clearest form, whether in the written paper or in the debate which follows it, will give definiteness and precision to his knowledge, bring home to him its deficiencies, and aid him in giving a human touch to his speaking which will greatly help him in convincing any audience, whether professional or lay. All this is lost to the man who goes to a meeting with his mind definitely made up to contribute nothing to the discussion. Even those who are incapable of standing up and making a speech are in a position to join in the informal discussion which continues for some minutes after the meeting has closed; and they can thus share in the reward which comes from unselfish readiness to give information.

Composition of the Audiences at Meetings

There are three groups of engineers to whom your appeal should come home with special force. First, the veteran members. Second, the consultants, the designers, and the men whose work is largely standardized. Third, the junior members and students. These will include practically all on whom you can rely for regular attendance. I leave out of account the responsible heads of contracting firms and the executive heads of public departments. Their time and attention are very largely taken up with the necessary work of carrying on the intercourse which will be help them in anticipating the ebb and flow of engineering construction or the probable expenditure on public works. Besides, they cannot always expose themselves to the risk of being questioned on matters which are still in the air. This does not mean, however, that they should stay away altogether. On the contrary, they ought not to miss any meetings at which there is no special risk of their being placed in awkward positions. The head of a firm of contractors, or the executive head of a department, is not exempt from the risk of getting out of touch with the profession, however diligently he may read the technical periodicals. To listen to the papers or speeches of other engineers, even of juniors who appeal to his sympathy by their very crudeness, will be a substantial help to him in directing the work of his staff. It will also sharpen his own attention to engineering literature.

The Place of the Veteran Members

By these I mean such as are released to a great extent from that continuous attention to the details of professional work which so largely limits the opportunities for professional intercourse during an engineer's most active years. They have one advantage, which is of value both in stimulating and restraining,—their perspective of experience. The years bring with them some privileges; and an elderly man can pay a compliment to an author or speaker with a grace, an acceptance, and a freedom from anything like patronizing, which many a younger man might envy. The veteran can probably remember the time when friendly appreciation meant much to him as a junior. It is not necessary for this appreciation to be shown in the form of a speech. It will be very acceptable when given quietly after the meeting.

Many of the younger members, and some of those in middle life, may lean towards the sledge-hammer style of debate. The veteran members can occasionally play a useful part in checking it. Let me take an instance from another profession. A clever but overbearing young surgeon read a paper before a medical society, in which he referred to a mistaken diagnosis of a case which had been made previously by another doctor, adding the comment, "He ought to have been shot." In the course of the subsequent discussion an old doctor asked him, "How do you know what that case looked like when the first doctor saw it?" We need the veterans to remind us that a course of action which would be fully justified by a complete knowledge of the facts might be entirely unjustified at an earlier stage, when the facts were only half known.

Veterans and Engineering Break-Downs

But the usefulness of the veterans need not be restricted to acting as a restraining influence. Only a few young engineers outside those engaged in railway or contracting work have much opportunity for seeing how to cope with break-downs. The very fact that so many of them are accustomed to the latest types of equipment is an actual drawback when a case has to be dealt with by the use of the appliances nearest at hand, whether they are up-to-date or not. Many occasions will arise in the course of discussion when the experience of the older engineers in this field can be tapped with advantage.

A Word of Caution

It must be borne in mind, however, that the assistance which the veterans can give is sometimes heavily discounted by a tendency to long-windedness. A veteran member should very rarely speak for more than five minutes; and his best speaking will often be done in three minutes. He ought to pass a private self-denying ordinance limiting himself to a frequency of one speech in three meetings. He should never forget that one of the most valuable elements in the success of a society is a group which can sit silent as a rule and still maintain a keen interest in the proceedings, showing its interest mainly by its regular attendance and animated listening.

The Mainstay of the Proceedings

The designers and the engineers engaged in more or less standardized work will as a rule have to bear most of the burdens of Institute administration. They are not drowned in professional detail, except during periods of rush work. As they are in most cases in line for promotion, they cannot afford to miss opportunities for maintaining not only their knowledge, but still more their professional keenness, at a high pitch. There is no more direct course to that end than regular attendance and thoughtful speaking at the meetings. Good speaking usually involves looking up the subject beforehand; and even intelligent listening will call for a certain amount of it. This is not a bad feature of the case. The graduate fresh from class-room and library may be willing to look up a subject, but the tendency is unfortunately to omit it as one grows older; though even a brilliant graduate has been known to become "a dead one" after ten years of lying back. The friendly interest in another man's paper which leads to the looking up of the subject beforehand can help even an engineer in his fifties to retain the power of concentrated attention to the treatment of engineering matters in the literature of his profession.

Papers by the Members

The writing of the more important papers will rest with the consultants and designers as a rule. But the juniors ought to be encouraged to write papers also, even though their opportunities for responsible design or construction may not be large. Instructive and interesting debates can be successfully based upon careful compilations from the literature of the subject; and suggestions for such work will be brought to the attention of the juniors from time to time if they attend the meetings regularly. Not every young engineer can expect to make even a modest contribution of an original nature; but honest, careful compilation is well worth doing, so long as the subject is of genuine interest to the compiler. It will invariably have its proper reaction, both on his audience and himself. To write a paper which shall say all that is necessary, say it concisely and clearly, and say it tactfully instead of priggishly, may well mark an epoch in the intellectual history of its writer. If he can profit by the criticism with which his paper is received, he will have reached his intellectual majority. But the time for such work is the period before responsibility has wiped out his leisure, while he retains his readiness for intellectual adventure, and his memory is still unencumbered and equal to the task of mobilizing information from many sources. The fact that the work has been done before need not stand in the way of its being done over again from a fresh point of view, provided the material is re-investigated, and mere plagiarism is avoided.

Popular Lectures

May I be allowed as a former school trustee to refer to this matter? A good many engineers, both old and young, have it in them to prepare one popular lecture on an engineering subject, which will be cordially welcomed by nearly every high school principal, to say nothing of other audiences. If such a lecture can be illustrated with lantern slides, it will be all the better; but an interesting lecture can be given without any lantern slides, provided the speaker is describing some engineering project of which he has made a first-hand study. It was a great surprise to me to find that the girl pupils of the high school in one municipality attended as closely as the boys during the delivery of two engineering lectures.

I am not suggesting that the branches of The Institute should make a special point of popular lectures. Such lectures are necessarily on a plane altogether different as regards treatment from the professional papers which are the special concern of The Institute. But Vancouver had an admirable example of a popular lecture about twenty years ago from a former chairman of the Branch, Mr. G. R. G. Conway, M.E.I.C., who took up the subject of "Bridges," and gave a number of audiences a higher conception of the nature of one work of the civil engineer than they had before. Judging by the eagerness, which was so widely shown not so long ago, to believe an ill-judged utterance of a provincial premier as to the possibility of a man's learning all that there was to be learned about civil engineering in six months, it might not be too much of a departure from the objects of The Institute if one of your members were to repeat the performance of Mr. Conway at the present time.

The Tone of the Debates

Professor Huxley was once writing a letter accepting the honorary presidency of a students' society, and took occasion to give the advice, "Boys, don't fight." Such an advice was doubly weighty, coming from a master of controversy. Within a few years, however, the society went through a troubled period, which was started by some caustic criticism, uttered by a leading official regarding the first attempt of a well-meaning but inexperienced member to write a paper. Even acute differences of opinion may be expressed in debate by members in established positions; but they must be expressed neither caustically nor sneeringly. It is well, however, in the case of junior members, to make any drastic criticisms privately to themselves. They will discover the worst faults in their papers without any aid in a few weeks. Hopelessly impossible members, who persistently endeavour to make every other speaker or writer look cheap, are best dealt with by a conspiracy of silence, though human nature does not always admit of its adoption. The chairman, however, should use his position to temper any sharp criticisms of well meaning but not completely efficient speakers and writers. It is expected of him, especially by the victims. But the senior members may well co-operate with him in the duty of keeping the meetings free from features which would give rise to stinging memories. Such a course need not prevent the fullest play of spirited argument.

It is not the business of an engineer to quote poetry; but I cannot help quoting a line which seems to me peculiarly applicable to the conduct of such a society as The Institute—

"Not failure, but low aim, is crime."

It is far from being a low aim to cultivate a friendly interest in one another's professional problems.

James Porter.

Petrol from Coal

A small plant placed in a corner of the vast works of Imperial Chemical Industries, at Billingham-on-Tees, has been producing grade No. 1 petrol from ordinary coal for more than a year.

This petrol has been subjected to exhaustive tests and found excellent in quality. But a slight advantage in price held by the natural product and a realization of the magnitude of the plant required to obtain petrol from coal in adequate quantities for commercial purposes, implying a heavy initial outlay, were considerations which acted as a deterrent to this company failing some definite gesture of support, or guarantee, from the British government.

That support has now been given, and it is announced that Billingham-on-Tees will become the centre of an industry aiming to produce 100,000 tons a year of grade 1 petrol, processing 400 tons of coal a day and using altogether 1,000 tons of coal a day. This will give permanent employment to 2,500 men and to others indirectly.

Over the next eighteen months 7,000 men will be engaged on building and erecting the plant. Imperial Chemical Industries will provide the whole of the initial capital required, two and a half millions sterling.—*Industrial Britain.*

A Primitive Pit Gear

An appeal has been made for the preservation of a primitive pit gear used at an old ironstone mine north of Rhymney, in Monmouthshire. The mine was 55 yards deep. A stout cast-iron frame carried a pulley over which passed a chain, which carried a pit cage on one side and a round tank to hold about two tons of water on the other. To raise the minerals the tank was filled with water which, when released by a brake, dropped to the bottom of the mine and was there released. The length of the headgear is about 18 feet 9 inches, the width 9 feet, and the height above ground to the top of the pulley 15 feet. It is suggested that this old plant, which is in excellent preservation, should be placed in the School of Mines at Treforest, or in the National Museum of Wales, as illustrating how mining was carried on before modern plant was devised.—*Engineering.*

BRIEF

FROM THE

National Construction Council of Canada

TO

The Royal Commission on Banking and Currency*

(*Abridged*)

The volume of construction work in Canada as measured by the total of construction contracts of all kinds awarded in Canada, using the figures found in the Canada Year Book, 1932, is as follows:

Year	First 6 months	12 months
1925		$297,973,000
1926		372,947,900
1927		418,951,600
1928		472,032,600
1929		576,651,800
1930		456,999,600
1931		315,482,000
1932	$74,761,200	132,872,400
1933	32,912,300	

The peak in 1929 showed a yearly volume of $577,000,000 against the first six months of 1933 of $33,000,000, or a present yearly rate of $66,000,000. We therefore are doing business this year at the rate of 11½ per cent of our maximum year.

From figures furnished by the Dominion Bureau of Statistics this industry employed in 1929 at the peak 300,000 direct workers. From the same source we are given a figure of 70,000 as the number of indirect workers, or a total of 370,000. It is very difficult to arrive at an accurate figure for the indirect workers in this industry on account of its far reaching ramifications. We believe this figure of 70,000 to be inordinately low. In the United Kingdom official reports have been issued from time to time using the relationship of one direct worker to one indirect worker, and if we follow this precedent—which we ourselves believe to be very conservative—we arrive at a total of 600,000 persons in Canada engaged in construction before the beginning of the present industrial depression.

It is obvious from the above that the lack of work in the construction industry is responsible in a very large measure for the numbers of unemployed in the country. It is also correct to state that if the construction industry were operating at 1929 rate 500,000 people would be back in employment today who are at present unemployed. In other words, about half of Canada's unemployment problem can be laid at the door of this industry.

Our industry in Canada has often been criticized on account of its size, and the same criticism can be levelled at a great many other industries in Canada. It is undoubtedly true that our industry is organized for a greater population than exists in the country. This is no fault of the industry itself as it is merely an instrument of service to the public and must grow to meet the demand. The trouble is entirely with the type of demand.

In 1920, and again in 1929, this industry was working under very heavy pressure. When the depression started at the end of 1920, although other industries were immediately affected, the construction industry, due to its size and momentum, carried on well into 1921 before the depression was really felt to any material extent. Again in 1929, long after the market crash in October, the construction industry was still working under a considerable pressure.

You will notice in the first table in this report that in 1930, $457,000,000 worth of work was carried out. Even in 1931, $315,000,000 was the figure, a heavier year than 1925 which is commonly taken as a normal year. It should further be noted that these figures are for contracts awarded and that the work represented is done on an average during the next twelve months. In other words, the effect of the 1930 volume would be felt to a large extent in 1931, and so on.

Conversely, at the end of every business depression the construction industry has always been the last industry to recover.

We therefore suggest to your Commission that they give serious consideration to this problem, which we submit is one of national importance.

We suggest on broad lines to take care of peak periods that the industry itself could, with the help of Federal departments and statistical data, provide appropriate measuring rods which would indicate when the danger point had been reached, at which point some external financial authority would require to step into the situation and put on the brakes, by refusing to provide credit for construction work which appeared to be unnecessary. We leave it to your Commission to decide whether the chartered banks of Canada are properly constituted or are strong enough to apply the necessary deterrent, or whether some other financial machinery should be set up.

At the other end of the cycle, when the depression is over and business is commencing to return to normal, the construction industry finds itself faced with lack of confidence in its erstwhile customers, and faced with lack of available funds. Financial institutions which would

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*Presented at Toronto, Ont., on September 8th, 1933, by J. B. Carswell, M.E.I.C.

normally provide these funds are themselves suffering from the same lack of confidence, and the construction industry is quite unable to get into operation although the demand for construction may exist in perfectly obvious form.

We again suggest to your Commission that at this point provision should be made whereby the credit of the state should be used to facilitate the supply of money to the construction industry.

In what follows we will attempt to set out the position of the industry in Canada today and the real necessity of taking some financial action which will tend to decrease the vast amounts being spent on direct relief and divert these monies into more profitable channels.

From a study of the figures published by the Dominion Bureau of Statistics a rough total for the value of all buildings standing in Canada is $5,000,000,000. This is exclusive of engineering works, which would vastly increase such a total. In the last three years of this depression, taking depreciation on buildings at the modest rate of 2 per cent per annum, we arrive at the fact that $300,000,000 should be spent in Canada every year to balance the ordinary wastage due to depreciation in buildings alone.

To find out more specifically what volume of construction work was actually held up in Canada during the past three years of the depression, the National Construction Council instituted a survey of the whole country, sending out questionnaires to all important municipalities. The result of this survey was compared with other figures obtained from the files of the Daily Commercial News in Canada, who keep running records of all construction operations. It was also compared with the very complete figures from MacLeans Building Reports, and the average figure obtained from all three sources shows that from January 1st, 1930, to July 1st, 1933, in a period of three and a half years, $225,000,000 worth of engineering works have been postponed in Canada, and $175,000,000 worth of building work, or a total of $400,000,000.

We do not wish to suggest for a moment that the entire list of work represented by this $400,000,000 is sound construction work that could be proceeded with under present financial conditions. The National Construction Council, using its best judgment, has attempted to sub-divide this total into three main headings as follows:

1. Federal and provincial public works which properly could be carried out at the present moment totalling $97,000,000.
2. Private projects, both engineering and building, held up through inability to borrow money at reasonable rates of interest, amounting to $85,000,000.
3. Federal and provincial works, as well as private work, awaiting the return of demand, amounting to $218,000,000.

The construction industry is facing another problem in connection with the housing situation in Canada. The figures just quoted on the volume of construction held up, do not include house building to any material extent as you will realize the difficulty in arriving at a figure representing the value of contemplated private house building.

The National Construction Council is at present investigating this situation very thoroughly. At the moment of writing figures are not available for the whole of Canada, but as an instance we may cite the situation in the city of Toronto. In the year 1927, according to figures furnished by Might Directories Limited, Toronto, there were 6,054 vacant houses in the city. In 1932 there were 3,885 vacant houses. In 1933 there were only 2,670 vacant houses, and from figures prepared by the Assessment Department of the city there are between 7,500 and 10,000 families who have doubled up since the beginning of the depression. The same department also reports that there are only 400 houses under construction in the whole city. These figures indicate at once that there is a serious shortage of housing in Toronto at the present moment, but under present conditions with the moratorium existing in Ontario, and with the lack of loaning facilities at reasonable rates of interest, it is quite impossible for the construction industry to commence house building without some external assistance.

From a survey carried out by the manufacturers of vitrified tile, which survey has just been completed, we are told that 272 municipalities of a population of 1,000 and over are in need of sewage systems but lack the financial ability to proceed. These municipalities are located as follows:

British Columbia	20
Alberta	8
Saskatchewan	11
Manitoba	8
Ontario	114
Quebec	87
Maritimes	24
	272

From all of the above, it should appear that despite its inactivity there is plenty of work for the construction industry to do, and it is undoubtedly true that while other industries are recovering gradually the construction industry, without some assistance, will be forced to wait too long. The longer it waits the longer will our unemployment problem be with us, and the longer it waits the more danger there will be of running into another peak in construction. The factors which stand in the way might be summarized as follows:

1. Federal and provincial reluctance to spend money on construction.
2. The inability of the municipalities through lack of credit to make any move.
3. The inability of private corporations and private individuals to obtain funds at reasonable rates of interest.
4. The lack of demand both for private and governmental work which is a corollary of every depression.

The construction industry, beyond all other industries, is unique in its ability to provide great diversity of employment. The ramifications of this industry are so far reaching that it is difficult to find any major industry in the country not seriously affected by its prosperity or otherwise. It follows that a dollar spent in the construction industry is diffused through the whole fabric of industry. No particular group and no particular locality is affected more than any other group or locality. A bridge on the west coast will provide work for steel makers in Sydney. An office building in Toronto provides work for the lumbermen in British Columbia.

To this aspect should be coupled a second significant factor, that for every dollar spent in this industry approximately 82 cents goes towards labour. In other words it goes into the pay envelopes of the workers in this country whether they be on the job or whether they be in the factory working on materials and supplies. The other 18 cents represents contractors' profits, which is simply wages in another form, togther with the cost of providing capital for the operation.

The subject matter which we have presented may be divided into two major headings.

In the first place we are sorely in need of some permanent financial machinery which can be set up the better to control this ponderous and important industry.

The men within the industry have for many years endeavoured to educate the public, and particularly to educate Federal, provincial and municipal authorities to the grave necessity of budgeting their construction work so that they will help to level out the peaks and valleys in volume. We have met with little success and we are convinced that what we now ask is the only real solution. What form this financial machinery should take, we reiterate, is a matter outside of our province, but it is our sincere hope that your Commission will give this matter serious consideration.

Second, in periods of intense depression such as we are experiencing just now, it is the judgment of this industry that the resources of the state should be utilized to stimulate the industry by the provision of easier credit and cheaper money. How this can be brought about is again without our province, but we do know that until steps along these lines are taken, every depression in the future will provide a repetition of the present serious unemployment.

APPENDIX "A"

List of Associations Whose Membership Forms the National Construction Council of Canada

Royal Architectural Institute of Canada.
Canadian Construction Association.
Canadian Manufacturers Association.
Engineering Institute of Canada.
Trades and Labour Congress of Canada.
Canadian Lumbermen's Association.
Brick Manufacturers Association of Canada.
The Canadian Ceramics Society.
Asphalt Roofing Manufacturers of Canada.
Structural Clay Tile Association.
Canadian Council of the International Society of Master Painters and Decorators.
Canadian Founders and Metal Trades Association.

Empire Standards

On March 14th, 1933, an Order-in-council was issued by the Privy Council of the Dominion government stating that whenever materials or goods not produced or manufactured in Canada are required by any government department, or by any contractor engaged in government work, provision shall be made in the tenders providing that such material shall be of Empire production or manufacture and that, where standards are specified, an Empire standard shall be adopted unless it is conclusively shown that goods or materials in question cannot be obtained in the Empire. It is understood that this will apply to the Canadian National Railways and every board, commission or other similar body under the control of parliament who are requested to adopt a similar rule with reference to purchase and contracts.

The Dominion Department of Public Works has recently included in their standard form of contract a clause referring to C.E.S.A. standards which reads as follows:—

> "*Unless otherwise expressly provided in the specification, all goods or materials supplied shall conform to the specifications of the Canadian Engineering Standards Association, or the specifications of the recognized Standards Association in the country of origin in the Empire, and in cases where goods or materials are required, which are not Canadian production or manufacture, the standards above mentioned shall apply.*"

This action on the part of the Dominion government should be of great assistance in promoting a wider adoption of C.E.S.A. standards.—*C.E.S.A. Bulletin.*

Motor Fuel and "Doping"

Abridged from the Times Trade and Engineering Supplement, September 9th, 1933

From an early date contracts for the supply of fuel to the R.A.F. will be let under two new specifications calling for an octane number determined by a method recently adopted as a standard by the Institute of Petroleum Technologists which it is hoped may ultimately be adopted internationally. It requires two classes of fuel—one in which tetra-ethyl-lead may not be used, and another in which "dope" may be used as required up to a quantity of 4 c.c. to the gallon. The former fuel will be available for all existing standard types of engine; the latter for new types or later "marks" of existing types about to come into Service use.

This decision of the Air Ministry marks an important stage in the progress of fuel technology. It has been known for some years that detonation can be overcome by "doping" fuels, but the only "dope" available has been tetra-ethyl-lead, which, having a metallic base is not completely combustible. During the last ten or twelve years great efforts have been made to discover a substitute for tetra-ethyl-lead consisting preferably of some organic compound containing only carbon and hydrogen. The fuel industry is now fairly certain, however, as the result of research in recent years that the metallic base cannot be avoided. Until that point was established it was not felt to be worth while to make engines to suit a particular "dope."

Curing Detonation

Very soon after the War the research work of Ricardo in England and Midgeley in the United States brought out the fact that the controlling factor in the limitation of power output was the tendency to detonation. The need to overcome it by means of "doping" is particularly necessary in aviation for a reason which does not affect most other users of petrol fuel. Ricardo showed that in ordinary circumstances the aromatic fuels, such as benzol, and those natural petrols containing a high percentage of aromatics, give much less trouble in the matter of detonation. Aviation is hampered in adopting this type of fuel partly on the grounds of supply and partly because of the liability of benzol to freeze at comparatively high temperatures. The search for a substance which could be added to the non-aromatic fuels to raise their knock ratings then began and Midgeley chanced upon tetra-ethyl-lead, a "dope" which proved to be very suitable because very little of it had to be added to a large quantity of fuel to produce the desired result.

Air Ministry Policy

The Air Ministry, as most people know, is seeking and obtaining long life in its engines. The period between overhauls has gone steadily up to five hundred flying hours, and in ordinary times considerations of economy will probably prevent any disturbance of that policy. There have been examples of the radical changes which may be made at need. The most striking was that of the Rolls-Royce "R" engine for the Schneider Trophy race, which, with a small increase of weight, was able to deliver no less than 2,300 h.p. during its short life of the order of three or four hours at full throttle, as compared with the very similar engine, the Buzzard, rated at 825 h.p. and running regularly for four hundred hours between overhauls. In the United States there appears to be less desire for long life. The average running time between overhauls is said to be about one hundred and fifty hours. Fuels of higher octane numbers are used and the engines are worked harder during their shorter lives.

This method of specifying fuels according to their knock rating is of great importance, because the design of a new engine is fundamentally influenced by the anti-knock quality of the fuel which will be available for it, and once an engine has been designed to operate on a fuel of a certain definite anti-knock quality it is desirable to be able to prescribe fuel of that particular quality for it.

The Octane Rating

As soon as it became evident that this would have to be done, a method of measuring detonation had to be found. Ricardo's suggestion in the first place was to define the quality of a fuel in terms of the maximum compression ratio which a certain test engine would stand without detonating, when using that particular fuel. That, of course, had the disadvantage of providing a different fuel rating for every type of test engine. It was next suggested that knock rating should be rendered in terms of the chemical constitution of a standard fuel. All petrol fuels are extremely complex mixtures—too complex, in fact, for such chemical prescription. It is possible, however, to take two pure substances—namely, iso-octane, which is definite chemical compound, and heptane, which can also be obtained as a pure chemical compound. The former is good in regard to detonation when used as a fuel in an engine, and the latter is bad. By combining the two in various proportions, any required standard of anti-knock quality may be obtained.

A particular fuel which detonates, for example, under the same conditions as a mixture of 30 per cent heptane and 70 per cent octane is said to have an octane number of 70. Using such a method of expressing knock rating, it is clearly of the greatest importance to have uniformity in the conditions under which this rating is reached. The rating, if it is to be of general value, must refer to a test in a particular engine and in particular conditions of r.p.m. and temperatures.

An attempt was made at the recent World Petroleum Congress held in London in July, to secure international agreement on this matter of a standard test engine and testing conditions. The movement towards unity is proceeding. Mr. D. R. Pye, deputy director of scientific research at the Air Ministry, who was chairman of a sub-committee of the Institution of Petroleum Technologists which undertook an investigation into the correlation of the knock-rating figures given by certain test engines under specified conditions, with the results obtained in aero engines, presided also at the meeting of the World Petroleum Congress which considered proposals for the standardization of rating tests throughout the world.

A Testing Engine

As a result of their extensive series of trials the committee recommended the adoption of what is known as the C.F.R. engine as the standard testing engine, and it was hoped that this engine at present built by the Waukesha Motor Company of the U.S.A. might be generally adopted as the international standard. The discussions at the World Congress, however, showed that conditions are not yet ripe for any universal agreement. The C.F.R. engine and one somewhat similar, known as the Series 30, have both been widely used in this country and in the U.S.A. for research work and the testing of knock ratings, but the Continental countries have hitherto had very little experience of these engines and are unwilling at present to agree to either as the universal test engine. But the international congress agreed that it was very desirable that further work should be done with a view to a general international agreement, and recommended that the results of all comparative test work in the various countries should be forwarded to the Institute of Petroleum Technologists in England for comparison and correlation.

British Standard Graphical Symbols for Electrical Purposes

In making diagrams of connections in electrical work, it has long been customary to employ symbols to denote the various machines and apparatus. This procedure, while theoretically making for simplicity, may easily lead to waste of time and confusion, unless everyone employs the same symbols to mean the same thing. Consequently, the standardization of nomenclature and symbols has formed an important part of the work of the British Standards Institution and of the International Electrotechnical Commission. Actually, a British Standard List of Graphical Symbols for Electrical Purposes was first issued in 1922, and the question was taken up by the International Electrotechnical Commission about the same time. The latter body published their Report on Symbols in 1930, and now a revised edition (B.S. No. 108-1933) of the British Standard List has been issued. In selecting and devising the symbols, the desiderata that they should be self-explanatory, easy to draw, and in general use, have been borne in mind, and the ideal that any particular form of symbol should only be applied to a single device, has been aimed at. To reduce the number of symbols, a mnemonic system of code letters has been provided so that the meaning to be conveyed is amplified or more closely defined. Copies may be obtained from the British Standards Institution, Publications Department, 28, Victoria Street, London, S.W.1, price 2s. 2d., post free.—*Engineering.*

The Baltic-White Sea Canal and Its Builders

Abridged from an article appearing in the September, 1933, issue of the Soviet Union Review

The new Baltic-White Sea canal, a waterway of great economic importance, and one of the finest engineering feats yet accomplished in the Soviet Union, was officially opened by government decree on August 2nd.

The canal, which connects the White Sea and the Baltic by providing a sea-level waterway from Soroka on the White Sea to Leningrad on the Gulf of Finland, is 227 kilometres long, reaching from Lake Onega to the White Sea. It contains nineteen locks, fifteen dams, twelve floodgates, forty-nine dykes and thirty-three inner canals. The distance by water from Leningrad to Archangel is now reduced to one-fourth from 2,840 miles to 674. The canal itself only takes up about twenty per cent of the waterway, the remainder is regulated rivers and lakes.

Through the Mariinsk system of canals and the Neva and Volga rivers, the canal also links the White Sea with the Caspian.

A vast amount of work was involved in the construction of the canal, under the most difficult geological and hydrological conditions. Twenty-one million cubic metres of earth was excavated, of which 2,000,000 was solid granite, 390,000 metres of concrete was laid, and 921,000 metres of caisson work performed. Two hundred kilometres of modern roads were built in Karelia, and 104 kilometres of the Murmansk railroad roadbed, which was in danger of flooding, was shifted to an elevated embankment.

The canal was constructed entirely of Soviet materials and machinery and by Soviet citizens. No foreign consultation was employed. Local material was used to a great extent—especially the lumber cut in clearing the way for the canal and the rock from blasting. Wherever possible iron and steel, of which there is a shortage in the U.S.S.R., were replaced by the wood so abundant in that region.

The work was carried out by Bielmorstroy (Baltic-White Sea Construction) under the leadership of the OGPU (United State Political Administration). The work was done entirely by prisoners from the correctional labour camps of the OGPU, most of whom were either freed entirely or given reduced sentences as a result of their work. The canal was started at the end of November, 1931, and completed on June 20th of this year, in less than twenty months, a record of hydrotechnical construction. The first ship went through on June 25th. It is of interest to note that the Panama canal, which is only 81.3 kilometres long, took eleven years to build, and the Suez canal, 164 kilometres long, took ten years.

In the progress of the work a tremendous amount of educational work was carried on among the prisoners who acquired labour discipline and industrial skill, and made an excellent showing. The highest honours which the Soviet government can bestow were awarded to the engineers and leaders in the building operations. Eight persons were awarded the Order of Lenin, and fifteen were awarded the Order of the Red Banner of Labour. Of the latter group nine had been condemned for wrecking activities, but released in 1932, before the expiration of the sentences, the remainder had been tried for theft, speculation and other crimes. These released prisoners had all preferred to remain and see the work through to completion rather than take advantage of the opportunity to go elsewhere.

The most widespread amnesty ever granted in the Soviet Union was also proclaimed in connection with the completion of the canal. During the building of the canal the OGPU completely exempted 12,484 persons from the remainder of their sentences. The terms were reduced in the case of 59,516 persons condemned to various terms of imprisonment who had shown themselves energetic workers. The conviction was completely erased and civil rights restored to 500 persons for especially self-sacrificing work in the building of the canal.

No job has yet been done in the Soviet Union with such dispatch, skill and efficient organization. In November, 1931, Mr. Yagoda, assistant chairman of the OGPU who was put in charge of the project, called a group of his co-workers to him and announced that the government had commissioned the OGPU with the task of building the canal. He said it was to be started at once and ready for navigation in 1933. He said it must be built economically, strongly, quickly. He asked them to call the engineers under the OGPU's care together to make the plans, and to be ready to leave for the place of construction by the end of the month.

In record time, the engineers, some of them serving sentences for damaging activities, drew up the plans and in November, 1931, the first group of prisoners—thieves, pickpockets, embezzlers, wreckers, bandits— some of them with many convictions to their records, arrived with their axes and crowbars among the snowdrifts of Karelia. Soon they had cut through a solid swathe of 85,000 hectares from Lake Onega to Soroka, and the digging of the canal, hand-digging, blasting, building of dykes, and dams and sluices began.

The workers were not made to feel that they were a "faceless" mass, of whom physical effort only was required. They were given full freedom in their leisure hours. A cultural and recreational department was organized immediately, with prisoners themselves in positions of leadership. As a result many of them on release have immediately obtained excellent positions as mechanics, electricians, tractor drivers, bookkeepers and so on.

The economic effect of the canal will be immediate. It is estimated that this year one million tons of cargo will be shipped on it. By the end of the second five-year plan traffic is expected to reach ten million tons a year. In the future it is planned to build a number of hydroelectric stations at various points along the canal to provide cheap power to the industries of the region.

New Electric Timers

A utility time switch to serve miscellaneous needs, a thermostat timer, and an electric-range timer are included in the new type T14 time switches which have been announced by Canadian General Electric Company Limited.

The utility switch turns on and turns off once every twenty-four hours. The timer has a clock face, with the setting dials below, and it is only necessary to plug it into any outlet and set it. It will turn radio sets on and off, and in a house it may also deter burglary by turning on a lamp to give apparent evidence of occupancy on evenings when the family is away.

The electric-range timer has the mechanism so arranged that the on-off cycle is not repeated automatically and is used to turn the oven of an electric range on and off automatically.

The thermostat timer is for use with double-range (day and night) thermostats commonly employed in the control of house-heating systems. There is an "a.m. and p.m." indicator and a dial for setting the clock at a.m. or p.m. time. Two other pointers are used to set the mechanism to the proper time setting for the day and night temperature regulators to be put in operation.

Elevators in the Rockefeller Centre

Passenger elevators recently put in operation at Rockefeller Centre, New York City, have twenty-four of the seventy-five Westinghouse elevators in the main building operating at 1,200 feet per minute.

During performance tests some of the cars were run at 1,500 feet per minute and one car has been tested and approved by city inspectors to operate at 1,400 feet per minute.

These elevators are of the automatic-landing type, with a travel from 497 to 770 feet. The highest rise cars make a round trip with terminal stops only, in 95 seconds. They will be in motion about 58 per cent of the time and for 40 per cent of the time will be running at full speed.

The building is seventy floors high, requiring for the eight high-rise elevators six cables 11/16 of an inch in diameter and each 1,600 feet in length. The cars have a rated capacity of 3,500 pounds and the total suspended load is 25,530 pounds, accelerated and decelerated at a rate of about eight feet per second.

To attain a speed of 1,200 feet per minute requires a travel of six floors and another six floors to stop. Their operation is simple. The attendant has but two mechanical functions to perform; he operates a toggle switch to close the power-operated hatch and car doors, and he pushes destination buttons as the passenger call out their floors. Otherwise, the operation is fully automatic. Upon the closing of the doors, the car starts, accelerates, stops at the correct floors and the doors immediately fly open.

Without attention of the attendant, a passenger on the corridor floor stops the first car approaching that floor in the direction he has indicated by pushing the correct directional button. This automatic stopping at floors is accomplished by a device known as the selector, located in the penthouse, and employs a carriage for each car. This carriage travels in a direct ratio with the travel of the car over a set of contacts. The travel of the carriage is governed by means of inductor switches on the elevator car which actuate circuits operating the carriage motor. There is a set of contacts for each floor, and the required circuits are set up from this point.

The corridor and car doors are power operated by individual electric motors. This is to minimize the standing time. The passengers are protected from any possibility of the doors striking them by a device for focusing two rays of light across the opening upon photo cells. Interruption of either ray (spaced about three feet apart one above the other) by a passenger causes the doors to remain open or to re-open if they have started to close.

The motors have a continuous rating of 100 h.p. applied on this basis because of the long runs, and weigh 25,000 pounds. The sheaves are 42 inches in diameter. Power is supplied to them through individual a.c.-d.c. motor-generator sets in order to govern their operation by means of generator voltage control and thus gaining smooth acceleration.

Application of the safety equipment must be made with a minimum delay and applied to stop the car at a rate (about gravity) which will not injure the passengers. This is a function of both the speed governor (fly ball type) and the car safety, a device mounted underneath the car and equipped with powerful jaws which grip the guide rails upon the tripping of the governor. The safety jaws are fully applied within a distance of eleven feet travel from a speed of 1,200 feet per minute.

Sale of 1/64-inch Rubber-insulated Twisted-pair Fixture Wire

The sale of this wire, which is not constructed in accordance with Canadian standards and is not labelled by either Underwriters' Laboratories or the Hydro-Electric Power Commission, as required by the Canadian Electrical Code, has recently grown to such proportions in Canada that steps have been taken to eliminate it from the market.

The Canadian manufacturers of wire and cable have agreed to cease the production of this wire, and the inspection authorities in the provinces of Saskatchewan, Ontario, Quebec and in the city of Winnipeg, have agreed to prohibit its sale on and after January 1st, 1934. The chief electrical inspector of Prince Edward Island has also agreed to recommend that its sale be discontinued in that province.

It is expected that this action will be followed by other Provinces and that this type of wire will shortly disappear from the Canadian market.

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 Wanted

ELECTRICAL AND RADIO ENGINEER, B.Sc., '28. Experience in the design and testing of broadcast radio receivers, including latest superheterodyne practice, and capable of constructing apparatus for testing same Also familiar with telephone and telephone repeater engineering. Thorough experience in design, and construction and inspection of municipal power conduits. Apply to Box No. 12-W.

MECHANICAL ENGINEER, Canadian, with technical training and executive experience in both Canadian and American industries, particularly plant layout, equipment, planning and production control methods, is open for employment with company desirous of improving manufacturing methods, lowering costs and preparing for business expansion. Apply to Box No. 35-W.

MECHANICAL ENGINEER, A.M.E.I.C. Married. Experience in machine shops, erection and maintenance of industrial plant mechanical and structural design. Reads German, French, Dutch and Spanish. Seeks any suitable position. Apply to Box No. 84-W.

YOUNG ENGINEER, B.A., B.SC., A.M.E.I.C., R.P.E., Ont. Competent draughtsman and surveyor. Eight years experience including design, superintendence and layout of pulp and paper mills, hydro-electric projects and general construction. Limited experience in mechanical design and industrial plant maintenance. Apply to Box No. 150-W.

PURCHASING ENGINEER, graduate mechanical engineer, Canadian, married, 34 years of age, with 13 years' experience in the industrial field, including design, construction and operation, 8 years of which had to do with the development of specifications and ordering of equipment and materials for plant extensions and maintenance; one year engaged on sale of surplus construction equipment. Full details upon request. Apply to Box No. 161-W.

STRUCTURAL ENGINEER, B.A.SC., '15, A.M.E.I.C., R.P.E., (Ont.) Married. Experience in structural steel and concrete includes ten years design, five years sales, two years shop practice and erection, and one year advertising. Available at two weeks notice. Apply to Box No. 193-W.

CIVIL ENGINEER, age 44, open for employment anywhere, experience covers about 20 years' active work, including 7 years on municipal engineering, 2 years as Town Manager, 3 years on railway construction, 3 years on the staff of a provincial highway department. 2 years as contractor's superintendent on pavement construction. Apply to Box No. 216-W.

REINFORCED CONCRETE ENGINEER, B.SC., P.E.Q., eight years experience in construction design of industrial buildings, office buildings, apartment houses, etc. Age 30. Married. Apply to Box No. 257-W.

MECHANICAL ENGINEER, B.Sc., McGill '19, A.M.E.I.C. Married. Twelve years experience including oil refinery power plant, structural and reinforced concrete design, factory maintenance, steam generation and distribution problems, heating and ventilating. Available at once. Location immaterial. Apply to Box No. 265-W.

ELECTRICAL ENGINEER, B.SC., '28, Canadian. Age 25. Experience includes two summers with power company; thirteen months test course with C.G.E. Co.; telephone engineering, and the past thirty months with a large power company in operation and maintenance engineering. Location immaterial and available immediately. Apply to Box No. 266-W.

PLANE-TABLE TOPOGRAPHER, B.SC., in C.E. Thoroughly experienced in modern field mapping methods including ground control for aerial surveys. Fast and efficient in surveys for construction, hydro-electric and geological investigations. Apply to Box No. 431-W.

ELECTRICAL ENGINEER, B.SC., A.M.E.I.C., AM.A.I.E.E., age 30, single. Eight years experience H.E. and steam power plants, substations, etc., shop layouts, steel and concrete design. Location immaterial. Available immediately. Apply to Box No. 435-W.

CIVIL ENGINEER, B.A.SC., and C.E., A.M.E.I.C., age 30, married. Experience over the last ten years covers construction on hydro-electric and railway work as instrumentman and resident engineer. Also office work on teaching and design, investigations and hydraulic works, reinforced concrete, bridge foundations and caissons. Location immaterial. Available at once. Apply to Box No. 447-W.

CIVIL ENGINEER, B.SC., A.M.E.I.C., with six years experience in paper mill and hydro-electric work, desires position in western Canada. Capable of handling reinforced concrete and steel design, paper mill equipment and piping layout, estimates, field surveys, or acting as resident engineer on construction. Now on west coast and available at once. Apply to Box No. 482-W.

Situations Wanted

MECHANICAL ENGINEER, B.SC. Age 28, married. Four and a half years on industrial plant maintenance and construction, including shop production work and pulp and paper mill control. Also two and a half years on structural steel and reinforced concrete design. Located in Toronto. Available at once. Apply to Box No 521-W.

CIVIL ENGINEER, Canadian, married, twenty-five years' technical and executive experience, specialized knowledge of industrial housing problems and the administration of industrial towns, also town planning and municipal engineering, desires new connection. Available on reasonable notice. Personal interview sought. Apply to Box No. 544-W.

ELECTRICAL AND MECHANICAL ENGINEER, B.SC., A.M.E.I.C. Experience includes C.G.E. Students Test Course and six years in engrg. dept. of same company on design of electrical equipment. Four summers as instrumentman on surveying and highway construction. Recently completed course in mechanical engineering. Available at once. Location preferred Ontario, Quebec, or Maritimes. Apply to Box No. 564-W.

CIVIL ENGINEER, age 25, single, graduate. Creditable record on responsible hydro and railroad work in both Eastern and Western Canada. Apply to Box No. 567-W.

MECHANICAL ENGINEER, A.M.E.I.C., with twenty years experience on mechanical and structural design, desires connection. Available at once. Apply to Box No. 571-W

Employment Service Bureau

This bureau is maintained by The Engineering Institute of Canada for the benefit of members and organizations employing technically trained men.

An enquiry addressed to 2050 Mansfield Street, Montreal, will bring full information concerning the services offered. Details can also be obtained from Branch secretaries who are located in the larger centres throughout Canada.

Brief announcements of men available and positions vacant will be published without charge in The Engineering Journal and the Bulletin. Replies addressed in care of the required box number will be forwarded to the advertiser without delay.

An additional service also offered those who are unemployed or wish to change their positions, is the opportunity of placing their names and records on file at 2050 Mansfield Street for consideration by employers wishing to employ engineers. This is of great assistance as many employers will not advertise or wish to locate a suitable man on short notice. If desired the information contained in these records can be kept confidential.

Forms for registration purposes may be obtained from The Institute Headquarters or Branch secretaries.

MECHANICAL ENGINEER, B.A.SC., '30, desires position to gain experience, and which offers opportunity for advancement. Experience in pulp and paper mill and one year in mechanical department of large electrical company. Location immaterial. Available immediately Apply to Box No. 577-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.

MECHANICAL ENGINEER, Canadian, technically trained; eighteen years experience as foreman, superintendent and engineer in manufacturing, repair work of all kinds, maintenance and special machinery building. Location immaterial. Available at once. Apply to Box No. 601-W.

CHEMICAL ENGINEER, S.E.I.C., B.SC., University of Alberta, '30. Age 31. Single. Six seasons' practical laboratory experience, three as chief chemist and three as assistant chemist in cement plant; one year's p.g. work in physical chemistry; three years' experience teaching. Desires position in any industry with chemical control. Available immediately. Apply to Box No. 609-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.

CIVIL ENGINEER, A.M.E.I.C., R.P.E., Ontario; three years construction engineer on industrial plants; fourteen years in charge of construction of hydraulic power developments, tower lines, sub-stations, etc.; four years as executive in charge of construction and development of harbours, including railways, docks, warehouses, hydraulic dredging, land reclamation, etc. Apply to Box No. 647-W.

Situations Wanted

MECHANICAL ENGINEER, A.M.E.I.C., Canadian, technically trained; six years drawing office. Office experience, including general design and plant layout. Also two years general shop work, including machine, pattern and foundry experience, desires position with industrial firm in capacity of production engineer or estimator. Available on short notice. Apply to Box No. 676-W.

ELECTRICAL AND CIVIL ENGINEER, B.SC., Elec., '29, B.SC., Civil '33. Age 27. JR.E.I.C. Undergraduate experience in surveying and concrete foundations; also four months with Canadian General Electric Co. Thirty-three months in engineering office of a large electrical manufacturing company since graduation. Good experience in layouts, switching diagrams, specifications and pricing. Best of references. Available immediately. Apply to Box No. 693-W.

MECHANICAL ENGINEER, JR.E.I.C., grad. Tech. Coll., age 29. Seven years experience pulp and paper mill design and maintenance. Hydro developments. Recently designing engineer road making machinery, hoists, crushers, gravel plants, graders, foundry and machine shop supervision. Paper machine design, building construction. Technical advertising. Location immaterial. Apply to Box No. 699-W.

MECHANICAL ENGINEER, B.SC., '27, JR.E.I.C. Four years maintenance of high speed Diesel engines units, 200 to 1,300 h.p. Also maintenance of D.C. and A.C. electrical systems and machinery. Draughting experience. Westinghouse apprenticeship course. Practical mechanical and electrical engineer with a special study of high speed Diesel engine design, application and operation. Location in western or eastern Canada immaterial. Apply to Box No. 703-W.

COMBUSTION ENGINEER, R.P.E., Manitoba. A.M.E.I.C. Wide experience with all classes of fuels. Expert designer and draughtsman on modern steam power plants. Experienced in publicity work. Well known throughout the west. Location, Winnipeg or the west. Available at once. Apply to Box No. 713-W.

YOUNG ENGINEER, B.A.SC., (Univ. Toronto '27), JR.E.I.C. Four years practical experience, buildings, bridges, roadways, as inspector and instrumentman. Available at once. Present location, Montreal. Apply to Box No. 714-W.

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

MECHANICAL ENGINEER, age 41, married. Eleven years designing experience with project of outstanding magnitude. Machinery layouts, checking, estimating and inspecting. Twelve years previous engineering, including draughting, machine shop and two years chemical laboratory. Highest references. Apply to Box No. 723-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.

DESIGNING ENGINEER, M.SC. (McGill Univ.), D.L.S., A.M.E.I.C., P.E.Q. Experience in design and construction of water power plants, transmission lines, field investigations of storage, hydraulic calculations and reports. Also paper mill construction, railways, highways, and in design and construction of bridges and buildings. Available at once. Apply to Box No. 729-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.

CIVIL ENGINEER, M.SC., 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

ELECTRICAL AND RADIO ENGINEER, B.SC. '31, S.E.I.C. Age 25. Nine months experience on installation of power and lighting equipment. Eight months on extensive survey layouts. Two summers installing telephone equipment. Specialized in radio servicing and merchandising. Available at once. Location immaterial. Apply to Box No 740-W

CIVIL ENGINEER, graduate '29. Married One year building construction, one year hydro-electric construction in South America, fourteen months resident engineer on road construction. Working knowledge of Spanish. Apply to Box No. 744-W.

SALES ENGINEER, B.SC., McGill, 1923, A.M.E.I.C. Age 33. Married. Extensive experience in building construction. Thoroughly familiar with steel building products; last five years in charge of structural and reinforcing steel sales for company in New York state. Available at once. Located in Canada. Apply to Box No. 749-W

DESIGNING ENGINEER, graduate Univ. Toronto '26. Thoroughly experienced in the design of a broad range of structures, desires responsible position. Apply to Box No 761-W.

MECHANICAL ENGINEER, graduate, '23, A.M.E.I.C., P.E.Q., age 32, married. (English and French.) Two years shop, foundry and draughting experience; one year mechanical supt. on construction; six years designing draughtsman in consulting engineers' offices (mechanical equipment of buildings, heating, sanitation, ventilation, power plant equipment, etc.). Present location Montreal. Available immediately. Montreal or Toronto preferred. Apply to Box No. 766-W.

CIVIL ENGINEER, S.E.I.C., B.SC. Queen's Univ. '29. Age 25. Married. Three years experience as construction supt. and estimator for contracting firm. Experience includes general building, bridges, sewer work, concrete, boiler settings, sand blasting of bridges and spray painting. Available at once. Apply to Box No. 767-W.

Situations Wanted

ELECTRICAL ENGINEER, B.SC. (McGill Univ. '29), S.E.I.C. Married. Experience in pulp and paper mill mechanical maintenance, estimates and costs and machine shop practice. Desires position with industrial or manufacturing concern. Location immaterial. Available on short notice. References. Apply to Box No. 770-W.

ELECTRICAL ENGINEER, Queen's Univ. '24, JR.E.I.C., age 32, married. Experience includes, student Test Course, Can. Gen. Elec. Co., four years dial system telephone engineering with large manufacturing company. Available at once. Apply to Box No. 772-W.

CIVIL ENGINEER, B.SC., '25, JR.E.I.C., P.E.Q., married. Desires position, preferably with construction firm. Experience includes railway, monument and mill building construction. Available immediately. Apply to Box No. 780-W.

DRAUGHTSMAN, experience in civil engineering, forestry engineering, land surveying and house construction. Good references. Apply to Box No. 781-W.

ELECTRICAL AND SALES ENGINEER, S.E.I.C., grad. '28. Experience includes one year test course, one year switchboard design and two years switchboard and switching equipment sales with large electrical manufacturing company. Three summers Pilot Officer with R.C.A.F. Available at once. Apply to Box No. 788-W.

SALES REPRESENTATIVE. Electrical engineer with ten years experience in power field interested in representing established firm for electrical or mechanical product in Montreal territory. Excellent connections Apply to Box No. 795-W.

CIVIL ENGINEER, S.E.I.C., graduate '30, age 23, single. Experience includes mining surveys, assistant on highway location and construction, and assistant on large construction work. Steel and concrete layout and design. Apply to Box No. 809-W.

CIVIL ENGINEER, college graduate, age 27, single. Experience includes surveying, draughting concrete construction and design, street paving both asphalt and concrete. Available at once; will consider anything and go anywhere. Apply to Box No. 816-W.

CIVIL ENGINEER, B.E. (Sask. Univ. '32), S.E.I.C. Single. Experience in city street improvements; sewer and water extensions. Good draughtsman. References. Available at once. Location immaterial. Apply to Box No. 818-W.

CIVIL ENGINEER, S.E.I.C., B.SC. (Queen's '32), age 21. Three summers surveying in northern Quebec. Interested in hydraulics and reinforced concrete. Available at once. Location immaterial. Apply to Box No. 822-W.

CIVIL ENGINEER, B.SC., A.M.E.I.C., with fifteen years experience mostly in pulp and paper mill work, reinforced concrete and structural steel design, field surveys, layout of mechanical equipment, piping. Available at once. Apply to Box No. 825-W.

ELECTRICAL ENGINEER, S.E.I.C., grad. '29, age 24, married; experience includes one year Students Test Course, sixteen months in distribution transformer design and eight months as assistant foreman in charge of industrial control and switchgear tests. Location immaterial. Available at once. Apply to Box No. 828-W.

SALES ENGINEER, M.E.I.C., graduate civil engineer with twenty years experience in the structural, sales, and municipal engineering fields, and as manager of engineering sales office. Available at once. Apply to Box No. 830-W.

CIVIL ENGINEER, B.A.SC., D.L.S., O.L.S., A.M.E.I.C., age 46, married. Twelve years experience in charge of legal field surveys. Owns own surveying equipment. Eight years on technical, administrative, and editorial office work. Experienced in writing. Desires position on survey work, assisting in or in charge of preparation of house organ, on staff of technical or semi-technical magazine, or on publicity, editorial or administrative office work. Available at once. Will consider any salary, and any location. Apply to Box No. 831-W.

CIVIL ENGINEER, M.SC., R.P.E. (Sask.). Age 27. Experience in location and drainage surveys, highways and paving, bridge design and construction city and municipal developments, power and telephone construction work. Available on short notice. Apply to Box No. 839-W.

CIVIL ENGINEER, S.E.I.C., B.SC. '32 (Univ. of N.B.). Age 25, married. Two years experience in power line construction and maintenance; one year of highway construction; one summer surveying for power plant site, location and spur railway line construction. Available at once. Location immaterial. Apply to Box No. 840-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.

CIVIL ENGINEER, B.SC. (Alta. '31), S.E.I.C., age 24. Experience, three summers on railroad maintenance, and seven months on highway location as instrumentman. Willing to do anything, anywhere, but would prefer connection with designing or construction firm on structural works. Available immediately. Apply to Box No. 846-W.

Situations Wanted

MECHANICAL ENGINEER, JR.E.I.C., technical graduate, bilingual, age 30. Two years as designing heating draughtsman with one of the largest firms of its kind on this continent handling heating materials; three years designing draughtsman in consulting engineers' office, mechanical equipment of buildings, heating, ventilation, sanitation, power plant equipment, writing of specifications, etc. Present location Montreal. Available at once. Apply to Box No. 850-W.

BRIDGE AND STRUCTURAL ENGINEER, A.M.E.I.C., McGill. Twenty-five years' experience on bridge and structural staffs. Until recently employed. Familiar with all late designs, construction, and practices in all Canadian fabricating plants. Desirous of employment in any responsible position, sales, fabrication or construction. Apply to Box No. 851-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.

MECHANICAL ENGINEER, B.SC. '32, S.E.I.C. Good draughtsman. Undergraduate experience:—One year moulding shop practice; two years pipe fitting and sheet metal work; one year draughting and tracing on paper mill layout; six months machine shop practice; and eight months fuel investigation and power heating plant testing. Desires position offering experience in steam power plants or heating and ventilating design. Will go anywhere. Apply to Box No. 858-W.

MECHANICAL ENGINEER, age 31, graduate Sheffield (England) 1921; apprenticeship with firm manufacturing steam turbine generators and auxiliaries and subsequent experience in design, erection, operation and inspection of same. Marine experience B.O.T. certificate thoroughly conversant with Canadian plants and equipment. Available on short notice. Any location. Box No. 860-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.

ENGINEER, McGill Sci. '21-'25, S.E.I.C., aerial mapping, stereoscopic contour work; lumber classification; highway, railway and transmission line locations; estimates; water storage investigations, etc. Five years ground surveys; three years aerial mapping. Bilingual. Available on short notice. Apply to Box No. 872-W.

CONSTRUCTION ENGINEER (Toronto Univ. of '07). Experience includes hydro-electric, municipal and railroad work. Available immediately. Location immaterial. Apply to Box No. 886-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.SC., Montreal 1930, age 26, single, French and English, desires position technical or non-technical in engineering, industrial or commercial fields, sales or promotion work. Experience includes three years in municipal engineering on paving, sewage, waterworks, filter plant equipment, layout of buildings, etc. Available immediately. Apply to Box No. 891-W.

ELECTRICAL ENGINEER, grad. Univ. of N.B. '31. Experienced in surveying and draughting, requires position. Available at once Will go anywhere. Apply to Box No. 893-W.

CIVIL ENGINEER, B.A.SC., JR.E.I.C., age 29, single. Experience includes two years in pulp mill as draughtsman and designer on additions, maintenance and plant layout. Three and a half years in the Toronto Buildings Department checking steel, reinforced concrete, and architectural plans. Available at once. Location immaterial. At present in Toronto. Apply to Box No. 899-W.

ENGINEER, JR.E.I.C., specializing in reconnaissance and preliminary surveys in connection with hydro-electric and storage projects. Expert on location and construction of transmission lines, railways and highways. Capable of taking charge. Location immaterial. Apply to Box No. 901-W.

MECHANICAL ENGINEER, Canadian, age 25, B.SC. (Queen's '32). Since graduation on supervision of large building construction. Undergraduate experience in electrical, plumbing and heating, and locomotive trades. Available at once. Apply to Box No. 903-W.

DESIGNING ENGINEER, A.M.E.I.C. Permanent and executive position preferred but not essential. Fifteen years experience in designing power plants, engine and fan rooms, kitchens and laundries. Thoroughly familiar with plumbing and ventilating work, pneumatic tubes, and refrigeration, also heating, electrical work, and specifications. Apply to Box No. 913-W.

INDUSTRIAL ENGINEER, B.SC. in M.E., age 25, married, is open for a position of a permanent nature with an industrial concern. Experience includes three years in various divisions of a paper mill and two years in an electrical company. Apply to Box No. 917-W.

Situations Wanted

ENGINEER, B.SC., A.M.E.I.C., R.P.E. (N.B.), age 35, married. Seven years' mining experience as sampler, assayer, surveyor, field work, and foreman in charge of underground development; two years as assistant engineer on highway construction and maintenance. Available on short notice. Apply to Box No. 932-W.

CIVIL ENGINEER, B.SC., '25, McGill Univ., JR.E.I.C., P.E.Q., age 32, married. Experience as rodman and instrumentman on track maintenance. Seven and one-half years with Canadian paper company, as assistant office engineer handling all classes of engineering problems in connection with woods operations, i.e., road buildings, piers, booms, timber bridges, depots, dams, etc. Apply to Box No. 933-W.

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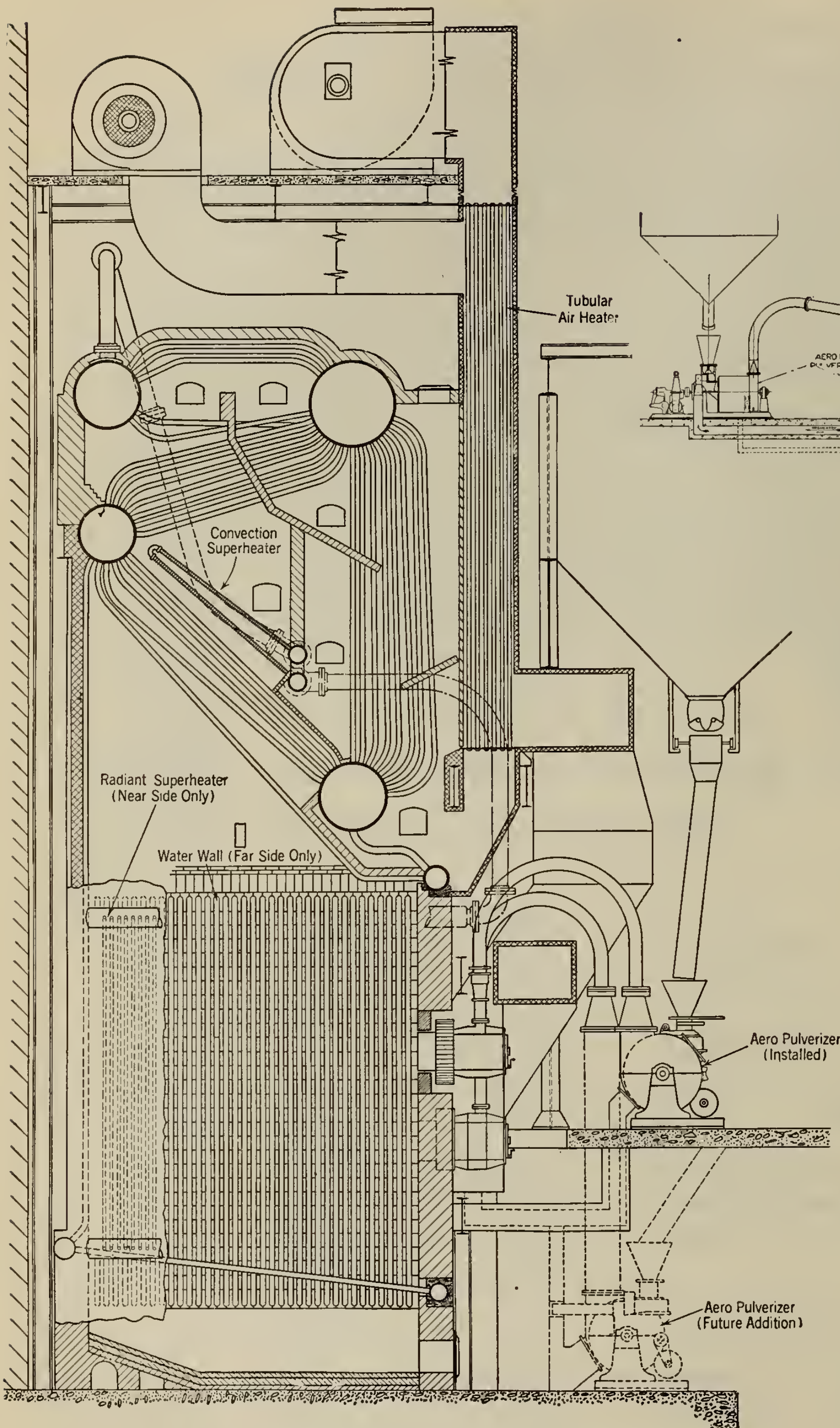

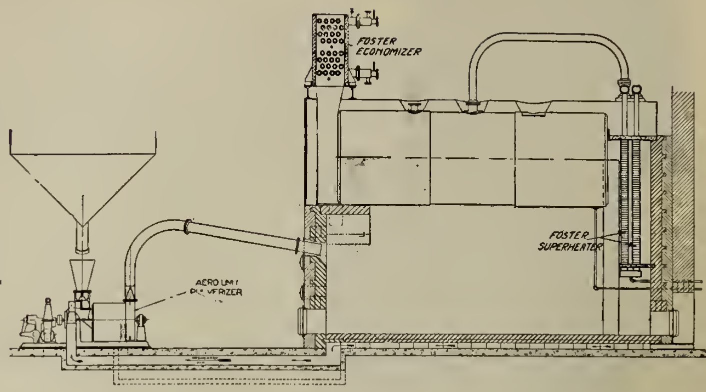

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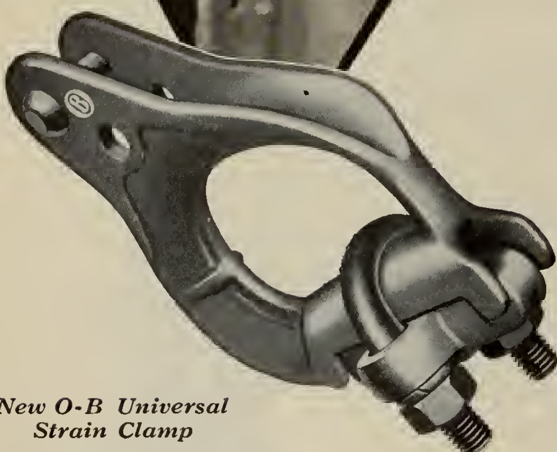

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"To facilitate the acquirement and interchange of professional knowledge among its members, to promote their professional interests, to encourage original research, to develop and maintain high standards in the engineering profession and to enhance the usefulness of the profession to the public"

November 1933 | Volume XVI, No. 11

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The Construction of the Masson Power Development

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Paper presented before the Montreal Branch of The Engineering Institute of Canada, April 27th, 1933.

SUMMARY.—The paper gives a description of the methods employed by the contractors on building the Masson power development on the Lievre river. This has an installed capacity of 134,000 h.p. on 185-foot head. An interesting feature is a tunnel 6,060 feet long and 25 feet in diameter carrying the water from the headworks to the power house. Information is given as to the various operations of excavation, concreting and grouting, the equipment employed, the time taken, and the provisions made for power, handling materials, and pumping during construction.

In a recent paper presented before The Engineering Institute of Canada, the hydraulic characteristics of the Lievre river, and the general design of the Maclaren-Quebec Power Company's power developments at High Falls and Masson were covered and this paper will, therefore, deal with the construction methods adopted on the various parts of the work at Masson.

The Lievre river has its source in the Laurentian mountains, and flows in a southerly direction to the Ottawa river one half mile south of the village of Masson, and fourteen miles east of the city of Ottawa.

The Masson power development, owned by the Maclaren-Quebec Power Company, is situated at the village of Masson and consists of a dam and intake 1,050 feet long, a tunnel 6,060 feet long, and a power house and switching station as shown in Fig. 1.

The Headworks

The headworks, which rest on a limestone foundation, consist of an intake section and gatehouse 170 feet long containing eight intake gates, emergency gates, and racks, and the intake tubes connecting with the tunnel through an inclined shaft, a waste gate section 78 feet in length containing two waste gates and a trash sluice, a control gate section of 272 feet containing eight control gates, and a spillway section 78 feet 6 inches long; a west abutment 216 feet long containing a log sluice and cut-off section, and an east abutment and cut-off section of 316 feet.

It was decided to construct this part of the work in three main operations. The first on the east side of the river included the intake section, and the inclined shaft to the tunnel; the second on the west side of the river included the west abutment, spillway, and six control gates, and the third operation in the middle of the river included the remaining control gates, and the waste gates.

First Operation

Construction work was started about the middle of February, 1931, on the intake section. A cofferdam built of timber faced on the outside with tongue and grooved sheeting was placed around the area, and unwatered. Excavation was started on the foundation for the intake, and on the inclined shaft to the tunnel. The excavation for the intake and beginning of the inclined shaft was handled by rock skips, guy derricks, and trains of dump cars, and disposed of in a disposal area along the east bank of the river, below the site of the dam.

When the foundation for the intake section was completed, panel forms previously prepared were erected, and concrete was placed by bottom dump buckets, which were delivered to the guy derricks on flat cars.

The concrete was mixed in a central mixing plant which will be described later, and delivered to the site of the work in trucks.

While concrete was being placed in the intake section, excavation on the inclined shaft was continued. The muck from the shaft was loaded into skips, and by means of an electric hoist and a car on an inclined track hauled to the surface, where it was dumped into dump cars by a stiffleg derrick, and hauled away to the disposal area.

The inclined intake shaft was excavated to full size to within 50 feet of the tunnel, and a pilot shaft 9 feet in diameter driven the remaining distance. The excavation in this shaft was discontinued at this point, and the remainder of the work was completed later by more economical methods through the main tunnel.

The main intake structure is connected to the inclined shaft by means of a steel penstock encased in reinforced concrete. The steel penstock was erected, encased in concrete, and the whole intake section completed, the intake openings closed with temporary stop logs, and the cofferdam removed by the end of December, 1931.

Second Operation

Work was started on the cofferdam for the second operation during the last week of June, 1931. The cofferdam was unwatered, and the excavation and disposal of the rock was carried out in the same manner as in the first operation.

The west abutment, log sluice, spillway, and piers for control gates Nos. 3 to 8 were completed along with the sills of gates Nos. 3, 4, 5 and 8.

It was decided to use control gate openings Nos. 6 and 7 as temporary sluices, and divert the flow of the river through them during the progress of the third operation, to take care of the flood conditions in the fall of 1931, and the spring of 1932; therefore, the sills were left low instead of being carried to the final elevation 311.50.

The temporary sluices were designed to pass 13,900 c.f.s. when the water was at elevation 320.0, and with the remaining control and waste gates open at that elevation, the total amount of water that would pass was 27,390 c.f.s. This proved to be ample.

In this operation panel forms were used, and concrete was delivered in bottom dump buckets on flat cars. The buckets were handled into the forms by guy derricks.

The second operation was completed and the cofferdam removed during the first week in September, 1932.

Third Operation

Work on the cofferdam for the third operation was started September 1st, 1932; the final closure was made on October 26th, and the stream diverted through the temporary sluices.

The excavation, and disposal of rock from the foundation, the forms, and concrete were handled in the same manner as in the second operation. This operation was completed in December, 1931.

Work was then discontinued on the headworks until the spring of 1932, when the deck over the control and waste gates was completed, the gates and gate operating mechanism installed, and the closure of the temporary sluices completed.

When the excavation was made for the headworks, a series of grout holes from 18 to 20 feet in depth were drilled in the rock along the line of the intake and dam, and pipes placed in them, and carried up above the gate sills. These holes were grouted under pressure to insure that all seams and fissures in the rock were sealed.

Concrete designed for a compressive strength of 1,500 pounds per square inch at twenty-eight days, using a maximum water content of 7½ U.S. gallons of water per bag of cement, was used in the abutments, spillway, control and waste gate sections.

Concrete designed for a compressive strength of 2,000 pounds per square inch at twenty-eight days, using a maximum water content of 6¾ U.S. gallons per bag of cement, was used on the intake section and penstock cover.

The total quantity of excavation in this area was 30,000 cubic yards of earth, and 15,400 cubic yards of rock; 50,500 cubic yards of concrete and 361 tons of reinforcing steel were placed, 283 tons of steel sheet piling driven in cut-off walls, and 312,000 bricks used in the gate house superstructure. Figure 2 is a downstream view of the completed structure.

Plant Layout and Equipment at Headworks

A number of structures were erected in this area: a compressor house with an installation of two motor-driven compressors, an equipped drill sharpening and blacksmith shop, an engineer's office, a time office and a store room. Also, in order to take care of temporary demands for additional air, portable gasoline driven compressors were available, and a water supply system for fire protection, and for supplying the various services.

Derricks equipped with electric hoists were used principally for handling the excavation, concrete and other materials on the work, and gasoline locomotives were used on narrow gauge track for hauling material.

Electric power was supplied from a 6,600-volt tie line to the transmission line from High Falls, to a bank

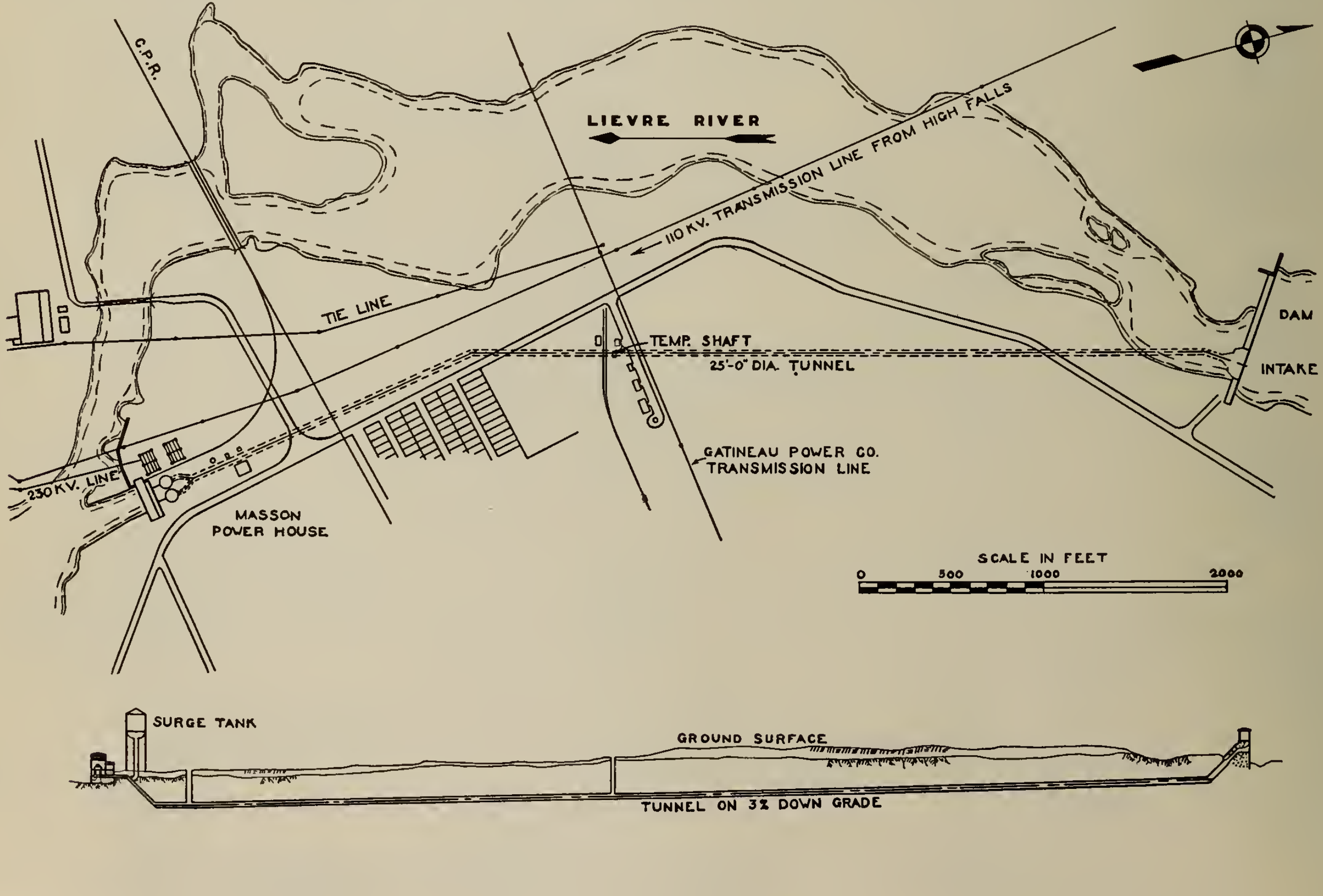

Fig. 1—Plan of Development.

of three 350-kw. transformers and stepped down to 550 volts for the various motors.

The Tunnel

Fig. 1 shows a plan and profile of the tunnel with the inclined intake shaft, temporary shaft, permanent shaft, and the inclined outlet shafts. The tunnel is approximately 200 feet below the surface of the ground. It is lined with

Fig. 2—Downstream View of Dam and Intake.

concrete, is 25 feet in diameter, 6,060 feet long, and descends on a three per cent grade towards the outlet.

In the preliminary investigations, in order to determine the location and character of the rock through which the tunnel was to be driven, diamond core drillings were taken 250 feet apart along the proposed line of the tunnel, each hole extending to the elevation of the invert. The cores taken indicated that the rock was of such a nature that there would be no difficulty in driving the tunnel, and also that when crushed it would be suitable for concrete. It consisted of limestone with small quantities of hornblende and rhyolite, and dykes of granite.

It was decided to sink a temporary shaft approximately 3,200 feet from the north end of the tunnel and do the greater part of the tunnel excavation from this point, in order to have a sufficient supply of rock available where it would be possible to construct and operate an economical crushing plant and to obtain storage room for crushed rock and sand, and easy access to the railroad.

A rectangular shaft 14 by 24 feet was driven down 10 feet below the invert of the tunnel. This was located 10 feet east of the centre line of the tunnel, and was enlarged on the east side at the bottom to provide space for pumps which were installed to take care of any water that accumulated in the sump below the invert of the tunnel.

The rock excavated in sinking the shaft was removed by means of a stiffleg derrick and buckets, and hauled by trucks to the disposal area. A mine hoist was installed in the hoist house, and a head frame erected, and when the north and south headings had been advanced far enough by hand to permit it safely, two material elevators, ventilating duct, air lines, cable conduits and stairways were installed in the shaft.

The north and south headings were driven simultaneously by the top heading and bench method, as shown in Fig. 3. Drifters were set up on columns of suitable length with cross arms for drilling the heading, and horizontal bar with centre support and arms for drilling the bench. All holes were drilled wet.

The cut holes were drilled 14 feet deep, the square up holes 12 feet deep, and the bench holes 16 feet deep. The cut holes were loaded with 60 per cent forcite, and the square up and bench holes with 40 per cent forcite. All were fired simultaneously with delayed action primers. Groups of fifteen holes connected in series were paralleled across a special 110-volt circuit, and fired from the top of the shaft.

The muck in each heading was loaded in 2½-cubic yard rocker type muck cars by a one cubic yard crawler type electric shovel.

About 2 feet 6 inches of muck was left on the bottom of the tunnel, and was not removed with the general excavation. This provided working space for the shovel, and a road-bed for a double track system from the shaft to the heading with necessary crossovers; 36-inch gauge track in 10 feet sections with pressed steel ties was used.

The empty muck cars were made up into trains at the shaft, and pushed up the right hand track to the heading by an electric locomotive.

The loaded cars were made up into trains on the left hand track, and hauled by locomotive to the shaft, where they were transferred to the elevators by a tugger hoist. The cars were then hoisted to the crusher platform, and the rock fed to the crusher, or taken to an adjacent waste dump.

The nominal excavated diameter of the tunnel was 28 feet 8 inches with certain allowable projections inside this circle. It was found unnecessary to do any timbering except in places where serious slips occurred due to seams, or where there was danger to the workmen from shaky or spalling rock in the roof. Where this condition occurred, steel arch rings were used. These rings were made up of 6-inch H sections shaped to conform with the line of the arch of the tunnel, spaced 4 to 6 feet centre to centre, and supported on 12- by 12-inch sills or posts, resting on hitches in the rock. Two inch hardwood plank lagging spaced 2 inches apart was placed on the arch rings, and the intervening space between the rock and the lagging packed with rock.

Grade and Alignment

The surface survey was carried down the shaft, and precise grade and alignment for this section of the tunnel was permanently established in each heading, and carried forward as the work progressed.

To facilitate the lining up of the heading at any time during the day or night shifts, a plug was put in the roof on the centre line of the tunnel after each round was drilled. These plugs were approximately 12 feet apart and were

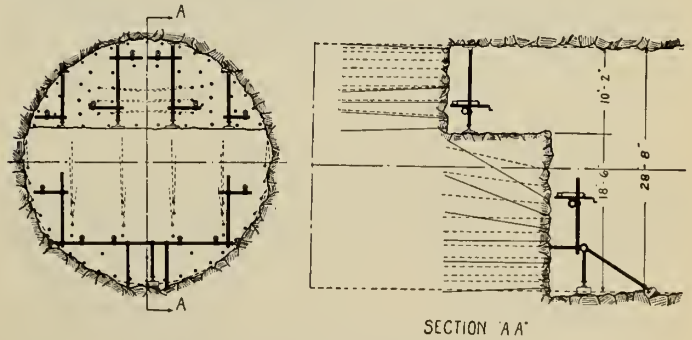

Fig. 3—Top Heading and Bench.

located by sighting forward by means of electric lights suspended from plugs previously installed.

The lights were suspended so that the bulb of each light coincided with the centre of the tunnel. The forward light was kept back from the heading approximately 250 feet.

A weighted line was then suspended from the plug adjacent to the face of the bench. By sighting back on the light, the centre of the tunnel was established on this line, and then projected on the face of the bench.

Using the point as centre, the circumference of the tunnel was painted on the bench and heading, and also on any tight spots left after the previous shot had been fired.

Ventilation

In order to clear the tunnel of gases after each shot was fired, and for general ventilation, an electric mine blower was installed near each heading. The blower exhausted the foul air from the heading through 16-inch diameter wood stave pipe, which was supported on the wall of the tunnel, and carried up the shaft to the surface. It generally took about three quarters of an hour to clear the tunnel of gases after each shot had been fired.

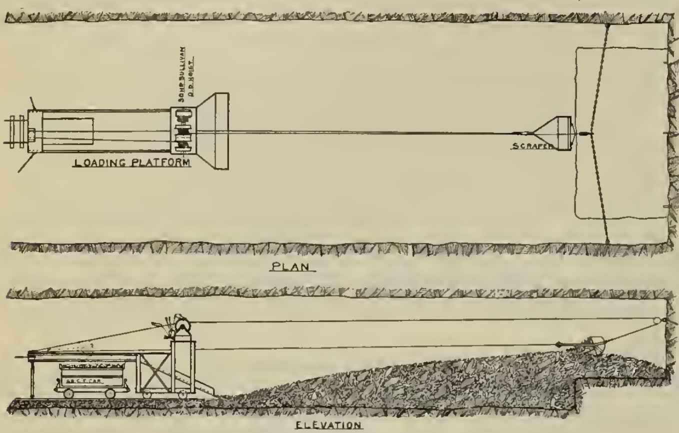

Fig. 4—Mucking Machine in Operation.

Operations were started at the temporary shaft in April, 1931. The south heading met the north heading driven from the permanent shaft in December, 1931, and the north heading reached the foot of the inclined intake shaft in November, 1932.

The maximum progress made in a week on one heading was 90 feet and 366 feet 6 inches for one month.

Operations were discontinued temporarily when the north heading was 760 feet from the foot of the inclined shaft. This was done to allow the concrete lining to be brought up near the heading, as it was found that after exposure to the atmosphere for a considerable time, the rock in the roof in some places tended to spall off, and make conditions dangerous for the workmen.

When the driving of a heading was completed, the shovel worked back towards the shaft removing the muck left for a road bed for the tracks, and cleaning up the bottom of the tunnel.

The Permanent Shaft

This shaft, 13 feet inside diameter, was designed to house the permanent pumps for unwatering the tunnel for inspection or repairs. The lowest point in the invert of the tunnel occurs opposite the shaft, and they are connected by a cross-cut.

As there was 25 feet of earth overburden at this shaft, a rectangular cofferdam of steel sheet piling was driven to rock. The excavation was carried on in the same manner as at the temporary shaft, and provision made for a sump and pumps at the bottom of the shaft.

When the cross-cut was completed, the heading turned, and space permitted, 36-inch gauge track was laid and 2½-cubic yard muck cars, and a portable car loading slide, and mucking scraper was put into operation to handle the muck from the heading, as shown in Fig. 4.

When the heading was shot, the loading slide was moved up to the muck pile, and clamped to the tracks. The tail block was then taken forward to the breast, and fastened to one of the heavy anchor eyes placed in the face near the top of the heading. Using the 50-h.p. double drum mucking hoist located on the frame of the slide, the operator hauled the scraper up to the heading, where it received its load of muck which it brought back over the slide, and deposited in a muck car.

When the car was loaded, it was moved by a tugger hoist to the foot of the shaft, and dumped into the loading hopper. The muck was then discharged from the loading hopper into the skips which carried it to the surface where it automatically emptied into a large discharge hopper. Trucks hauled the muck from the discharge hopper to the disposal area.

In order to allow the drillers to set up their drills, and start drilling the heading with as little delay as possible, the muck was removed from the bench first. The tail block was then moved back about 12 feet, and anchored to a chain sling along which the block could be shifted to scrape new areas.

The South Heading

The section of tunnel south of the permanent shaft was driven first, and the breakdown method illustrated in Fig. 5 was used. A bottom heading and bench was driven in the lower half section of the tunnel. Drifters were set up on columns for the heading, and horizontal bars for the bench.

The holes were drilled, loaded, connected up and fired in the same manner as in the headings at the temporary shaft. The bottom heading and bench was driven south till it met the two headings from the inclined outlet shafts.

Work was then started on the top half section of the heading. Break down timbers were brought down, and put in place as shown in Fig. 5. These timbers were 12- by 12-inch B.C. fir, and hardwood logs placed as shown on bents 3 feet centres with a clearance of 5 feet 6 inches between the bent caps and the top of the rail.

Columns were then set up and the heading drilled with drifters. The holes were from 14 to 16 feet deep.

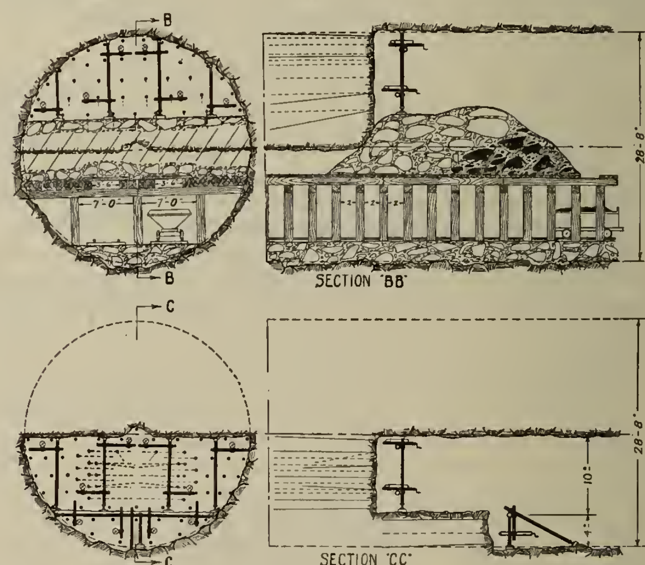

Fig. 5—Breakdown and Bottom Heading and Bench.

When the shot was pulled, the muck came down on the breakdown timbers and was then loaded into cars through the openings provided between the timbers. As the work progressed, the timbers were moved forward and used over again.

The North Heading

When the excavation in the bottom half section of the south heading was completed, work was started on the north heading. A bottom heading and bench were driven in the same manner as previously described until it met the south heading which had been driven from the temporary shaft.

The top heading was then driven southward. Columns were set up on the muck pile, and the heading drilled in the same manner as in the breakdown section. When the shot was pulled, the muck piled up on the bottom of the tunnel and it was loaded into cars with the electric shovel and hauled to the temporary shaft. In this operation, the drilling and mucking were carried on simultaneously. When this was completed, the electric shovel started at the foot of the outlet shaft and worked north, cleaning up the bottom, the muck being delivered to the temporary shaft.

The Inclined Outlet Shaft

In conjunction with the excavation for the surge tank and power house foundations, the outlet shafts were driven down approximately 80 feet from the surface. This was as far as the muck could be reached with a guy derrick and rock skips and the balance of the excavation was completed from the bottom of the shafts, as it could be more economically handled from the permanent shaft.

Overbreak

The average overbreak in the main tunnel, excepting those locations where arch rings were used, was 8¼ per cent. The average overbreak in the inclined intake, and outlet shafts, and the transition sections was 15 per cent.

Explosives

The average amount of explosives used on the benches and headings was 2 pounds and 7 pounds respectively per cubic yard of rock. The average total amount of explosives used was 4 pounds per cubic yard of rock.

Water

No difficulties were encountered in taking care of the water in the tunnel, as it was collected in sumps at the temporary and permanent shafts, and pumped to the surface.

The maximum flow of water at the temporary shaft was 312 gallons per minute. This was taken care of by an installation of two pumps, one rated at 414 gallons per minute against a head of 264 feet, and the other rated at 550 gallons per minute against a head of 200 feet.

The maximum flow of water at the permanent shaft was 175 gallons per minute, and this was taken care of by an installation of pumps identical with those at the temporary shaft.

Work was started at the temporary and permanent shafts in April, 1931. The section of tunnel south of the temporary shaft was completed in January, 1932, and that at the north in November, 1932.

The Concrete Tunnel Lining

The specifications called for a concrete lining for the inclined shafts and tunnel of a minimum thickness of 22 inches with certain allowances for rock projections. This concrete was to be designed for a compressive strength of 2,000 pounds per square inch at twenty-eight days using a maximum water content of 6¾ U.S. gallons per bag of cement. It was further stipulated that one additional bag of cement was to be added to each cubic yard of concrete.

After a series of tests it was found that 495 pounds of cement would give a greater strength than the required test. To each yard of this concrete an additional bag of cement was added to increase the density.

The average of the tests made on this with a cement content of 600 pounds per cubic yard gave a compressive strength of 3,285 pounds per square inch at twenty-eight days.

Wooden forms built at the carpenter shop were used in the inclined outlet shafts, from the lower end of the steel penstock to the point where the wye and transition section met the standard section of the main tunnel.

The concrete for this section of the work was hauled in trucks to the top of the permanent shaft where it was delivered through a hopper to a skip bucket. It was then taken down the shaft, and delivered through another hopper to two one-cubic yard guns which shot it through 6-inch pipes to the forms.

When this section of the lining was completed, a steel invert form 150 feet in length, which moved on a special track, was erected, and the concrete invert was carried south from the foot of the temporary shaft.

The concrete for this section was delivered from the mixing plant to the top of the temporary shaft on an 18-inch belt conveyor and then dropped 200 feet to the bottom of the shaft through a 10-inch extra-heavy steel pipe to a boot which emptied into an 8-cubic yard hopper. The concrete was delivered from the hopper to trains of 2½-cubic yard side dump cars, and hauled by electric locomotives to the form.

The invert forms were jacked away from the concrete after it had set and moved forward, and placed in position for the next section of invert.

When the concrete invert in the section of the tunnel south of the temporary shaft was completed, the steel invert form was dismantled. A movable steel arch and wall form was then erected at the south end of the tunnel (Fig. 6). This form moved on a special track and was composed of a wall and an arch section each 60 feet in length.

The working platform on this form, which was 14 feet above the top of the concrete invert, was approached by a ramp carrying a track connecting with the main tunnel tracks. The ramp was arranged so that it could be raised by a gantry and chain blocks to give enough clearance for cars to pass through the forms on the main track at any time when connecting operations were discontinued.

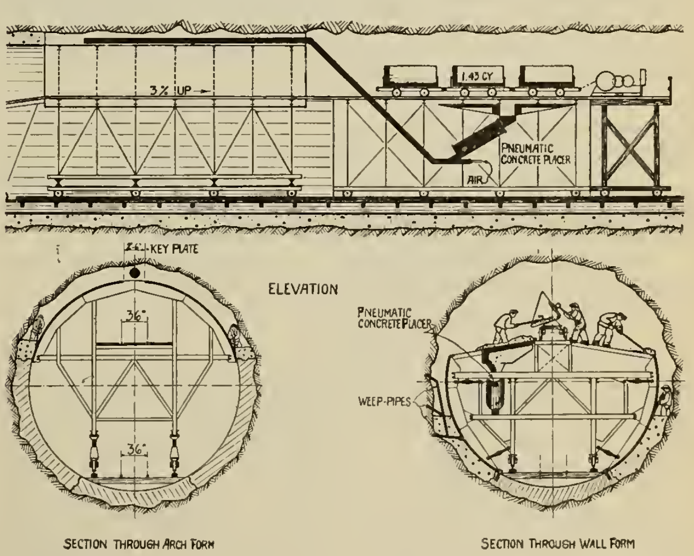

Fig. 6.

The concrete trains were hauled to the foot of the ramp. A cable was then attached to the forward car, and by means of an electric hoist situated on the rear end of the form, hauled up the ramp to the working platform.

Concrete in the arch section of the form was first placed. This concrete was placed with a one-cubic yard concrete gun, situated below the working platform, and fed from a large hopper in the floor. The concrete was delivered from the gun to the forms at the top of the arch through an extra heavy 8-inch steel pipe, and special manganese steel bends. At the beginning of the operations, the delivery pipe was placed along the crown to within 5 feet of the rear of the form. The pipe within the form was in 5-foot sections and as the concrete built up, sections of the pipe were removed through openings left in the forms. Figure 7 is a section of the tunnel showing the arch form in place.

Fig. 7—Wall and Arch Forms Showing Arch Section.

When an arch section was completed, the hopper to the concrete gun was covered, and concrete was dumped from the cars on the sloping platform, and pushed into the wall form.

The concrete was allowed to set fourteen hours in the arch or eight hours in the wall before the forms were moved. The forms were then jacked away from the concrete by means of special jacks built into the framework, and moved forward, with the aid of the hoist located on the working platform, and prepared for the next section.

The gun handled on an average run, taking into account the delays in removing sections of pipes, etc. about 35 cubic yards per hour.

The slump test on the concrete going into the arch section was from 4 to 5 inches, on the wall section 3 to 4 inches, and on the invert section 2 to 3 inches.

The wall and arch lining was brought up as far as the temporary shaft, and later carried forward behind the invert to the foot of the inclined intake shaft.

Wooden forms were used in the inclined intake shaft and elbow, and the concrete was placed with a gun.

Weep Pipes

Where water bearing seams were encountered, the water was collected to points where 2-inch pipe nipples were set in place with quick setting cement. When these points were located in the invert section where concrete was being placed, they were generally connected together in one or more systems, and the water carried away, and discharged on the completed section. In most cases, it was found necessary to connect a small pump to the piping in order to reduce the water pressure until the concrete was set.

When these points were located in the wall or arch section, the weep pipes were carried out to the face of the form; holes were burned in the plate to allow the water to drain away. Figure 6 shows the method of making the connections.

The total amount of concrete placed in the tunnel and shafts was 52,000 cubic yards.

Grouting

When the concrete lining was completed as far north as the temporary shaft, grouting equipment was installed in this section of the tunnel, and preparations made to place grout behind the lining in order to fill up voids, and stop leakage of water through weep pipes, construction joints, and temperature cracks.

The grouting equipment for each unit consisted of a one-cubic yard grout tank, in which the grout was mixed by compressed air, a grout pump operated by compressed air, and the necessary piping and hose.

This equipment was mounted on an operating platform, which was moved along on the track previously used for the steel forms, as shown in Fig. 8.

The grouting was carried out in three operations as follows:—

The first operation consisted of filling the voids behind the concrete lining and the false arch rings with grout.

A line of holes were drilled through the concrete along the crown of the arch on 30-foot centres. A short piece of 2-inch pipe threaded on one end was driven into each hole, and securely caulked with oakum. A stop cock was screwed to the protruding end of each pipe.

The hose connection from the grout pump was connected to a grout pipe, and all stop cocks adjacent to the hole being grouted were left open. Grout was then pumped into one hole till it appeared at the stop cock of another hole. The stop cock on the hole being grouted was then closed, and the grout hose disconnected. This operation was repeated at alternate holes, and continued until all the holes were grouted. When the operation was completed the grout pipes were burned off below the face of the concrete.

The second operation included the grouting of all weep pipes installed in the invert, wall and arch sections when the concrete lining was being placed. This was carried on in practically the same manner as the first operation.

As to the third operation, when the first and second operations were completed, water started to appear in other areas on the wall and arch sections, and at some of the construction joints and temperature cracks. Grout holes were drilled in the wet areas, 2-inch grout pipes were set, and the grouting was carried on in the same manner as in the first operation.

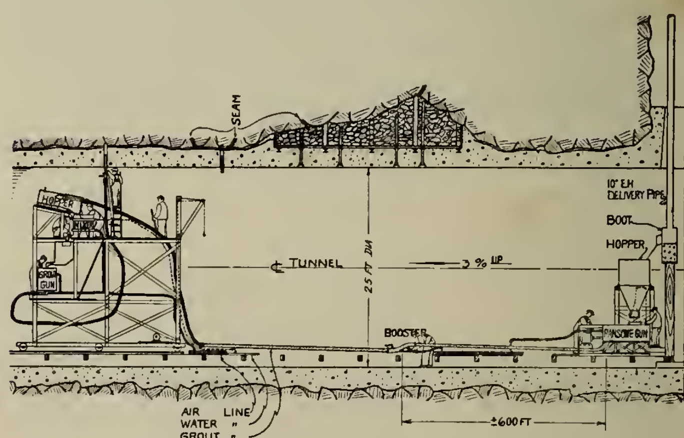

Fig. 8—Grouting Operations.

Where leaks occurred at construction joints or temperature cracks, V-shaped grooves one inch wide and one inch deep were cut along the joints, and ½-inch porcelain tubes were put in as weep pipes to collect the water. The joints were then filled with gunite. Later the weep pipes were broken off below the surface of the concrete and plugged.

The grout used for the concrete lining was composed of one part cement, one part sand and water. The grout used for stopping off the water was composed of neat cement and water. A pressure of 350 pounds per square inch was used in grouting.

The voids in the packing behind the arch rings were filled with grout composed of one part cement, one part sand and water, and the work was carried on at the same time as the first operation.

Two 1½-inch grout pipes were set in each panel and located so that they were staggered with those in the adjacent panel, and a 1½-inch vent pipe was placed at the crown of the arch in every alternate panel. Stop cocks were used on the grout pipes as in the first operation.

Grout was forced through the grout pipes until it appeared in the vent pipes. The final grouting was completed through the vent pipes.

As a large quantity of grout was used behind the arch rings, it was mixed in the mixing plant, and delivered at the bottom of the shaft in the same manner as the concrete. It entered a concrete gun situated at the bottom of the shaft, and operated under 100 pounds air pressure, was transported in a 4-inch pipe to a hopper located at the point where the grouting operations were taking place. The grout was fed from the hopper to a gun, which was connected by hose to the 1½-inch grout pipe.

As the grout for the arch ring sections was transported up to distances of 2,950 feet it was necessary to place boosters in the 4-inch transport line. This grouting operation is shown in Fig. 8.

The total grout used in the tunnel amounted to 2,853 cubic yards.

Grouting operations were started during the first week in August, 1932, and completed in February, 1933.

Plant Layout and Equipment in Tunnel Area

On account of the central location of the temporary shaft, it was decided to place in this area the main office, stores, repair shops, and the greater part of the equipment used in connection with the construction of the tunnel. The principal reasons for this were as follows:—

The land was available, and suitable for the purpose. A spur line connection could be conveniently made to the Canadian Pacific Railway.

The greater part of the construction of the tunnel was to be carried on from this shaft.

The rock excavated from the tunnel would be available, and sufficient to supply the coarse aggregate for concrete for the whole job.

There was sufficient room to store the crushed stone without excessive rehandling.

The sand, which was hauled in trucks from a pit located about 7 miles north of the job, could be conveniently stored by dumping it over a steep bank on the north side of, and adjacent to the mixing plant. Fig. 9 shows a general plan of the plant layout in this area.

The following structures were erected and equipped for the carrying out of the work: a compressor house with an installation of five electrically driven compressors, supplying air through aftercoolers, and receivers, at 100 pounds pressure to the tunnel and various buildings, also a motor generator set delivering 150-kw. direct current at 125 volts to the trolley wire for operating the electric locomotives in the tunnel.

A machine shop fully equipped, and adjoining it a blacksmith's shop and a tool sharpening shop, a change house equipped with locker, showers and toilets, and a boiler house containing two locomotive type boilers, used for heating buildings and concrete aggregate in winter.

A water supply system for fire protection, and for supplying water to the various services.

The main job office, and general stores which were connected by a telephone system with all parts of the work.

Electric power was supplied from a 6,600-volt tie line to the High Falls transmission line, and stepped down to 550 volts through a bank of three 1.000-kw. transformers located adjacent to the compressor house.

Gasoline locomotives were used on narrow gauge track for hauling material.

The Crushing and Screening Plant

Figure 10 is a plan of the crushing and screening plant showing its location relative to the temporary shaft and mixing plant. The loaded rock cars were hoisted from the bottom of the shaft to the charging platform at the surface. The cars were then hauled by a tugger hoist to a charging hopper, where the rock was dumped on an apron feeder which fed it to a jaw crusher, where it was crushed to a size of 6 inches. Cars containing waste rock were switched past the charging hopper, and dumped from a trestle into a waste pile.

From the jaw crusher the stone was carried on a belt conveyor to a stationary grizzly which discharged into a gyratory crusher. Stone 2 inches in size and under passed through the grizzly to a vibrating screen. Through this screen all stone 2 inches in size, and under, by-passed the gyratory

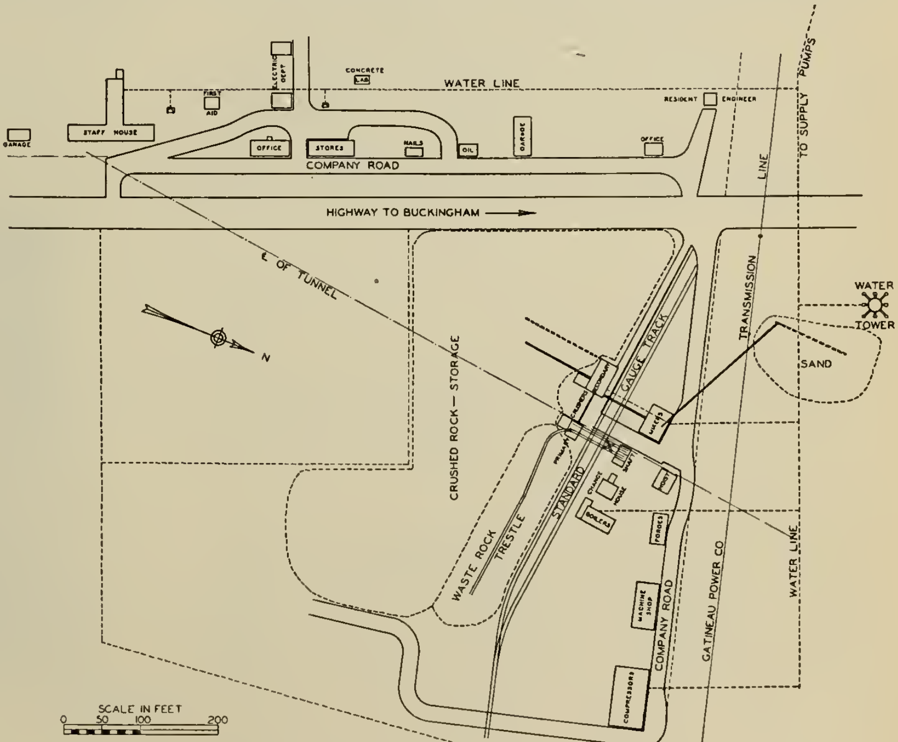

Fig. 9—Plan of Area at Temporary Shaft.

crusher, the dust passing by belt conveyor to a dust bin, and the remainder going to a bucket elevator, where it was elevated with the stone discharged from the gyratory crusher to two vibrating screens.

The screens were arranged for sizing the stone when necessary, but were primarily used for separating the dust, which discharged to the dust bin. Over-sized stone was returned to the gyratory crusher.

The stone was discharged from the vibrating screens into a rotary screen where it was washed. It was then elevated in a bucket elevator, and discharged, either on a belt conveyor, which conveyed it to the storage bins in the mixing plant, or on a conveyor which transferred it to storage.

The crushed rock was reclaimed from the storage pile by means of a belt conveyor operating in a tunnel,

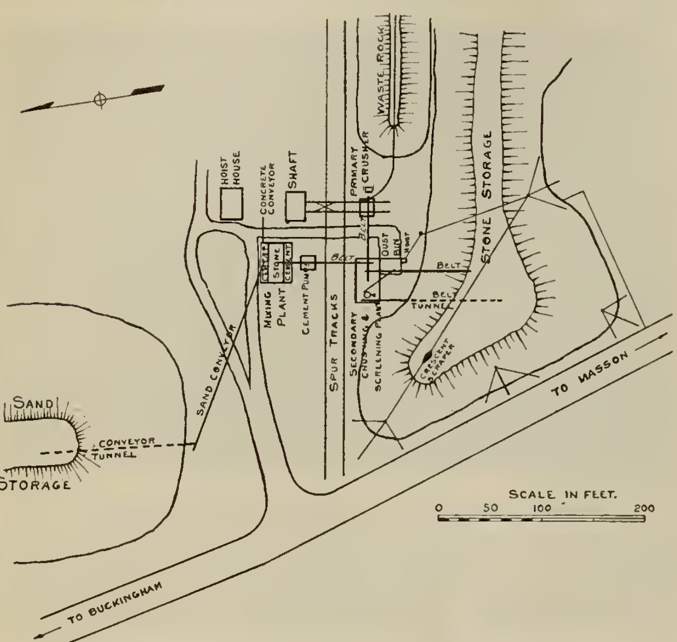

Fig. 10—Layout of Crushing and Mixing Plants.

which conveyed it to the bucket elevator, and passed it over the vibrating screens. It was then taken by the belt conveyor to the storage bins situated over the mixing plant. Arrangements were also made whereby the crushed stone could be loaded into cars on the spur track, or into trucks. The total amount of stone crushed was 202,000 tons.

The Mixing Plant

Figure 10 shows the mixing plant in its location relative to the sand storage, crushing plant, mixing plant, spur tracks and temporary shaft.

The sand was conveyed by means of a belt conveyor in a tunnel to an inclined conveyor, which delivered it into two storage bins situated over the mixing plant.

The stone was delivered by belt conveyor from the crushing plant and discharged into two storage bins situated over the mixing plant.

The cement was delivered in bulk in box cars on the spur track on the south side of the mixing plant, and by means of a 3-inch pump was pumped direct from the cars to the two storage bins situated over the mixing plant.

From the storage bins the sand passed into two inundators, the stone into two stone batchers, and the cement was fed through two rotary feeders to two cement weigh batchers. The water was measured by volume and supplied from two measuring tanks.

The sand, stone and cement were then discharged into two one-cubic yard mixers and mixed for one and one half minutes. The concrete was then discharged on to a conveyor belt which conveyed it to the top of the temporary shaft to be used in lining the tunnel, or into two hoppers from which it was loaded into trucks to be hauled to the dam or power house.

Electric vibrators were used on the weighing hoppers to clear them of cement after each batch was discharged, and to prevent the chutes from blocking. Productimeters were also adapted to the weigh batchers, and automatically kept a record of the number of batches.

Trucks had to be used for transporting the concrete to the dam and power house areas, as grades and the main lines of the Canadian Pacific Railway practically prohibited the use of a railway.

The total amount of concrete mixed in this plant was 131,000 cubic yards.

The Power House Area

There are two steel surge tanks each 68 feet in diameter and 202 feet high, of the differential type, supported on heavy reinforced concrete foundations, and connected through 17-foot diameter risers to the two steel penstock outlets from the tunnel.

The power house, 241 feet long by 96 feet 6 inches wide, has a reinforced concrete substructure, and a steel and brick superstructure, and consists of a valve room containing four butterfly valves, a switching section containing switching and control equipment, and a main section containing the turbines and generators, and space for a future frequency changer. The four turbines of the Francis type each develop 34,000 h.p. at an effective head of 185 feet and 166.7 r.p.m. and are direct connected to four 28,000-kv.a. 13,200-volt, 3-phase, 25-cycle generators.

The 250-kv.a. outdoor switching station consists of a bus tunnel 280 feet long, carrying two banks of 63,000-kv.a. single-phase, 25-cycle transformers on its deck, three oil circuit breaker platforms, and piers for disconnect switches, towers, etc.

The spur track connects the power house with the main line of the Canadian Pacific Railway.

Fig. 11—North Side of Power House, Showing Surge Tanks and Part of Switching Station.

Excavations

In this area, there was a clay overburden varying in depth from 6 to 22 feet over bed rock, which was limestone.

The earth was removed from the area to be excavated by a one-cubic yard steam shovel and hauled to the disposal area in trains of 4 cubic yard dump cars.

The rock from the surge tank foundations and all of the power house except the draught tube pits, was removed by rock skips, guy derricks, and cars. The draught tube pits and tailrace excavation was removed by steam and gas shovels and cars, except a narrow dyke at the junction of the tailrace and the river, which was removed by two drag lines after the draught tube openings had been closed with stop logs.

Under ordinary conditions it would have been necessary to have built a cofferdam about 450 feet long around the area where the tailrace joined the river. Due to the abnormally low water in the fall of 1931, this was not necessary.

Concrete

The forms for the concrete on this part of the work were either built in place or made up at the carpenter shop.

Concrete developing a compressive strength of 2,000 pounds in twenty-eight days was used in the greater part of this work. The concrete was mixed in the central mixing plant and delievered in trucks.

The concrete work in the switching station, surge tank foundations, tailrace, and in the draught tubes and substructure walls of the power house was completed by the end of December, 1931.

The steel penstocks connecting the tunnel outlet shafts with the surge tanks and butterfly valves in the valve room were erected during the winter of 1932, and encased in reinforced concrete the following summer.

The erection of the superstructure for the power house was started in June, 1932, and completed in January, 1933.

The installation of the hydraulic equipment was started in July, 1932, and completed in January, 1933. The installation of the generators and switching and control equipment was started in November, 1932, and is practically completed. The erection of the surge tanks was started in July, 1932, and is practically completed. Figure 11 is a view of the north side of the power house and shows the two surge tanks.

The total quantity of excavation in the power house area was 69,000 cubic yards of earth and 28,000 cubic yards of rock; 30,000 cubic yards of concrete and 287 tons of reinforcing steel were placed, and 744,000 of brick were used in the superstructure of the power house.

Plant Layout and Equipment

The following structures were erected and equipped for the carrying out of the construction work in this area:—

A compressor house with an installation of two electrically-driven compressors and, in order to take care of temporary additional demands for air, portable gas-driven compressors were used.

A drill sharpening and blacksmith shop, a boiler house with an installation of one locomotive type boiler for supplying steam for standby pumps in the permanent shaft, and for heating buildings and forms in winter.

A carpenter shop equipped with a table saw, a planer, a band saw and a wood working machine which supplied shopwork for the whole job. There was also a layout platform 72 by 72 feet in connection with this shop, used for building panel forms, curved forms, intake tube forms, draught tube forms and special forms for the tunnel; a change house; an engineer's office, time office and stores for hand tools and supplies, connected with the main office by an interplant telephone system.

A water supply system for fire protection and for supplying various services.

Electric power was supplied from a 6,600-volt tie line to the transmission line and stepped down to 550 volts for the motors.

Work in this area was started in April, 1931, and all structures were completed in January, 1933.

Steam Power Plants in Central and South America

Some Points in Design and Operation

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Paper presented before the Montreal Branch of The Engineering Institute of Canada, February 2nd, 1933.

SUMMARY.—The author discusses a number of problems occurring in the construction and operation of three steam power plants working under tropical conditions. Some points more particularly referred to are the erosion of furnace lining, the corrosion of pipes and turbine blades, difficulties due to settlement of foundations, troubles from incrustation of pipes and tubes, and protection from explosions with natural gas firing.

The object of this paper is to discuss some of the problems presented to engineers responsible for the design, construction and subsequent operation of steam power plants situated in localities where climatic and other unusual conditions have imposed obstacles not usually encountered in temperate climates. To treat such a subject fully is, of course, entirely beyond the scope of a paper of this kind, and the author proposes to confine his remarks to a number of problems which have arisen in three steam power plants with which he has been closely associated during the last few years. The plants involved are:

(1) La Arriaga plant of the Venezuela Power Company, Limited, which is situated on the west shore of Lake Maracaibo in Venezuela in about 11 degrees N. latitude. This plant burns residual oil as fuel. Steam pressure 225 pounds per square inch at 600 degrees F. temperature.

(2) The Georgetown plant of the Demerara Electric Company, Limited, situated in Georgetown, British Guiana, on the east bank of the Demerara estuary in about 7 degrees N. latitude. The fuel used in this case is Wallaba wood in the form of logs. Steam pressure 250 pounds per square inch at 600 degrees F. temperature.

(3) The Bella Vista plant of the Monterrey Railway, Light & Power Company, situated in the city of Monterrey, Nuevo Leon, Mexico, in about 25 degrees N. latitude, burning natural gas as the staple fuel, with fuel oil as an alternative. Steam pressure 450 pounds per square inch at 650 degrees F. temperature.

La Arriaga Plant

This plant, which went into operation in October, 1927, provides power for the city of Maracaibo and the surrounding district. It is located about four miles from the centre of the city and has a total installed capacity of 6,000 kw.

In a plant located so far from the source of supply of equipment simplicity is essential. For this reason many otherwise desirable refinements were omitted in the design and a relatively low steam pressure and temperature adopted.

The plant is housed in a simple, roomy, well-ventilated building consisting of steel frame covered with corrugated asbestos sheeting, a form of construction which has proved very satisfactory in hot climates both as regards comfort and first costs. (See Fig. 1.)

The boilers are installed on ground level in the southern half of the building and each main flue and steel stack handles the gases from two boilers. The turbo-generators,

Fig. 1—La Arriaga Power Plant.

with their condensers, pumps and air ejectors, are installed in the northern half of the building and are mounted on reinforced concrete structures built up from the ground floor, a light steel grating platform being provided at turbine level. This arrangement obviates the provision of any basement and keeps the whole of the equipment in the open, where it is under the eye of the operator and easily accessible for overhaul.

Although no artificial ventilation is provided (beyond the induction of air into the boiler furnaces) the power plant is about as comfortable a building in hot weather as any in the district.

The sub-soil conditions at the site were found to be quite good and the design of foundations presented no special problem. Each unit is mounted on a reinforced concrete mat. In the case of two of the units it was deemed advisable to drive greenheart piles, but generally the bearing value of the sub-soil was sufficiently high to carry the loads imposed.

For the storage of fuel oil two steel tanks are provided capable of holding about one month's supply. Oil is delivered by barge alongside a jetty which also carries the pipe lines and pumps necessary to transfer the oil to the storage tanks.

Turbo-Generating Units

The main generating units comprise two turbo-generators of 1,500 kw. capacity each and one of 3,000 kw. capacity. Figure 2 shows the two smaller sets which formed the original installation. All three units are designed for steam at a pressure of 200 pounds per square inch and a temperature of 600 degrees F. The condensers, which are suspended from the turbines, each contain 4,000 square feet of cooling surface in the case of the 1,500 kw. sets, and 6,000 square feet in the case of the 3,000 kw. set. The condensate pumps are of the centrifugal type, motor-driven, and steam ejectors are provided for the removal of air.

The cooling water temperature varies between 80 and 90 degrees and the condensing plant was designed to maintain an absolute pressure of 2 inches of mercury with a circulating water temperature of 85 degrees F.

Cooling water is obtained from the lake and is led into the power house through an intake canal, from which it is pumped through the condensers by individual circulating pumps for each unit and returned to the lake through a discharge canal on the other side of the power house. This water is salt; its density varies, reaching a maximum in the dry season of about three-quarters of the density of sea water.

In the early stages of operation considerable trouble was experienced due to the presence of foreign matter, such as palm leaves, cocoanut fibre, etc., in the circulating water. To obviate this, a travelling screen was installed and has proved quite effective.

Boiler Plant

The boiler plant consists of three Babcock & Wilcox standard double drum boilers, each having 4,780 square feet of heating surface and equipped with superheater, designed to deliver steam at a pressure of 225 pounds per square inch and 600 degrees F. temperature. The boilers are installed in separate settings; the furnaces are of the ordinary solid refractory wall type designed to burn fuel oil under induced draught. The induced draught fans are driven by electric motors and the main flues so arranged that fans can be freely interchanged between boilers.

The oil-burning equipment is of the Engineer Company's mechanical atomizing type. Each boiler is provided with five burners. The oil pumping and preheating units are of the manufacturer's usual type, and the piping so arranged as to permit interchange between pump units and boilers.

Under present load conditions one boiler is used to carry the base load, a second being brought onto the line to handle the evening peak, leaving the third available for cleaning, etc.

For a considerable period great trouble was experienced in maintaining boiler furnace refractories. An examination of the load conditions revealed that for some time at any rate the boilers had been loaded to the point where the heat release rate exceeded 35,000 B.t.u. per cubic foot per

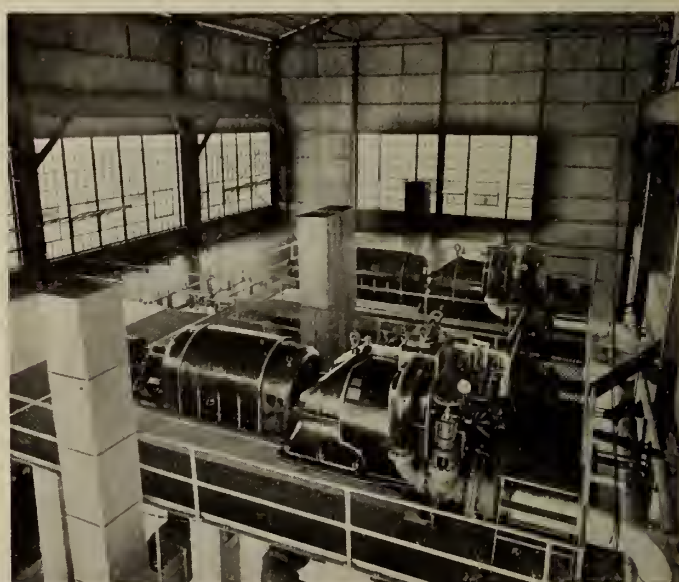

Fig. 2—Engine Room, La Arriaga Plant.

hour. This was beyond the load contemplated when the boilers were designed and led to rapid deterioration of the refractories. Various kinds of fire bricks and cements have been tried out, but until recently none of them gave anything like satisfactory service. It was eventually decided to try a more expensive type of brick, i.e., Babcock & Wilcox No. 80. The furnace lining of one boiler was entirely removed and a new lining installed using this brick in the zones subjected to the most severe punishment. At the same time some changes were made in the location of the oil burners with a view to keeping the spray from coming into contact with the brick work. The floor of the furnace was entirely removed and a hollow bottom installed, the air being induced through the passages in the hollow bottom into the furnace, which is always at sub-atmospheric pressure. The condition of this boiler after four months of operation, leads to the hope that excessive furnace repairs are a thing of the past.

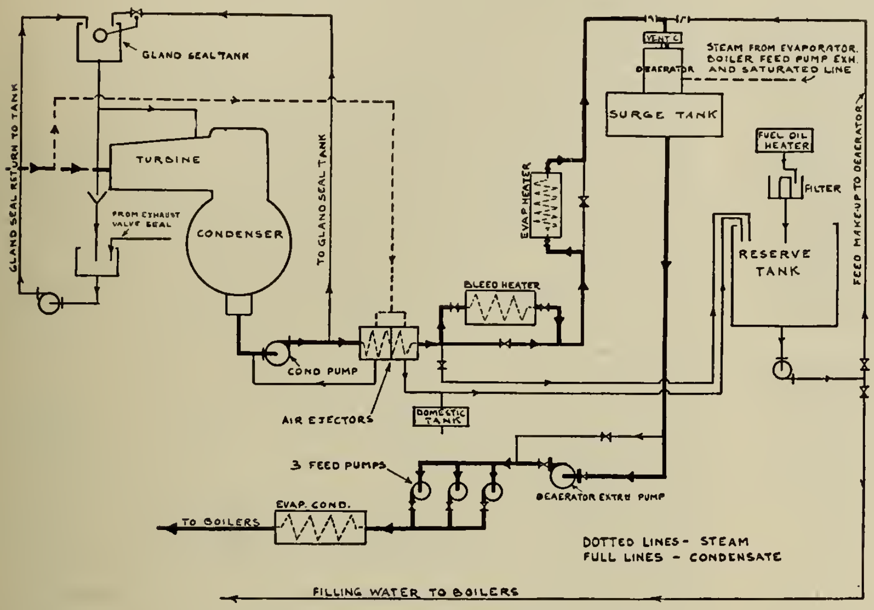

Fig. 3—Diagram of Condensate Circuit.

Feed Water System

The diagram (see Fig. 3) shows the feed water system as it exists at present, including the evaporating and deaerating plant. The provision of suitable water for boiler feed was an important problem in this case; in fact, good fresh water is at a premium in the whole district. Within a short distance of the site there was in existence a well of considerable age which was known to have yielded what is locally known as "sweet water" for a number of years. Careful tests were made, and as a result of these it was decided to make use of this water for boiler feed. For the first year of operation it appeared to be quite satisfactory and then quite suddenly it became evident that chlorides and other impurities in considerable quantity were being introduced with the well water. The demand had gradually increased, with the result that the ground water level had been drawn down by several feet, thus permitting infiltration of salt water, most probably from the lake.

An evaporating plant was installed and conditions appeared to improve to some extent. This improvement turned out to be temporary only and it soon became evident that some extremely active corrosive agent was at work. The corrosion was principally evident in the turbines; the steel blades in the impulse wheels of the machines were found to be wasting away at an extraordinarily rapid rate. The impulse wheels of the two smaller machines were re-bladed, and upon examination some six weeks later, the new blading was found to have wasted to an alarming extent. The steel forging forming the rotor had also been attacked and even the cast iron of the turbine cylinders had suffered to some extent. The condition of the damaged surfaces indicated that the wasting was due to corrosion by oxidization. Immediate steps were taken to test samples of condensate and also condensed steam drawn directly from the main header, which tests indicated that oxygen and CO_2 were present in large quantities. It was also found that considerable quantities of impure water were entering the turbines at the glands which were sealed with well water.

Further tests on various parts of the system proved conclusively that oxygen and CO_2 were entering with the supplementary feed water.

To remove these gases a complete deaerating plant was installed. At the same time steps were taken to seal the turbine glands with condensate instead of fresh water, thus removing any possibility of the ingress of raw water to the system at that point. The effect of these changes was an immediate cessation of the corrosion. This particular instance is the most impressive example of the necessity for deaeration which has ever come to the writer's attention.

Boiler Feed Pumps

Feed water, after leaving the deaerator, is delivered to the boilers by means of turbo feed pumps. Three pumps are installed, two of them electric motor driven; the third a steam turbo pump. Previous to the installation of the deaerating plant these pumps, which were called upon to handle water at temperatures not exceeding 130 to 140 degrees, operated perfectly satisfactorily. The installation of the deaerator equipment increased the temperature in the feed pump suction line to about 210 degrees, which immediately produced flashing at the pump intakes. The possibility of this had been foreseen and a booster pump provided in the line between the deaerator and the feed pumps. The operation of this pump imposed a head on the feed pump suctions sufficient to prevent flashing and satisfactorily disposed of this difficulty.

It will be realized that the fuel consumption of a plant which has suffered as this one has must be far from ideal. At the present time it is reported about 1.44 pounds of oil per kilowatt hour, but as the rate is improving steadily, there is every reason to believe that within a short time it will have been restored to normal.

The Georgetown Plant

This plant, which was put into operation in September, 1928, provides power for the city of Georgetown, British Guiana, and the surrounding district. It is located on the east bank of the Demerara estuary immediately behind the old sea wall and practically at the centre of load.

As in the case of the Maracaibo plant, simplicity of operation was held to be a major consideration in the design. The installed capacity is 3,750 kw., and Wallaba wood, fired in the form of logs, is used as fuel.

The plant is housed in a building consisting of steel frame covered with corrugated asbestos sheeting very similar to the one in Maracaibo. The same general method of installing the equipment has been followed, i.e., the turbines are placed in one half of the building and the boilers in the other. In this case the handling of ashes in the boiler room necessitated a dust-proof partition between the turbine and boiler rooms.

The boilers, two in number, are, as in the previous case, installed on the ground floor and an air pre-heater is provided which is common to all boilers. The turbo-generators are mounted on steel structures encased in concrete with the condensers below the turbines and a light platform of steel grating is provided at turbine level, thus eliminating any basement.

A timber jetty extends from the power house out into the river. This jetty, in addition to forming the receiving platform for the fuel which is delivered in barges or punts, is used to carry the circulating pumps, the circulating water delivery piping and the narrow gauge rail track along which the wood fuel is transported to the storage ground.

Foundation conditions in the whole locality are exceptionally difficult, the whole district being simply a mud bank several hundred feet deep. The bearing value of this mud is very low and piling was essential. Each unit of plant is mounted on a separate foundation consisting of a reinforced concrete mat supported on closely spaced greenheart piles. In designing these foundations care was taken to arrange the centre of support immediately under the centre of gravity of the load so that should any sinkage take place, the various units might remain on an even keel. That this precaution was justified has been amply proved, as, during the first two years of operation, though the turbines sank as much as $\frac{7}{8}$ inch and the boilers over $1\frac{1}{2}$ inches, all maintained a horizontal position and no trouble has appeared. There has been no further sinkage and it is apparent that the foundations of all the units have reached a stable level.

In designing the steam piping special provision was made to secure flexibility between the boiler outlets and the steam header and between the header and the turbines. In the latter case Aiton's corrugated steel piping made up in compound bends was used. Periodic tests for pipe strain are made and it is evident that the sinkage of the various units has not set up any undue stresses in the piping.

Turbo-Generating Units

The main generating units comprise three turbo-generators each with a maximum capacity of 1,250 kw. The units consist of Rateau turbines designed for steam at 225 pounds pressure and 600 degrees F. temperature, running at a speed of 6,000 r.p.m. connected through double helical reduction gearing to salient pole type alternators running at 1,500 r.p.m., the frequency of the electric system being 50 cycles.

Each condenser is placed immediately below its turbine, and has 1,870 square feet of cooling surface. The condensate extraction pumps are of the centrifugal type, motor-driven, and steam ejectors are provided for the removal of air. The cooling water temperature varies between 80 and 88 degrees F. and the condensing plant was designed to maintain an absolute pressure of 2.25 inches of mercury with circulating water at 85 degrees F., which it accomplishes without difficulty.

Circulating water is obtained from the Demerara estuary at a point immediately opposite the power house and some 400 feet from it. The main circulating pumps are mounted on the extreme end of the fuel reception jetty and deliver water through two separate cast iron pipe lines to the condenser supply bus pipe in the engine room. The individual condensers are fed by branches from this main bus pipe. After passing through the condensers the water is discharged to an outlet bus pipe which is led back to the river, its outlet being submerged so as to take advantage of siphonic action.

The circulating pumps, two in number, are of the centrifugal type, each has a capacity of 2,500 imperial gallons per minute and is driven by a 40-h.p. motor. The delivery piping is arranged to allow of interchange between pumps and condensers.

The water of the Demerara estuary is partially salt and actively corrosive; it also carries in suspension large quantities of extremely fine silt. In view of these conditions it was decided to install the circulating water piping in a manner which would permit of the lines being opened up for examination and cleaning at fairly frequent intervals. Duplicate cast iron pipe lines are provided, equipped with Victaulic joints, which form of joint, in addition to providing a convenient means of taking out a length of pipe, gives great flexibility to the line.

In order to protect the pipes from the corrosive action of the dilute salt water, they were lined with bitumen applied by the centrifugal process, the lining being about $\frac{1}{4}$ inch thick. It was hoped that this would also reduce the adhesion of marine growth, so common in all tropical waters, but experience has proved that it had no deterring effect.

About six months after the plant went into operation it was found that the circulating pump delivery pipes were rapidly becoming choked by the growth of mussels. Apparently the mussel spawn had entered through the pump suction strainers and had hatched in the circulating water pipe lines. At the time the discovery was made the whole of the internal surface of the pipes between the pumps and the condensers was coated with a layer of mussels some two inches thick. As the rate of growth was obviously very rapid, the situation looked somewhat alarming until the local staff decided to try the effect of fresh water on the mussels.

One of the pipe lines was isolated and filled with fresh water from the city supply lines and left in this condition for several days. At the end of that time it was discovered that the mussels had to a large extent become detached from the walls of the pipe. A blank flange at the far end of the delivery line was removed and the pipe flushed out from one of the circulating pumps. The quantity of dead mussels which emerged was astounding but after the operation the pipe was found to be very nearly clean. As a result of this experience a proper system of flushing valves was installed and the pipes are regularly treated with fresh water, which has proved entirely effective. This trouble occurred only in the piping between the pumps and the condensers, the rise in temperature in the condensers apparently killing the spawn.

The condenser tubes, which are of Admiralty metal, have withstood the highly corrosive water very well; there have been a few renewals during the last year.

Feed Water System

As will be evident from the diagram (Fig. 4), the feed water system is of the simplest possible form. Condensate

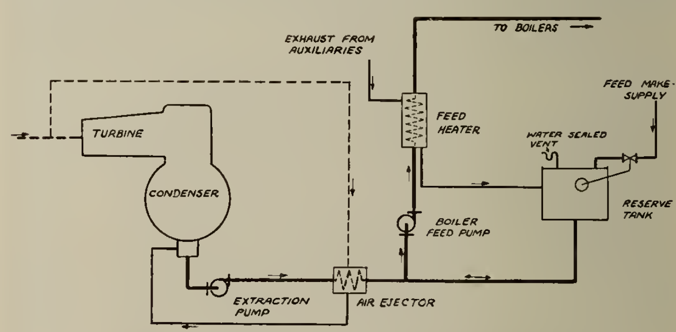

Fig. 4—Diagram of Feedwater Circuit.

is delivered by the extraction pumps into a bus pipe, one end of which is connected to an elevated surge tank. The main boiler feed pumps draw water from this line at a point between the condensate pump delivery and the reserve tank, so that the condensate is never exposed to the atmosphere and consequently cannot pick up oxygen. The pumps deliver the water through a surface heater to the boilers, the heater being supplied with exhaust steam from the feed pumps and induced draught fan engines. Thus all the heat in the auxiliary exhaust steam is recovered.

Supplementary feed water from the city mains is admitted to the reserve tank by a float-controlled valve.

In view of the excellent internal condition of the boilers in the old steam plant, which had operated for over thirty years on this water, no deaerating equipment was considered necessary. Experience has supported this view, as there are no signs of corrosion in any part of the feed water system.

Boiler Plant

British Guiana contains enormous reserves of timber and for a great many years the company had been using Wallaba logs as fuel in the old steam plant. Investigations showed that power could be generated at least as cheaply from this wood as from either oil or coal. A further inducement to use this wood as fuel was the fact that practically the whole of the fuel bill would be expended in the community—an important consideration from a public utility company's point of view. Various methods of firing wood in log form were investigated, but eventually an entirely new design of furnace, capable of burning either logs or coal with pre-heated air, was produced, chiefly due to the work of John T. Farmer, M.E.I.C.

The boilers, which are of the cross drum, sectional header marine type, are set at a considerable height, thus providing a very deep furnace and liberal combustion volume. (See Fig. 5.) A steel cased setting is used to reduce the weight on the foundations to a minimum. The fuel, in the form of logs about three feet long, is introduced through doors at the top of the sloping back and is allowed to slide down the slope to the fuel bed on the grate at the bottom of the furnace. These doors are balanced by counterweights so that they are capable of easy and quick opening and closing. The logs, after they reach the firing platform, are loaded on special trucks with sloping decks, from which they can slide easily and quickly into the furnace. By this means a charge of 300 or 400 pounds of wood can be introduced in a very few seconds.

In the first instance a shaking grate was installed to facilitate the removal of ashes from the furnace. This proved an unnecessary provision, and as it was easily damaged by falling logs, it has been replaced by stationary firebars.

Firing doors, to permit of using coal, have been provided at grate level and are used for clearing ashes when burning wood.

Altogether, this setting has proved very satisfactory and the cost of maintenance has been very small.

The gases from the boilers pass to a common main flue and thence through an air pre-heater of the Carrier-Owen type to the induced draught fans. These fans are steam-driven to facilitate regulation of furnace pressure. Forced draught fans driven by electric motors deliver air through the pre-heater to the lower part of the boiler setting, where it is admitted to the furnace through dampers. In operation every effort is made to maintain the furnace pressure as near to atmospheric as possible in order to reduce the amount of cold air drawn through the fuel admission doors.

Each boiler has 4,500 square feet of heating surface and is equipped with superheater, soot blowers and the usual accessories, designed to deliver steam at 250 pounds pressure and 600 degrees F. temperature. So far the steam demand has not exceeded 18,000 pounds per hour, which one boiler supplies with ease.

The wood, as received, contains a considerable quantity of moisture, and in order to get rid of as much of this as possible before firing it is stored for a period of around two months under sheds in the fuel storage yard. During this period an appreciable portion of its moisture content evaporates, the average reduction in weight being about 11 to 12 per cent. The consumption of fuel per kilowatt hour varies between 4.4 and 5.0 pounds, depending on the amount of moisture it contains when fired.

The Bella Vista Plant

This plant went into operation at the end of April, 1931, and supplies power for the city of Monterrey and the surrounding district. The installed capacity is 10,000 kw. In addition to supplying electrical energy, it also supplies

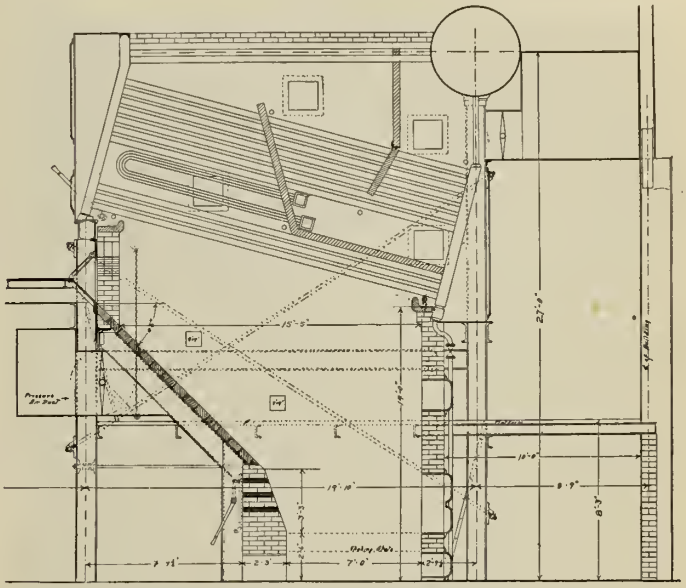

Fig. 5—Boiler Setting for Burning Wood or Coal.

low pressure steam for process work—a somewhat unusual feature in a central power station. The plant is located in the northern section of the city in what is known as the Bella Vista district, in close proximity to a number of industrial plants and, therefore, quite near the load centre. The altitude of the site is about 1,700 feet above sea-level.

The staple fuel is natural gas, which is piped to Monterrey from the Texas fields, a distance of over 200 miles. The power company purchases gas from the pipe line owners and, in addition to using it as fuel in the power plant, distributes it to domestic and commercial users in the city. As a precaution against an interruption of gas supply, the boilers have been equipped with oil burning apparatus and a stock of fuel oil is carried for use in emergency.

Water is a scarce commodity in the district and as there was no source capable of supplying continuously the quantity required for cooling the condensers, it was necessary to resort to cooling towers. Water is obtained from the city supply system, which, incidentally, is also owned by the power company, and is delivered to the site by a concrete pipe line.

The water is very hard and contains so large a quantity of scale-forming solids in solution that it was decided to treat the whole of the water used in the plant, whether for condenser cooling or boiler feed, by the cold lime-soda process. This decision was largely the result of experience in the company's old steam plant, which obtained its water from the same general source, the Santa Catarina river bed. In this case the deposit of hard scale on the condenser tubes was so rapid that it was impossible to operate a condenser for more than a few weeks without shutting down for scaling.

The efficacy of the treatment is evidenced by the fact that the generating unit in Bella Vista recently made a continuous run of a year, at the end of which the back pressure in the condenser was still maintained within ¼ inch of the designed value.

The softening plant is capable of dealing with 20,000 U.S. gallons per hour and the feed water, in addition to the lime-soda treatment, is treated with sodium-phosphate.

The plant is housed in a building consisting of steel frame, brick walls and corrugated asbestos roof and provides space for a second generating set and its auxiliaries. Temporary walls of corrugated asbestos are used where necessary to provide for future extension.

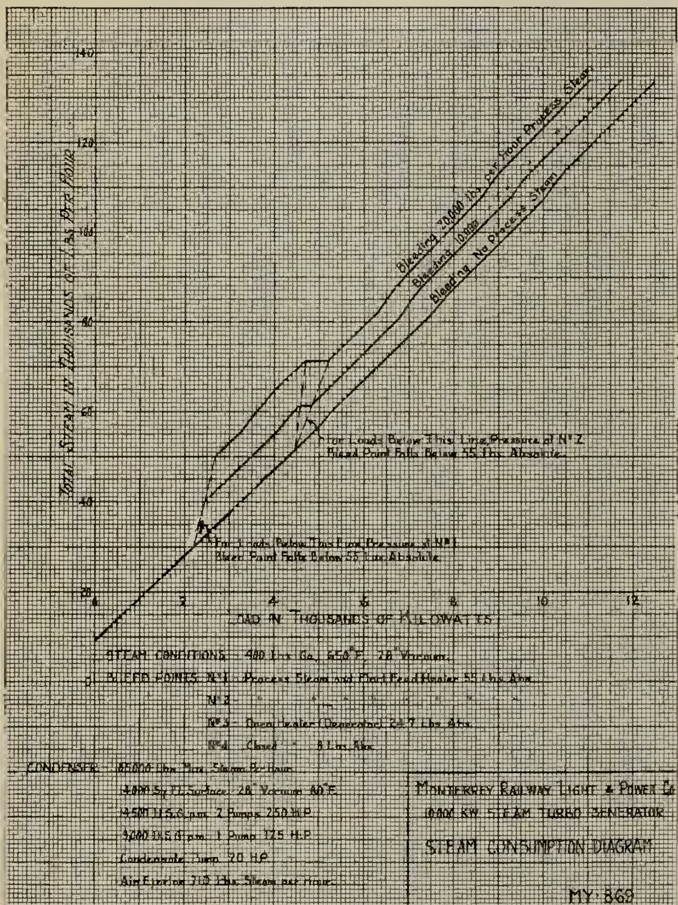

Fig. 6.

The same general method of installing the equipment is followed in this station as in the two previously described. The main part of the building houses the turbo-generator with its auxiliaries, the whole of the switchgear, which is located in a gallery running along the north wall, and the feed pumps, heaters, etc., which are installed in a bay at the south side. The boilers and the fuel oil pumping and heating units are located in the annex to the south. The cooling tower is north of the main building and the water softening plant is located immediately behind it. For the storage of oil fuel a 5,000-barrel steel storage tank is provided within the plant compound far enough away to minimize the fire hazard.

Generating Unit

At present the plant contains only one turbo-generator, standby capacity being provided by the old plant. This machine has a capacity of 10,000 kw. and runs at a speed of 3,600 r.p.m. The turbine is of the combined impulse reaction type designed for steam at 400 pounds per square inch pressure and 650 degrees F. temperature and is arranged for bleeding at four points. As has already been stated, the plant supplies low pressure steam for process work and ordinarily an automatic pass-off turbine would have been selected for this purpose. However, this is fundamentally a base load unit and the quantity of steam bled is small compared with that expanded down to condenser pressure. It was, therefore, decided to use a straight condensing design which enables the larger quantity to be utilized in the most economical manner, although it involves increased losses on the smaller quantity of bled steam. To meet this situation the Westinghouse Company evolved a scheme for obtaining this low pressure steam from the two upper bleed points of this standard design machine which has proved quite successful.

Process steam is required at 40 pounds gauge pressure and it will be noticed from the steam consumption diagram (Fig. 6) that the pressure at No. 2 bleed point reaches this value when the load on the machine exceeds 4,500 kw. At all loads in excess of this process steam is drawn from No. 2 bleed point, but at lower loads it is necessary to draw from No. 1 bleed point.

The flow of steam from the turbine to the process line is controlled by a pair of automatic regulating valves, one applied to each of the bleed points and so arranged that when the pressure at No. 2 bleed point proves insufficient to maintain the required pressure in the process line the valve controlling No. 1 bleed point automatically opens sufficiently to restore the line pressure. Non-return valves are provided to prevent steam re-entering the turbine through either of these points, thus preventing any steam short-circuiting the intermediate stages of the machine. (See Fig. 7.)

A turbine of this capacity expanding steam down to condenser pressure and running at 3,600 r.p.m. must of necessity have high blade tip velocity at the exhaust end and the blades in the later stages are, therefore, called upon to resist very severe erosive action. The maximum blade tip velocity in this case is 1,149 feet per second and called for special protection of the blades in the low pressure end of the machine. This was provided by applying hardened tantalum strips to the convex surfaces of the stainless steel blades at the entering edge. The first time the machine was opened up for examination, after about six weeks of operation, some of the blades in the later rows were found to have suffered erosion, the entering edges having been cut back in one or two cases as much as 3/16 inch. Careful examination revealed that the tantalum shields on these particular blades had been brazed on slightly out of place, leaving a narrow strip of the stainless steel at the entering edge unprotected. These unprotected strips had disappeared entirely but the tantalum shields had withstood the erosive action. Subsequent examinations—the last in October, 1932, after a continuous run of three hundred and sixty-six days, eighteen hours—failed to reveal any measurable extension of erosion, and it is evident that the measures adopted to protect the low pressure blades have proved effective in this instance.

The condensing plant, with its pumps, etc. was also supplied by the Westinghouse Company and is designed to maintain an absolute pressure of 2 inches of mercury with cooling water at a temperature of 85 degrees F. The condenser, which contains 14,000 square feet of cooling surface arranged for two water passes, is suspended from the exhaust branch of the turbine and is not supported at any other point, thus obviating the necessity of providing an expansion joint at the turbine exhaust. Duplicate motor-driven condensate extraction pumps are installed and the steam air ejectors are also in duplicate.

The circulating pumps, also in duplicate, are driven by 125 h.p. motors. Either of the pumps operating alone is capable of circulating 9,000 U.S. gallons per minute; both pumps operating together will circulate 14,500 U.S. gallons per minute, the quantity required to maintain designed vacuum with full load on the turbine. The unit is capable of operating at full load with only one pump in service but the back pressure would naturally be somewhat higher than that designed for. For loads up to about 6,000 kw. one pump only is used, thus effecting a very considerable saving in station power consumption.

After passing through the condensers the circulating water is delivered through a cast iron pipe distribution system to a cooling tower consisting of five cells. This tower is of the forced draught type, two fans per cell being provided. The fans, which are of the airplane propeller type, are placed at the base of the tower and driven by direct connected electric motors. So far it has only been necessary to use these fans in hot weather but when the machine becomes fully loaded it is anticipated that some of them will require to be operated all the time. The cooling tower superstructure, which is of Californian redwood, is built on a concrete foundation which forms the reserve tank.

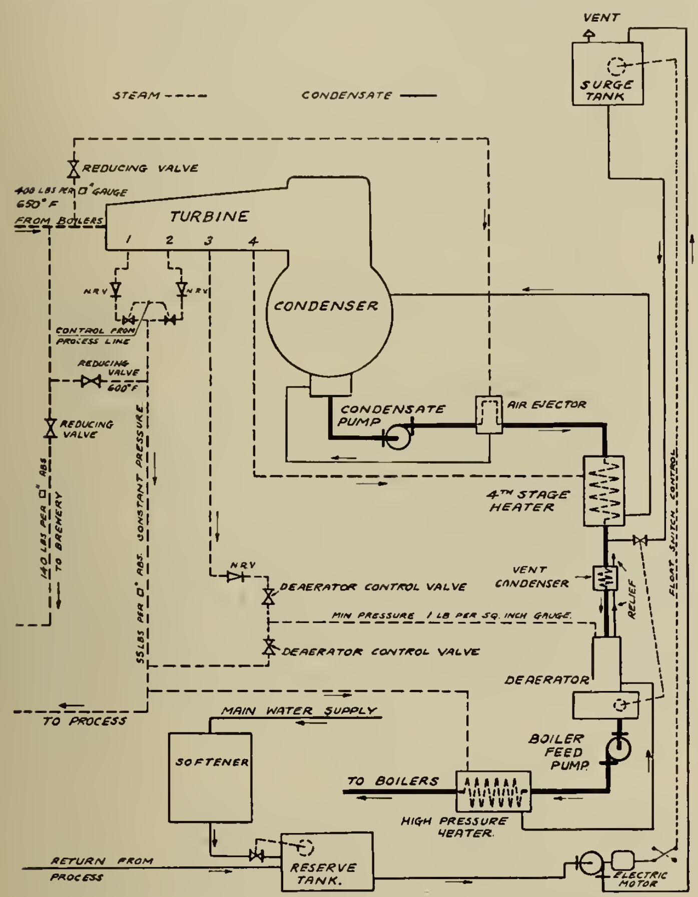

Fig. 7—Bled Steam and Feed Heating System—Monterrey Plant.

Feed Water System

The condensate extraction pumps deliver the water through the air ejector coolers, the low pressure closed heater (supplied with steam from No. 4 bleed point) and the deaerator vent condenser into the open deaerating heater, which is supplied with steam from No. 3 bleed point. In order to ensure that the deaerator shall have sufficient steam for proper operation at all turbine loads, a by-pass connection is provided from the process steam pipe controlled by regulating valves. The water flows by gravity from the deaerator direct to the boiler feed pump suctions and these pumps deliver it through a high pressure closed heater (supplied with steam from the process line) to the boiler check valves.

In order to prevent any possibility of flashing in the boiler feed pumps, the deaerator is placed at an elevation sufficient to ensure a static head of about 25 feet on the pump suctions.

To take care of small fluctuations in the feed demand an elevated surge tank is provided. A large feed reserve tank has been built outside the boiler room to store a quantity of treated water. Motor-driven pumps controlled by floats in the elevated tank transfer the water from the reserve tank to the elevated surge tank as required. Two boiler feed pumps are installed, one driven by an electric motor and the other by a steam turbine.

Boiler Plant

The boiler plant comprises two similar steam generating units supplied by Messrs. Foster Wheeler, Limited. (See Fig. 8.) Each unit consists of a Kidwell boiler with 7,420 square feet of heating surface designed for a working pressure of 450 pounds per square inch, a superheater capable of superheating the steam to a temperature of 650 degrees F. and a tubular air pre-heater with 6,755 square feet of heating surface. Plain tube water walls are provided for the back and sides of the furnace. Each furnace is equipped with four Peabody burners suitable for burning both natural gas and fuel oil. The units operate under balanced draught, both forced and induced draught fans being driven by electric motors. The fans for operating units of this size require considerable power, particularly at high ratings, and in order to reduce the power consumption at low loads each fan is fitted with two motors,—one for low and one for high speed operation,—the change-over being effected by push buttons on the boiler control panel.

Boiler meters, draught gauges and temperature recorders are applied to each steam generating unit and are mounted on a steel panel on the operating floor. This panel also carries the push buttons for fan control and the damper control levers are within easy reach so that the operation of the units is centralized at the instrument panel.

The manufacturers guaranteed an overall efficiency, when burning natural gas, of 80.8 per cent at a load of 60,000 pounds of steam per hour, which corresponds to approximately 273 per cent rating. This performance was realized without difficulty and the station operating reports show that in normal operation an average efficiency of between 78 and 80 per cent is maintained over the whole twenty-four-hour period during which the rating varies from about 190 to 290 per cent.

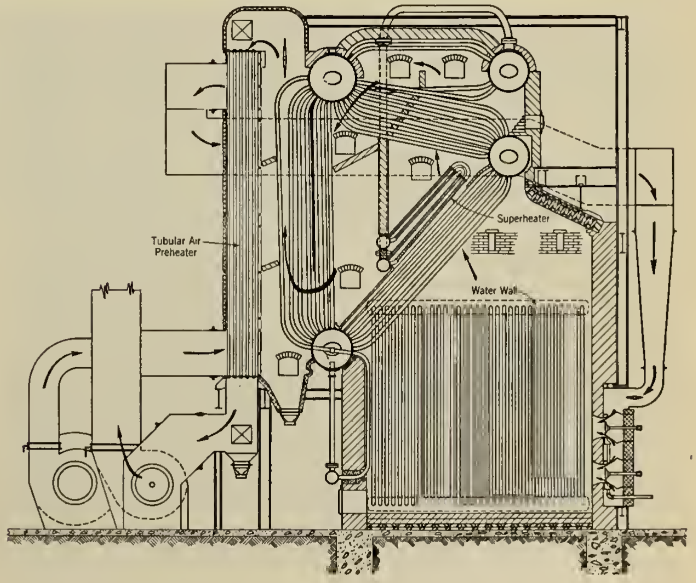

Fig. 8—Steam Generator—Monterrey Plant.

The oil fuel pumping and heating units, of which there are two, are installed between the boilers, each being of sufficient capacity to operate one boiler. A fuel transfer pump is also provided to deliver oil from the storage tank to the pumping and heating units. This pump is of the rotary displacement type, motor-driven and is installed in a separate building in the plant compound. All fuel oil piping is provided with internal steam heating pipes.

A certain amount of hazard is inseparable from the burning of natural gas and the utmost care is necessary to avoid furnace explosions. When designing the settings a large number of explosion doors were provided but these have not proved by any means adequate to release the pressure quickly enough to avoid damage to some parts of the setting. So far two explosions have taken place,—one while tuning up the plant shortly after construction, and the other a few weeks ago, while lighting up a cold boiler when power was not available to drive the fans. In both cases the explosion apparently took place in the upper part of the settings and the damage was limited to displacement of brickwork in that locality, neither the pressure parts of the boiler nor the walls of the furnace being injured.

The covering over the tubes between the two upper drums of the boilers is made as light as possible and consists only of loose tiles set close together with some filling material, such as insulating cement, to seal the joints. In the case of both explosions this covering was lifted, and permitted the gases to escape. This undoubtedly saved the rest of the setting from more serious damage. In both cases the Dietrick arch was disturbed but not so badly damaged that it could not be reinstalled without much trouble.

After the first explosion it was realized that the light brickwork in the upper part of the furnace was certain to be disturbed whenever an explosion occurred, and screens were installed to prevent the displaced material falling down onto the operators. In the case of the second explosion the screens proved quite effective and none of the operators suffered any injury.

Process steam is delivered through steel pipes, one 10-inch and one 4-inch. A 2-inch line is provided for condensate return. The pipes are carried about a foot above the ground on concrete pedestals, provision being made for free movement due to expansion. These lines are welded throughout and lagged with 85 per cent magnesia covered with asphalt.

The load in Monterrey, as in many other places, has suffered considerably due to curtailment of local manufacturing activities, and the average machine load factor is at present only about 36 per cent, which is too low to show very high economy.

Under these conditions the consumption of gas has averaged about .51 cubic meters per kilowatt hour, equivalent to about 17,890 B.t.u. As the boiler efficiency is 78 per cent the heat consumption in the turbine, air ejectors, piping, etc., is 13,950 B.t.u.

Conclusion

A comparison of the cost per kilowatt of installed capacity in these three plants is interesting. These costs are:

Venezuela	Completed 1927	6,000 kw. in 3 units	$130 per kw.
Demerara	" 1928	3,750 " " 3 "	$130 " "
Monterrey	" 1931	10,000 " " 1 "	$ 87 " "

These costs include land and improvements thereto, interest during construction and all other charges incidental to the construction. Even allowing for the fact that the Venezuela and Demerara plants consist of several small units and the Monterrey plant of a single large unit only, the costs indicate in a marked manner the fall in prices of equipment between 1927-8 and 1930. Were Demerara duplicated today the cost would probably not greatly exceed $100 per kilowatt.

The Value of Photography to Engineering

Paper prepared by a Committee* and presented before the Hamilton Branch of The Engineering Institute of Canada, February 1st, 1933.

(Abridged.)

SUMMARY.—Sketching the uses of photography in electrical engineering, more particularly as regards motion pictures and oscillography, the paper touches on the photographic methods which have done so much for metallurgy and chemical engineering. Attention is drawn to special developments such as the use of ultra-violet and infra-red rays, and some of the aspects of photography in industrial advertising are discussed.

Introduction

Photography proves useful to engineering on so many occasions that it is necessary to limit this paper to the major purposes of the art, and mainly to those cases where the camera is superior to the eye.

Roger Bacon, in 1214, refers to the projection of images and this principle, probably in the same form, was in common use early in the nineteenth century in the camera lucida. (Fig. 1.) It is generally supposed that the camera obscura was the invention of an Italian in the sixteenth century. Later it was discovered that the pictures obtained in that camera, which at that time was of the pin hole type, could be held for a short time on a chemically treated paper. What we now know as contact prints were first made by Wedgwood in 1802. Dry plates were not available commercially until 1880. Thus centuries of effort and research have now given us an art which is used by practically every engineer.

In 1889 Thomas Edison and George Eastman discussed the possibilities of the new transparent celluloid roll film which they believed was the solution of the problem of "moving pictures."** That same summer Edison invented the first practical moving picture camera.

Today the sales engineer with a complete projector, and films is able to demonstrate, with the aid of actual pictures, his equipment or wares in service.

Reference has been made to the advantage of the plate over the eye; one such advantage is that it does not differentiate between particles and waves; it is affected by the impact of fast electrons, positively charged helium or alpha particles and electro magnetic radiation.

Physics is a part of engineering science, and in physics photography plays a part of great value. The minute actions of falling or moving bodies may be observed; hidden sounds may be located by separate microphones, and the combined results recorded by means of a photographic apparatus so that the "discovery" is almost instantly ready for visual inspection.

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**Life of Thomas A. Edison by Francis Trevelyan Miller, LL.D.

A younger branch of engineering photography is photoelasticity. The complicated stresses inside loaded, bent or twisted bodies are rendered visible in transparent models by means of polarized monochromatic light, and photographed. The darkening of the plate is measured and the distribution of the stresses deduced.

Astronomical photography, although not an engineering science, is undoubtedly closely allied to the work of the surveying engineer.

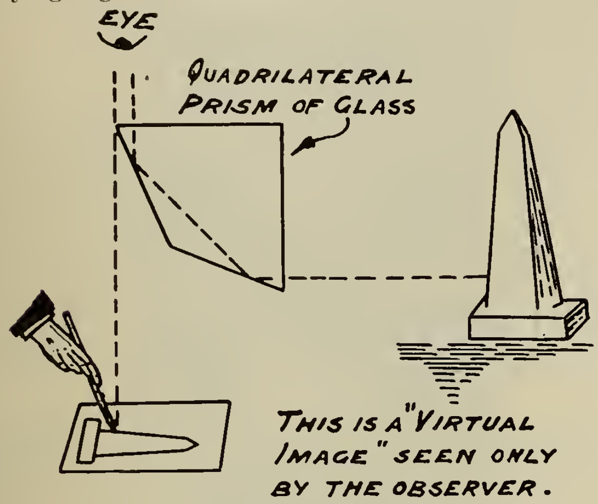

Fig. 1—Camera Lucida.

Photogrammetry is the process of measuring angles and is also a branch of the photo-surveyor's acquisition from photography. It is essential to photo-topography which is carried on with the aid of a theodolite or the plane table or the photo-theodolite. This work may be carried out in a somewhat similar manner from an aeroplane. When carried on from the air, a mosaic map may be easily constructed, although this is generally of less accuracy than the correct map but is suitable for much work.

Colonel Laussendat of the French army was the pioneer in the application of photography to surveying, his books on this subject dating from 1883 to 1900.

The value of aerial photography was realized many years ago and in 1858 photographs of Paris were taken by M. Naden from a balloon, but the aeroplane has supplied the means for a greater sphere of usefulness.

The season 1931 marks the end of the first ten-year period since the inauguration of aerial surveys by the Department of the Interior, Ottawa. These are carried out for the most part by the Royal Canadian Air Force in co-operation with the Surveyor General.

During the fiscal year ending March 31st, 1932, 76,000 square miles were photographed and up to that time a total of 402,500 square miles had been covered, of which 125,000 square miles were of the vertical, and 277,500 square miles of the oblique type. The vertical photograph is used for mapping on fairly large scales, or where the country is rough or mountainous, while the oblique type is pre-eminently adapted for the exploratory mapping of those areas of forest and lake which represent so large a percentage of our unsettled areas.*

Construction

In construction work, the simplest photographic records are pictures of work under construction, methods and appliances, and may take the form of records of stages of construction. The progress of construction work may be recorded by making a series of still photographs at definite intervals, or by means of a motion picture camera connected with a time lapse apparatus which makes exposures at any desired interval.

*Annual Report of the Department of the Interior.

Other purposes include photographs of scenes of unusual happenings or accidents, difficult working conditions, floods, etc., either for the purpose of record or for use in showing variations in conditions.

With the rapid advance in methods and appliances, detail in construction may be brought out in a picture which ordinarily is unseen by the eye. This effect is obtained by the use of films of different colour sensitivity, and in addition, by placing over the lens a light filter that passes or absorbs the different colours reflected from the subject.

The Industrial Engineer and Photography

In the study of the many problems confronting the industrial engineer frequent reference is made to photographic records.

The most common form of photography is the straightforward pictorial record of equipment before or after completion, and this is often used as proof of erection or test in the shop. It is also valuable to illustrate the various uses to which the article may be put, and, of course, for advertising purposes. One small firm in Hamilton, employing only about thirty-five men, has as many as fifteen hundred photographs of equipment built during the past thirty years.

A further important use is found in the inspection of castings and forgings. These pictures are made by the X-ray and at the present time the greatest thickness which it is possible to photograph by this method is 10½ inches, and any faults in the materials such as blow holes, slag and flaws may readily be discovered.

Photographs have been made of such things as the explosions in the cylinders of an internal combustion engine, a quartz window being let into the head of the engine, and a record made of the happenings inside against a one-element oscillograph.

The moving picture camera has also proved useful to the engineer in recording continuously the exact happenings

Fig. 2—Photograph of the Opening of a Contactor.

during a cycle of events. For instance, during a time study to speed up production, a photograph record may be made showing the operation in process with a clock in the blackground. After a few changes a duplicate record can be made when it is then possible to compare any phase of the operation.

The effects of stress on materials may be recorded in a similar manner; the type of equipment varying according to the test to be carried out.

The Electrical Engineer and Photography

The value of photography to electrical engineering is greater than one would suppose on casual inspection and has been further enhanced through the invention of a high-speed multi-exposure camera developed by J. W. Legg in 1918 in which sixteen lenses are focused on a plate over which a disc revolves. The shutter speed may be set as high as 3,000 exposures a second and the use of the oscillograph with this high-speed camera is an excellent combination. Figure 2 shows photographs of the opening of a contactor taken with a high speed camera of approximately 3,000 exposures per second.

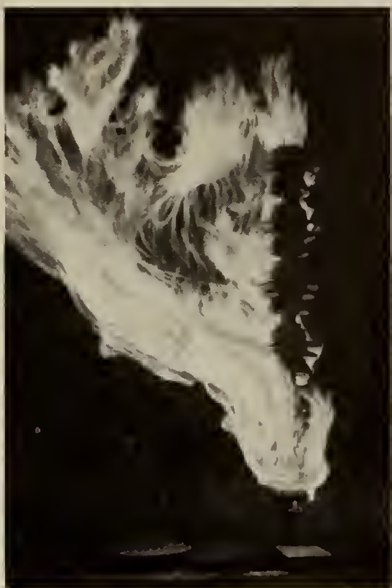

Fig. 3—Testing Insulators to Failure.

The study of the striated formation of high-voltage arcs has been greatly facilitated through the use of this camera. From a study of these in a particular case it was found that the striations are separate and distinct arcs occurring at the rate of two per cycle. Because of the motion of the air from convection currents and natural air currents, the successive arcs do not retrace the same path. The magnetic blowout effect no doubt contributes to the motion of the arc. As the arc increases in length, the gases cool more and more during the period of no current flow until a point is reached when the air is sufficiently de-ionized to withstand the voltage as it builds up and at this point the arc is extinguished. When a flame envelopes a group of insulators tested to failure, the effect is as illustrated by Fig. 3. The bottom insulator looks as if it were being consumed by an intense fire within; yet when the test is over, very little evidence of heat is found.

With high voltage discharge produced for laboratory development and proof of new apparatus by huge transformers, it is possible to produce arcs that are quite different in both sight and sound from lightning. The 60-cycle arc takes on the character of a flame in general, accompanied by a resonant hum which grows to a roar if sufficient power is released. A 50-foot column of flame produced with a million-volt transformer is illustrated.

Under some conditions the flame of a 60-cycle arc develops a delicate tracery (see Fig. 4), a series of striations caused by the arc being extinguished and re-established one hundred and twenty times a second in synchronism with the power supply. When air currents fan the arc to spread out these markings, an endless variety of patterns can be seen by the eye and recorded by the camera.

Moving pictures are sometimes used, especially when a test of apparatus is made to the point of destruction. In one case a safety chain was apparently drawn into a reactor which was carrying a heavy current and started an arc between turns. The motion picture showed conclusively that the arc had started before the chain was drawn in and that a modification of the reactor design was required.

Slow motion pictures are of great assistance, especially in the study of mechanical problems in electrical apparatus. A film was made of a low voltage contactor to determine whether the proper rolling action between the contacts was being obtained.

Electrical manufacturers make a practice of photographing finished equipment in the factory. This provides a record which can be filed with the drawings and other data, providing a very complete docket of information for future use. In construction work the progress of the erection of intricate electrical equipment is followed by means of photography, and in some cases a re-design of cable arrangement can be made before the job is completed.

Switchboards photographed with all the accessories mounted form a valuable proof of assembly if trouble arises later through pilferage and other evils of a like nature.

The Klydonograph

Since the beginning of high-voltage transmission, the question of the nature of transient voltages on transmission systems has been a troublesome problem. Many troubles have been attributed to surges, but without positive evidence of their existence. The klydonograph developed by J. F. Peters and W. L. Teague has proved valuable in showing surges, with a continuous graphic record of detailed information regarding magnitude, time of day, polarity, steepness of wave front, direction of travel and whether or not the surge was oscillatory. The instrument is founded on the phenomena known as Lichtenberg figures. Dr. G. C. Lichtenberg in 1777 observed that when a condenser was discharged on to a terminal in contact with a plate of insulating material, such as ebonite, between it and a grounded metallic plate and particular kinds of powder were sprinkled on the insulating plate, the powder would arrange itself about the positive of the terminal in a definite and consistent manner. Substituting a photographic plate for the powder is briefly the essential difference between the klydonograph and the earlier powder experiments. Figure 5 shows typical figures of surges taken with a klydonograph.

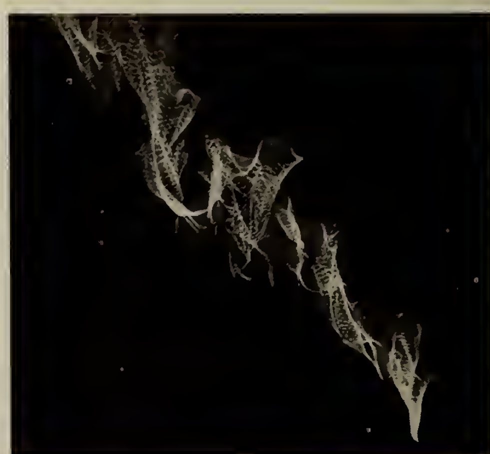

Fig. 4—Delicate Tracery from a 60-Cycle Arc.

To obtain an idea as to the value of the klydonograph the following actual investigation is described.

Tests were made on a 26,400-volt transmission system consisting of connected cable and open wire. Grounding was varied between solid and 150-ohm resistance. One instrument was installed on one phase at a substation having cables extending in each direction, and another instrument on the same phase on the open wire line, 18 miles from the junction of cable to open wire.

During a twenty-day investigation eighteen surges were recorded. The largest number in one day was three. All were obtained on the instrument on the open wire line. Of these surges, seven were alternating, seven were positive and four negative. As to magnitude of voltage, two were twice normal, six were 1.5 times normal and ten were 1.3 times normal or less.

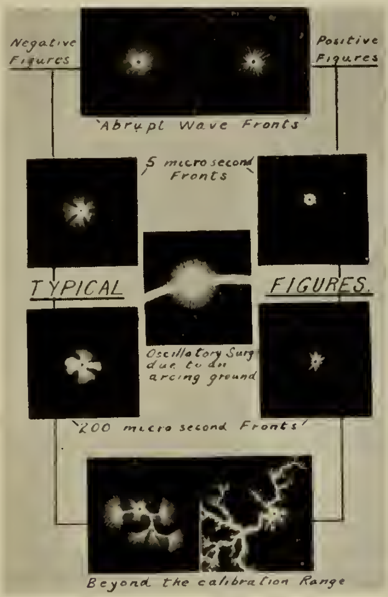

Fig. 5—Klydonograph Record of Surges.

Oscillography

The electrical industry is ever making more and more use of the oscillograph within the laboratory and in set tests in the field.

The development of large power systems for the generation, transmission, and distribution of electrical energy created new engineering problems arising from power oscillations whose frequency is beyond that which can be measured by any other type of recorder than the oscillograph. Modern oscillograph equipment has been made portable, and therefore, quite appropriate for field use. Figure 6 illustrates an oscillogram taken with transverse film to show the characteristics of an arc in air. It will be noticed that as soon as the arc is struck the voltage drops, the time taken for a breakdown to occur to the ionization of the gas being approximately four cycles. Figure 7 illustrates an oscillograph taken with rotating film.

There are two fundamental applications of oscillograph equipment for use in power systems:

1. During staged tests.
2. During chance disturbances.

Staged tests on a system may be arranged for measuring certain quantities for a definite set of conditions. These tests are used to verify certain points in the calculations and to obtain empirical coefficients of systems which differ widely for different systems. These coefficients can be obtained only by experiment on actual systems. Such tests are usually arranged to determine the effect of certain changes in adjustment of apparatus or operating practices.

Recently, a new and very important application has been found for the oscillograph in automatically recording different quantities during chance disturbances. This has been proved by the gathering of much important data as to actual power transients resulting from various causes such as lightning, bushing flashovers, broken splices, and unknown causes.

It is difficult to establish, even by witness testimony, the correct picture and sequence of events of any occurrence. The operating engineer has a difficult problem to determine what occurs in a system during a disturbance which may last only one or two seconds. Indicating meters, which are good for steady state conditions, are too sluggish to follow transient disturbances and, for the same reason, graphic instruments record only the occurrence of a disturbance without giving its correct magnitude and, what is more important, with no record of the sequence of events. In such cases, automatic oscillographic recorders, placed at strategic points of the system, give correlated records of voltages, currents, power, and any desired variation of these quantities in their correct time phase, position and true sequence. This permits the reconstruction of a short-lived disturbance, the determination of its cause, and consequently, the adoption of some means by which its repetition may be prevented. The operating engineer may measure directly and accurately the magnitude of the short-circuit currents, the actual time lag of relays, the operation of circuit-breakers, the change in the speed of the prime mover, the gate opening of a water turbine, etc. In the case of power systems, the number of quantities simultaneously recorded is limited only by economic considerations and those selected for measurement depend upon the nature of the investigation and upon the characteristics of the particular system.

Oscillograph equipment may also be used for the investigation of individual parts of the system. For instance, it may be desirable to make a study, for a period of time, of the excitation system. Or it may be desirable, with the assistance of circuit-breaker manufacturers, to study the operation of circuit-breakers on the system for a few months. Many such applications will occur to the engineer.

The oscillograph is a very valuable tool in conducting these investigations. In one case, serious vibration was encountered on a large water-wheel generator unit. Oscillographic records of the pressure were made at various points and instead of showing a steady pressure equal to the value indicated by a gauge, this was found to be pulsating at a large amplitude. These indications showed that the vibration was due to the shape of the blades of the runner, and when a small portion of these blades was cut away the vibration ceased.

In typical circuit-breaker tests, three currents, three voltages, and the mechanical motion of the parts may be recorded by normal oscillographic galvanometers. In addition, the power developed during the current interruption may be measured by an instantaneous wattmeter element. Such a test requires a nine-element oscillograph. On a single film all of these eight quantities may be recorded for a circuit-breaker under test and their correct time-phase relation can be accurately shown. One galvanometer may be used for recording transient current in the closing or tripping solenoid. The record of currents in all three phases indicates whether the contacts of all three phases begin to

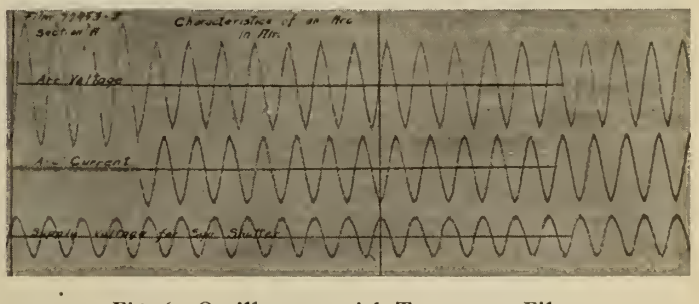

Fig. 6—Oscillogram with Transverse Film.

open simultaneously, whether the arc is interrupted at the same time, and also the time, or number of cycles it takes to open the short-circuit. The curve of the motion of the mechanical parts shows the amount of motion when the arc is built up as well as when the arc is extinguished. By counting the number of cycles between the appearance of current in the tripping coil and complete interruption of current in the circuit-breaker, the time may be determined

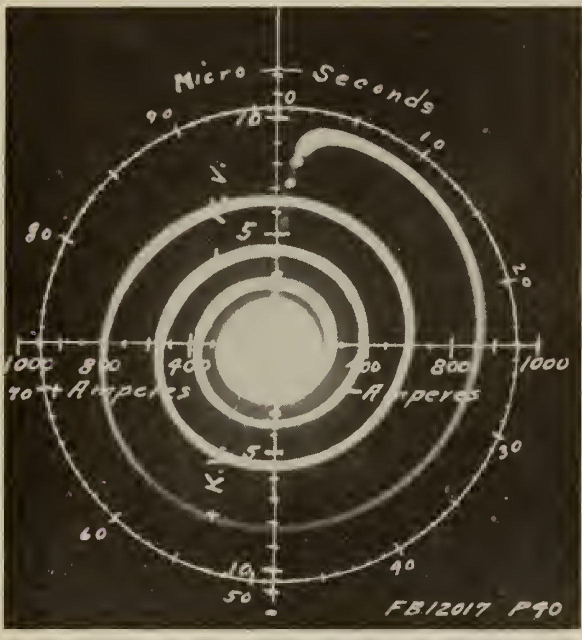

Fig. 7—Oscillogram with Rotating Film.

from the moment the relay closes to the moment of complete short-circuit interruptions.

Photography in Ferrous Metallurgy

In ferrous and non-ferrous industries, photography has latterly made great progress. It has been a factor in each step or stage, assisting in defining and enlightening, as well as recording for comparison.

The information gained by photography provides greater control in production, and a more reliable and uniform finished product.

Through the demands of various metals for definite processing along certain lines, the metallurgist has, with the camera, been able to depict the various changes resulting from different workings or treatments and to protect or guide such treatments within certain definite limits. With this control comes commercial satisfaction and regularity in repetition.

The apparatus used in ferrous photography consists of a camera and a first class microscope rigidly fixed and constructed. The preparation of the specimen is of the utmost importance, especially when the magnification increases above 200 diameters. The use of proper etchants is essential to the best results.

Photo-metallurgy covers the field of both low (macro) and high (micro) power magnification, and these are generally recognized as its two divisions.

Macrophotography for instance is used to great advantage in developing proper design in dies and punches for both hot and cold upsetting work. For heading and shaping bolts, rivets and forgings flow lines are developed by etching at each operation, after sectioning the pieces, and these show the direction or manner of displacement of the steel as it upsets or flows.

Microphotography deals with high rather than low power magnification, that is from ten diameters upwards. In the micro laboratory of The Steel Company of Canada, the equipment is capable of magnification up to eight thousand diameters. The greater amount of photographic work is carried out on this continent at about one hundred or two hundred diameters and these are considered standard for purposes of comparison.

It must also be pointed out that microphotography is of the greatest practical importance in the every day production of iron and steel, particularly the latter. The quality steel maker is always striving toward perfection. Steel making is carried out at extremely high temperatures and the metallurgical reactions of the process are difficult to fix positively. The product of these reactions is of such a character that in passing from the liquid to the solid state, steel freezes in a crystalline mass. The examination and comparison of crystalline structure is obviously best carried out by the microscopical camera, when variations of seemingly slight degree may be etched, magnified and photographed so they become not only perceptible but frequently striking. With balanced judgment and experience these variations may be interpreted and by proper specification put into daily use to guide in producing a still higher quality of steel.

Photography in Chemistry and Chemical Engineering

Just as other sections of this symposium have shown the benefits derived from the use of photography in their various branches of engineering, so in chemical engineering the development of the art has placed a new tool in the hands of the chemist and analyst.

The section on microphotography has really demonstrated the major use of this art in chemical engineering, in showing how the chemical composition as well as crystal structure of a metal or alloy can be made plain and studied in a microphotograph. As in steel, so in many other alloys a large part of the story is told by a photograph of either the polished or etched surface of such a metal, and fundamental data both as regards manufacture or usability for a specific purpose are obtained in this way.

Photography has also shown us the cause of failure in metal structures and eliminated disasters by showing the tendencies of certain metals and alloys to crystallize under strain and fatigue.

The X-ray has been of great value here, when used to detect flaws in castings and for similar work. By using very short X-rays, or gamma rays from radium emanation, sections of steel ten inches thick have been successfully radiographed. They have been used to detect internal strain and to investigate the effect of work and heat treatment on metals and alloys.

Fig. 8—Samples of Good and Inferior Aluminum Paint.

Photography has aided materially in determining the best temperatures, conditions and compositions for galvanizing and other metal coating.

In addition to aiding in the satisfactory coating of metals it has played a useful part in the study of the corrosion of metals under various atmospheric conditions. Photography gives us the means of recording the progress of relatively slow corrosive action and the relative resistance of various bodies to destructive action.

For example, the film of a certain enamel may appear to be glossy and in good condition, but the record by microphotography reveals the fact that it is weathering badly.

Photography is also a useful tool with which to determine the value of protective films such as paints and lacquers, and is used to good purpose along with weatherometers, sprays, freezing and thawing equipment, giving excellent records of the progress of such tests. Figure 8 illustrates the paint film of a well balanced aluminum paint, showing minimum metal exposure and, another well-known brand of commercial aluminum paint showing the improper leafing of the aluminum, with excessive metal exposure.

By such means the tendencies of a film to resist the action of various solvents may be followed and a ready and fairly reliable measure of the protection offered against a particular substance determined. The manner of the breakdown under specified conditions can also be shown, and the information so gained used to advantage in introducing new ingredients to overcome inherent faults.

Microphotography has also been used successfully to determine the degree of penetration of iron waterproofing into the surface of concrete and limestone and to study the filling of the pores and waterproofing by expansion during oxidation. This information is of value, not only in determining the best method of application, but also in fixing the sizes to which the iron should be ground to give the best results.

It has further been of value in studying the sizing on silk. With the micro camera, the laying of various coatings on the fibre can be plainly seen, and the effect of creasing, abrasion, and washing studied in detail.

In a similar way the art has been used to study the solution of solids in liquids, the deposition of metals by electrolysis, and the act of crystallization. In this connection, Major Thomson has used not only microphotographs, but moving pictures to study the setting of gypsum by crystallization. The outcome of this research was a distinct contribution to the theory of the setting of gypsum and the products containing this substance.

Further, through X-rays, it has been possible to obtain an increased knowledge of the structure of crystals and the arrangement of atoms in the molecules of various substances. Some light has been cast on the size and type of some molecules such as rubber, about whose molecular structure very little is known, and in the study of organic substance of a fibrous and non-crystalline nature. It is not possible to use X-rays in place of chemical analysis, but they can be and are used for spectrum analysis, as in the detection of substances like chromium carbide in stellite and other instances where the photography of spectrum lines shows the presence of mixtures difficult to analyse otherwise.

Photographic methods can also be used to identify the various phases which are present in solids, to distinguish between mixtures and solid solutions, and to determine the limit of solubility of solid solutions, to determine grain size, recrystallization temperatures and regularity of orientation. It is interesting to note that a photographic plate is probably one of the surest and simplest means of determining the presence of radioactive substances.

There are undoubtedly many items that could be added to this list, but the above instances will serve as an indication of the usefulness of photography to the chemist and chemical engineer.

Recent Advances in the Perfecting of Materials and Equipment of a Photographic Nature Applicable to the Work of the Engineer

During the great war a tremendous impetus was given to the improving of photographic emulsions and especially to the increasing of colour sensitivity. So called "panchromatic" emulsions are not really a new resource for the photographic worker; but during the last three years the advances made in this type of film and plate have been remarkable. Speed has been increased to such an extent that almost unbelievably short exposures are possible, and this factor has helped greatly in the work undertaken in the field of high speed moving pictures. Motion pictures, taken at such high lens speeds that the film actually travels through the instrument at 20 miles per second, have been successfully produced.

Photographic emulsions are capable of being sensitized to special wave lengths of light and even to certain invisible rays both longer and shorter than those visible to the eye. The presence of ultra-violet light in such sources as the mercury arc has been utilized to a large extent in everyday photography, but it is not generally known that it will produce rather unexpected results when special colour filters are used to cut out all but the ultra violet wave lengths. Old faded manuscripts, records, etc. on which the eye can scarcely discern any writing, are made legible by photographing them in ultra-violet light. A photographic record of a badly charred document can also be made by placing a sensitive film in intimate contact with the charred document for several hours, and then developing.

Similarly infra-red rays, the longer light waves beyond the deepest red of the visible spectrum, produce effects on properly prepared emulsions. They are "heat" waves and it is possible to utilize them to produce pictures in places where haze and even fog obscure the view of the eye. Their use is also valuable when it becomes necessary to look through stains, etc. that may be obliterating portions of documents or plans. Old documents have been deciphered by this method.

The infra-red camera has lately taken to the air and some remarkable long range pictures have been obtained. Almost the only distance limit seems to be the ultimate horizon due to earth curvature. Figure 9 illustrates an example of distance conquered by the combined use of the camera and the aeroplane, and is a copy of the longest distance photograph made to date. It shows Mount Shasta 331.2 miles from the camera, the exposure being

Fig. 9—Photograph with Range of 331 Miles.

made from an altitude of 23,000 feet. A remarkable feature is that a haze reduced visibility to the eye to 100 miles.

The plate or film has been useful to mineral prospectors in north western Canada, as the radio active ores in that district throw off emanations that affect the emulsion and the presence of these ores has been repeatedly discovered by the streaking and fogging effects on plates.

A great advance was made possible by the perfecting of the 16 mm. width film and an emulsion so fine grained that it is capable of smooth appearing projections up to considerable size. The cameras and projectors for this film came naturally as purely mechanical and electrical adaptations of existing principles, but it opened a new field to the engineer. He can photograph objects in motion, at low cost and under all kinds of conditions. He can do it himself with little or no actual knowledge of photography, and produce records, etc., that may be studied at leisure and from which he can deduce improvements in design or new applications of engineering principles. As an example one might cite the case of a Hamilton industry which has a large plant in France where they were about to undertake the manufacture of certain products which had been made in Hamilton for several years. Moving pictures were made of the entire series of operations, showing methods and continuity. When these pictures were sent to the new plant, they needed no laborious translation into another language; the workman in France saw how, why, and when the operations took place.

Photography in Industrial Advertising

The work of the producing engineer in industry is largely dependent on the distribution of the product; hence advertising is a vital matter to the engineer. He has therefore utilized photographs to tell his story, and has used them to gain and hold attention where words would fail to do so. Most photographs used to illustrate and sell engineering products are retouched, and so long as such work is confined to making good the deficiencies of the camera in order to represent the product as it appears to the eye, it is legitimate, but too often the retoucher is made to show things in an impossibly idealistic way, with results that are false and ridiculous to a thoughtful observer. Retouching has long been a crutch for the photographer to fall back on to cover up his own deficiency, and has led to carelessness, as he knows that anything missed can be put in, with interest, by the retoucher. The modern photographer is sweeping away this old mistaken idea.

As regards detail, the human eye is not as critical as the camera lens, as the eye can only see one thing at a time, and that over a very limited area. In a photograph, this fact can be used to emphasize a particular part. This is shown in sharp focus, whilst the remainder of the picture is allowed to be slightly out of focus. The eye will therefore rest on the portion in focus, not disturbed by other details. A photograph that is all detail lacks perspective, the eye jumps from one spot to another, gets tired, and remembers nothing. This latter result is fatal in an advertisement.

Passing from the rather limited field of simply showing the product in action without an imaginative setting, the new field so well exemplified by the Eastman Kodak Company in its series of volumes "Applied Photography" can be considered. Along these lines, advertisers are producing striking results. The fundamental requirement of all advertising is "attention value," and it has been often demonstrated that a display that arouses little attention will attract crowds as soon as the idea of motion is introduced. A problem of advertising on the printed page is to introduce this quality of motion into a design, and modern photography in the hands of artists is achieving this object.

In such dramatic presentation of a product, the eye must be led into the picture and held there as long as possible. Psychologists have proved that the eye will submit to a single stimulus for not more than three seconds, and this is the fatigue period. The normal speed at which the attention shifts is more than once a second. This leaves the advertiser with but a fraction of a second in which to make the first impression on the observer. His illustrations must be planned so that in this brief time the reader's eye will catch something to make it remain for a longer period. One means of holding the eye is a repetition of the object so that as the eye moves from the first thing it sees over the picture, it still receives the same impression. An odd angle, line, or shadow, properly placed, or a circling line which brings the eye back to where it started—these are a few of the methods employed by the modern photographer to get and hold the attention of the reader, and leave some definite idea in his mind before he turns the page.

Summary

In conclusion, the authors feel that the material gathered and submitted in this symposium shows definitely that photography is firmly established as one of the essential arts and sciences employed by engineers in the pursuit of their many and varied professional duties.

Acknowledgments

The Committee acknowledges, with sincere appreciation, the assistance of all those who have contributed to the information and photographs contained in this paper, and particularly Mr. Noel J. Ogilvie, Director, Geodetic Survey of Canada, Ottawa; Mr. F. E. Lathe, Director, Division of Research Information, National Research Council, Ottawa; Dr. Mees, and Associates of the Eastman Kodak Co., Rochester, New York; Mr. Davis of Davis Lisson Co., Hamilton; Mr. J. D. Taylor, Technical Institute, Hamilton; and Canadian Industries Limited, Montreal.

Edward Henry Keating 1844-1912

President of The Canadian Society of Civil Engineers, 1901

A Biography prepared in 1923 by the late C. E. W. Dodwell, M.E.I.C.

In 1812 Captain John Keating, the grandfather of Edward Henry Keating, sailed with his wife and only child from Liverpool for Philadelphia to take possession of some property that was claimed by Mrs. Keating by inheritance from her father, Gabriel Wayne, a brother of Anthony Wayne of the United States Army.

On the voyage their vessel met and spoke to an east bound craft, from which they got the alarming news that the United States had declared war against England. It is therefore not surprising that they were forbidden a landing on the shores of the belligerent young republic, and that the fortunes of the Keating family were profoundly affected. The property they came to possess was sequestrated, and after twenty-one years confiscated and sold by the United States government.

Their ship, denied sanctuary in the Land of the Free, headed southward and finally landed her passengers—the Keating family at any rate—on the shores of the north coast of South America, where, a few years later, Captain John Keating died of yellow fever at Paramaribo, Dutch Guiana, his widow and only child returning to England. Mrs. Keating remarried, her second husband being Captain Alexander Johnston of the 60th Regiment (King's Royal Rifle Corps), which regiment was shortly afterwards ordered to Halifax, N.S. The boy, W. H. Keating, was left in England to be educated, but in October, 1819, he came to Halifax in the sailing transport "Royal Charlotte" and from that date until his death he was a prominent citizen of that old city by the sea. Here, as a barrister, he practised his profession, and for a number of years also he was Deputy Provincial Secretary for Nova Scotia. His wife was a daughter of Captain A. S. Van C. Forbes, and by her, in grateful recognition of his duty to his adopted country, and as if to atone for his father's shortcomings, he had eighteen children of which the subject of this memoir was the fifth. Edward Henry Keating was born in Halifax on the 7th of August, 1844. He was educated at Dalhousie College, where his studies were more particularly directed with the view of his becoming an architect. The demand for engineers in those days, however, to take part in the general development of the country and especially in the construction of railways, caused him to divert his energies and talents to the broader and more promising field of the sister profession, in which he enjoyed a distinguished career of nearly half a century.

His first practical experience was gained under George Whitman, Provincial Government Engineer of Nova Scotia. For three years he was engaged on the surveys, location and construction of the Truro and Pictou Railway, then a provincial undertaking. Following that he was chief draughtsman of the Windsor and Annapolis Railway (subsequently the Dominion Atlantic Railway, and now for some years part of the Canadian Pacific Railway). At the close of 1867 he was with the Intercolonial Railway as assistant engineer on some of the heaviest construction of the road. In the spring of 1872 he was appointed division engineer in charge of exploratory surveys for the Canadian Pacific Railway but he resigned at the end of the same year to become city engineer of Halifax, and during his period of office there he was resident engineer in charge of the construction of the Halifax graving dock, at that time the largest on the American continent. During his incumbency at Halifax he also designed water works for Truro, Windsor and Dartmouth, N.S., and for Moncton, N.B. For two years, 1891 and 1892, he was city engineer of Duluth, Minn., where he designed extensive improvements in the water works. He was then offered the office of city engineer of Toronto, Ont., which he accepted. Shortly after taking up the duties of this position he reported on a comprehensive plan for the improvement of the water supply system, which was considered too expensive at the time but carried out later. He also designed and completed some important works of improvement in Toronto harbour, including the Keating channel which was named after him. In 1898 he resigned as city engineer to become general manager of the Toronto Street Railway. In 1904 he went to Mexico, where for nearly two years he was engineer and manager in the construction of the Monterrey Railway Light and Power Company's street railway and power and lighting plant, and of the Monterrey water works and sewerage systems, and of these properties he remained consulting engineer for some time after his return to Toronto. For the last six years of his life he was active as a general consulting engineer and as an arbitrator in valuation questions and proceedings, for which his sound judgment and absolute sense of justice admirably fitted him. In 1903 Mr. Keating was chairman of the Royal Commission to report on the construction of a graving dock for the city of Montreal. At various times he was expert adviser or consultant on the water works and sewerage systems of Ottawa and Hamilton, Ont., Victoria, B.C., and other places. He was a Member of the American Society of Civil Engineers, and of the (British) Institution of Civil Engineers. He joined the Canadian Society of Civil Engineers in its early days, and served on its Council for three years, 1896, '97 and '98, as Vice-President for two years, 1899 and 1900, and as President of the Society for the year 1901.

EDWARD HENRY KEATING, M.E.I.C.

In his early Intercolonial days he married Mary Little Blanchard of Truro and during a singularly happy wedded life had six children, two sons and four daughters; the eldest son, H. E. C. Keating, took a commission as lieutenant in the British Army in 1892 and was killed in October, 1899, with a party of about a dozen men, by the natives of the Upper Niger in Africa when some frontier posts were relinquished by the French and replaced by British garrisons after the convention of June 14th, 1898. Mr. Keating's second son, Sedley, is in business at Regina, Sask. Of the four daughters, one died in England at the age of nineteen. The other three daughters are all married, two now living in Grimsby, Ont., and the other with her husband, Lieutenant-Colonel G. W. Denison, D.S.O., R.E., recently retired and living at Cosgrove Lodge, Colchester, England.

The writer of this memoir, though nine years his junior, is proud to recall an intimate personal and professional friendship with Mr. Keating extending over many years. As draughtsman and general utility assistant in his Halifax office for some months in the winter of 1873-74, he had opportunities of learning much of the estimable features of Mr. Keating's character both as a man and an engineer.

Keating had the unaffected modesty of true merit. There was nothing he disliked more than aggressive self-assertion or the limelight of publicity. Every advance to a higher position or to more highly paid and more important professional activities and responsibilities—and he had many of them—was due to intrinsic and unquestioned personal worth, as exemplified in rare professional knowledge, attainments and experience, in sound judgment and the most absolute and unswerving probity and professional honour.

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The Engineers' Code in the United States

As is well known, an extensive programme of public works, under the direction of the Public Works Administration, forms one of the main features of the recovery movement in the United States. Designed to furnish employment in the construction industry and allied branches, its progress is being watched by Canadians with sympathetic interest. It is understood that after some initial delays the programme is now moving forward more rapidly, and that cities and states, engineers and architects, are co-operating effectively with Washington to this end.

Side by side with this movement, the National Recovery Administration is dealing with the recovery problem as it affects practically all industries, so that, among others, it has proved necessary to undertake the regulation of the construction industry and those concerned in it. As in the case of many other industries a bewildering multiplicity of codes has been the result. It is stated that as regards construction alone nearly one hundred and fifty codes of one sort or another have been proposed, many sponsored by local organizations, or at least bodies having no national standing.

The first draft of a Code of Fair Competition for the Construction Industries* was submitted to the National Recovery Administration on August 7th. It is a "master code," covering generally all branches of the construction industry, and was sponsored by the Construction League of the United States. At the time of submission it was remarked that this code would have to be supplemented by a number of subsidiary codes covering specifically the activities of the various bodies concerned in construction work. The first of these subsidiary codes was that for General Contractors,† and it soon became evident that the maintenance of fair and equitable conditions in the contracting field concerned not only the contractors, but also the engineers and architects who design and supervise construction work. Codes for engineers and architects, it was pointed out, would be necessary. These would aid in preventing unfair practices, would define the professional man's position, and would also afford much needed protection to junior employees as regards long hours and poor pay. Action on the part of the engineers was not long in following. While the construction industry code itself was undergoing amendment and revision, the Executive Committee of the American Society of Civil Engineers decided to prepare a code of fair competition in the engineering profession in so far as it is concerned with the construction industry. After consultation with representatives of other national and local professional societies a draft of the code‡ was made, and was approved on August 25th for submission to the National Recovery Administration. The first public hearing upon it was held in Washington on October 9th. It is noteworthy that in the form first submitted no attempt was made to fix minimum fees for professional engineering services or rates of pay for engineering employees, but these features seem likely to form the subject of much discussion while the code is undergoing further amendment prior to being put in operation.

Although its scope is limited to engineering practice in construction work, the resulting document is of great interest to all who are concerned in the organization of the engineering profession, either in the United States or elsewhere. It merits close attention by reason of the high standing of the professional bodies who have engaged in its preparation, and the urgency of the problems with which it deals.

Defining first the terms used, such as "professional engineer" and "engineering assistant," the code provides that the latter shall have the right to organize and deal collectively with an employer, and shall be paid not less than the minimum rates which may be established regionally or locally by the proper authorities. Working hours are dealt with, and the Code of Ethics of the A.S.C.E. is made obligatory on the engineer. Certain objectionable practices are prohibited, including competitive bidding for professional engagements, the giving of free engineering services or free cost estimates in competition with other engineers, and the soliciting of outside employment by salaried engineers. The proper relations between engineers and contractors are described and their responsibility towards each other defined. The code proceeds to give a generalized statement of the duties to be performed by an engineer as regards construction work, and specifies in some detail the various services for which engineers should be engaged.

The administration of the code is to be in the hands of a National Control Committee composed of representatives of the national professional engineering organizations subscribing to the code, with the addition of two members representing engineers who have no national society affiliations. The expense of such administration is to be borne proportionally by all engineers "in so far as their practice is a function of the construction industry."

A somewhat similar code as regards the responsibilities and duties and professional practice of architects has been submitted by the American Institute of Architects, and is being treated, like the engineers' code, as a supplementary code under the general code for the construction industry. With other supplementary codes, such as that for contractors, it will be placed in the hands of the policy committee of the Construction League of the United States so that that committee can adjust any possible conflicts with other codes.

*See Engineering News-Record, Aug. 3, 1933, p. 148.
†See Engineering News-Record, July 20, 1933, p. 82.
‡See Engineering News-Record, Sept. 7, 1933, p. 290.

Action in this matter seems to have been forced upon American engineers because the main code for the construction industry, when approved by Mr. Roosevelt, will necessarily govern everybody concerned in the industry, including the engineers. That code is of such a general nature that it does not afford engineers the necessary protection. The supplementary code for engineers supplies this need. It has necessarily been developed rapidly, a fact which should be borne in mind when studying its provisions. But it does deal specifically with objectionable practices which are only too common in the United States (and are not unknown in Canada) and which can only be controlled if engineers and architects co-operate with contractors in condemning and preventing them. It is encouraging to find that in the United States such co-operation now seems to be assured.

The Work of the Membership Committee

One of the topics to be discussed at the sixth Plenary Meeting of Council will be the question of the maintenance and increase of The Institute's membership.

At the meeting of Council in February, 1933, this question came up for discussion and the following committee was appointed to encourage membership activities in all our Branches: D. C. Tennant, M.E.I.C., chairman, A. Frigon, M.E.I.C., F. S. B. Heward, A.M.E.I.C., C. K. McLeod, A.M.E.I.C.

It was then realized that many of our members were finding it difficult to get along on reduced income and that a considerable number were without employment, these conditions having led in some cases to resignation, and in others to requests to be put on the suspended list. As a consequence, Council was as far as possible making arrangements to meet the wishes of members in difficulties.

The opinion was freely expressed, however, that under such circumstances it was all the more necessary that real efforts be made to obtain new members, especially since there were undoubtedly capable, qualified engineers in many of the Branch centres who were not yet members of The Institute, and who would be willing to make application if suitably approached.

In April last a circular letter was sent to all Branches, drawing attention to the need for action and requesting Branch assistance to this end.

Following this, in June, a circular was sent to all corporate members of The Institute, accompanied by a form which each member was invited to fill in with the names and qualifications of any engineers known to him who might be prospective members, or who, if members of The Institute, seemed eligible for tr nsfer.

This action resulted in the submission of nearly three hundred names, but the Committee feels that this list is by no means representative of the number of eligible engineers in the country who do not yet belong to The Institute. Branch membership committees have been requested to investigate and approach those considered desirable as prospective candidates, and this is now being done.

The Committee does not agree with the opinion of those few members of The Institute who consider that in view of the present unfavourable economic conditions, no effort should be made to attract members for The Institute; on the contrary, it is felt that steps should now be taken, not only to retain the present members, but also to enlist the co-operation of the many qualified engineers who for various reasons have not yet joined.

The attainment of this result depends upon the active support of individual members in all our Branches, which the Committee confidently believes will not be lacking at this time.

Nominations

The report of the Nominating Committee was presented to and approved by Council at the meeting held on October 6th, 1933. The following is the list of nominees for officers as prepared by the Nominating Committee and now published for the information of all corporate members as provided by Sections 68 and 74 of the By-laws.

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."

List of Nominees for Officers for 1934 as Proposed by the Nominating Committee

President:	F. P. Shearwood, M.E.I.C.	Montreal.
Vice-Presidents:		
**Zone "B"*	E. G. Cameron, A.M.E.I.C.	St. Catharines.
	C. D. Howe, M.E.I.C.	Port Arthur.
	J. L. Lang, M.E.I.C.	Sault Ste Marie.
**Zone "C"*	A. B. Normandin, M.E.I.C.	Quebec.
**Zone "D"*	Alexander Gray, M.E.I.C.	Saint John.
Councillors:		
‡*Cape Breton Branch*	C. M. Smyth, M.E.I.C.	Sydney.
‡*Moncton Branch*	H. J. Crudge, A.M.E.I.C.	Moncton.
	T. H. Dickson, A.M.E.I.C.	Moncton.
‡*Quebec Branch*	Hector Cimon, M.E.I.C.	Quebec.
††*Montreal Branch*	C. B. Brown, M.E.I.C.	Montreal.
	Aimé Cousineau, A.M.E.I.C.	Montreal.
‡*Ottawa Branch*	C. M. Pitts, A.M.E.I.C.	Ottawa.
	E. W. Stedman, M.E.I.C.	Ottawa.
‡*Peterborough Branch*	R. L. Dobbin, M.E.I.C.	Peterborough.
†*Toronto Branch*	J. R. Cockburn, M.E.I.C.	Toronto.
‡*Hamilton Branch*	F. W. Paulin, M.E.I.C.	Hamilton.
‡*Niagara Peninsula Branch*	Walter Jackson, M.E.I.C.	Niagara Falls.
‡*Sault Ste Marie Branch*	J. H. Jenkinson, A.M.E.I.C.	Sault Ste Marie.
	A. E. Pickering, M.E.I.C.	Sault Ste Marie.
‡*Winnipeg Branch*	F. G. Goodspeed, M.E.I.C.	Winnipeg.
‡*Lethbridge Branch*	C. S. Clendening, A.M.E.I.C.	Commerce, Alta.
‡*Calgary Branch*	R. C. Harris, M.E.I.C.	Calgary.
	F. M. Steel, M.E.I.C.	Calgary.
‡*Victoria Branch*	J. C. MacDonald, M.E.I.C.	Victoria.
	H. L. Swan M.E.I.C.	Victoria.

The following name is proposed by Council for election as Councillor for one year to complete the term of Mr. Shanly who has resigned as Councillor for the Saguenay Branch:

Saguenay Branch	G. F. Layne, A.M.E.I.C.	Riverbend.

*One Vice-President to be elected for two years.
‡One Councillor to be elected for two years.
†One Councillor to be elected for three years.
††Two Councillors to be elected for three years each.

Reduction in Entrance Fees

At its meeting held on October 6th, Council decided that as a temporary measure, the entrance fee for all classes of membership should now be reduced to five dollars, this ruling to remain in force for a limited time, and subject to confirmation at the Annual General Meeting in February next.

OBITUARIES

James Edward Browne

Regret is expressed in recording the death at Ottawa, Ont., on October 13th, 1933, of James Edward Browne.

Major Browne was born at Great Yarmouth, England, on November 28th, 1872, and received his professional education at the School of Military Engineering, Chatham, England, and at the Royal College of Science, London.

From 1894 to 1897 he was assistant instructor in military surveying at the School of Military Engineering, Chatham, and in 1898-1899 was assistant surveyor with the Anglo-Portuguese Boundary Commission in South East Africa. Coming to Canada in 1900, Major Browne was appointed instructor in civil and military surveying at the Royal Military College, Kingston, Ont., and in 1904 became topographical engineer, Surveys Division, Militia Headquarters, Ottawa. From 1914 to 1916 Major Browne was overseas, and returning to this country in 1917 resumed the office of Supervisor of Topography, Department of National Defence, Ottawa.

Major Browne became a Member of The Institute on July 9th, 1923.

Charles Scott Cameron, A.M.E.I.C.

Deep regret is expressed in placing on record the death at Regina, Sask., on September 27th, 1933, of Charles Scott Cameron, A.M.E.I.C.

Born at Beaverton, Ont., on December 6th, 1884, Mr. Cameron was educated at the University of Toronto, receiving his diploma at the school of Practical Science in 1911.

During the seasons 1908 and 1909, he was assistant engineer with the Yukon Gold Company, Dawson City, and immediately following graduation he became associated with the staff of the city engineer, Regina, on waterworks installation. In 1913 Mr. Cameron was assistant to the Chief Surveyor, Land Titles, and on March 15th, 1913, received a commission as a Dominion Land Surveyor, becoming a Saskatchewan Land Surveyor on July 7th of the same year. In 1914-1915 he was in private practice as a land surveyor at Regina, Sask. During the war Mr. Cameron served overseas with the Engineers, and returning to Canada, resumed his practice. In 1922 he organized the Saskatchewan Concrete Culvert Company, which later became Concrete Products Limited. Of this company Mr. Cameron was president and manager up to the time of his death.

Mr. Cameron was elected an Associate Member of The Institute on November 16th, 1915.

Henry Maurice Scott, A.M.E.I.C.

The death is recorded at Croydon, England, on October 11th, 1933, of Henry Maurice Scott, A.M.E.I.C.

Mr. Scott was born at Montreal, Que., on June 11th, 1880, and graduated from McGill University in 1901 with the degree of B.Sc.

Following graduation Mr. Scott was until 1902 assistant engineer with the New York Telephone Company, later becoming assistant lighting engineer with the Manhattan Railway, New York. In 1904 he was in charge of lighting installation for the Interborough Rapid Transit Subway, New York, and in 1906 supervised the installation of wiring and switching for the Necaxa power house, in Mexico. From 1907 to 1909 Mr. Scott was engaged on the design and installation of hydro-electric equipment for the Mond Nickel Company at Victoria Mines, Ont., and in 1910 was consulting engineer on design and installation for the Jacobs Asbestos Company at Thetford Mines, Que. He was later with the Cedar Rapids Power Company in Montreal. During the war Mr. Scott served overseas, having the rank of lieutenant, and was invalided out in June, 1918. In 1926 Mr. Scott settled at Varangeville-sur-Mer, Seine, France.

He became an Associate Member of The Institute (then the Canadian Society of Civil Engineers) on April 13th, 1912.

PERSONALS

Michael Dwyer, A.M.E.I.C., has been appointed to the portfolio of Minister of Public Works and Mines for the Province of Nova Scotia. Throughout his professional career, Mr. Dwyer has been associated with Nova Scotia's

THE HON. MICHAEL DWYER,
Minister of Public Works and Mines for the Province of Nova Scotia.

coal and steel industry, having been for many years with the Nova Scotia Steel and Coal Company in engineering capacities. He occupied the positions of mechanical superintendent, manager of the Princess colliery, manager of the wash plant and coke ovens, assistant works superintendent and general superintendent. In 1924 Mr. Dwyer was appointed president of the Indian Cove Coal Company at Sydney Mines, N.S., which office he held until 1932.

Mr. Dwyer's appointment as Minister of Mines is a particularly popular one, on account of his technical experience and his sound judgment, both of which, it is felt, will benefit the engineering and mining interests in the province.

Since becoming an Associate Member of The Institute in 1925, Mr. Dwyer has taken an active interest in its affairs, and was chairman of the Cape Breton Branch in 1929. He was elected president of the Mining Society of Nova Scotia in 1931.

International Waterways Commission

During the week of October 2nd, 1933, a number of eastern engineers were in Winnipeg in connection with the hearing of the International Waterways Commission on Rainy Lake Reference and the meeting of the Lake of the Woods Control Board. Among those present from the east were: Messrs. W. S. Lea, M.E.I.C., J. T. Johnston, M.E.I.C., I. R. Strome, A.M.E.I.C., Dr. T. H. Hogg, M.E.I.C., and S. S. Scovil, M.E.I.C. The following local engineers also took part in the meetings: Messrs. C. H. Attwood, A.M.E.I.C., B. B. Hogarth, A.M.E.I.C., J. W. Porter, M.E.I.C., F. G. Goodspeed, M.E.I.C., J. W. Sanger, A.M.E.I.C., and E. V. Caton, M.E.I.C. The Commission adjourned on Saturday, October 7th, to reconvene in Minneapolis, most of the Canadian engineers being present.

RECENT ADDITIONS TO THE LIBRARY

Proceedings, Transactions, etc.

North-East Coast Institution of Engineers and Shipbuilders: Transactions 1932-1933.
The Royal Technical College, Glasgow: Calendar 1933-1934.
Society for the Promotion of Engineering Education: Proceedings of 40th Annual Meeting, 1932.
National Council of the State Boards of Engineering Examiners: Proceedings, 1933.
American Society for Testing Materials: Year Book 1933.
The Mining Institute of Scotland: List of Members 1932-1933.
Institution of Naval Architects: Transactions 1933.

Reports, etc.

Air Ministry, Aeronautical Research Committee, Great Britain:
Reports and Memoranda:
No. 1451: Wind Tunnel Interference and Streamline Bodies.
No. 1452: Drag and Pressure—Distribution Experiments on Two Pairs of Streamline Bodies.
No. 1491: Experiments on Swept-Back and Swept-Forward Aerofoils.
No. 1512: Effect of Tractor Airscrew on Body-Wing Interference.
No. 1513: Heats of Formation of Nitrous Oxide and Carbon Dioxide.
No. 1520: Air Torque on a Cylinder Rotating in an Air Stream.
No. 1527: Binary Servo-Rudder Flutter.
No. 1532: The Best Basis of Aircraft Performance Reduction.
No. 1533: Loads in a Fuselage under Combined Bending and Torsion.
No. 1534: Spinning of High and Low Wing Monoplanes.
No. 1535: Simplified Presentation of the Subject of Spinning in an Aeroplane.
No. 1538: Effect of Ribs on Stresses in Spans.
No. 1541: Second Report on Tail Buffeting.
No. 1528: Determination of the Stresses in Braced Frameworks.
No. 1542: Silencing Aircraft.
No. 1545: Principles of the Air Injector.
No. 1546: Tests of Full Scale Anchors in Various Sea Beds.

Mining Society of Nova Scotia:
Recent Investigations on the Nature, Preparation, Storage and Coking of Typical Coals from the Sydney Area, Nova Scotia, by R. E. Gilmore and R. A. Strong.

Forest Products Laboratories of Canada:
Review of the Literature on Softwood Distillation.

World Power Conference: Sectional Meeting, Scandinavia, 1933:
General Report:
Energy Supply of Large Scale Industry.
1*a*—Electrical Energy; 1*b*—Gas; 1*c*—Solid and Liquid Fuels.
2. Power and Heat Combinations.
3. Special Energy Problems of the Steam Heat Consuming Industries.
4. Special Energy Problems of the Iron and Steel Industry.
5. Electrical Heating.
6. Transmission and Adaptation of Motive Power for Industrial Machinery.
7. The Power Questions of the Railways—Steam, Diesel and Electric Traction.
8. Energy Problems of Urban and Suburban Traffic.
9. Energy Problems of Marine Transport.

American Institute of Steel Construction Inc.:
Annual Report 1933.

Institution of Mechanical Engineers:
The Handling and Storing of Grain with Special Reference to Canadian Methods, R. H. Broughton.

Technical Books, etc., Received

Mechanical Catalogue 1933-1934. (*American Society of Mechanical Engineers.*)
A Combustion Course, by Otto de Lorenzi. (*Combustion Engineering Corporation Ltd., Montreal.*)

BOOK REVIEW

Vocational Guidance in Engineering Lines

Sponsored by the American Association of Engineers, 1933. Cloth, 6 by 9 in., 490 pages and appendix, illustrated, $2.50. Mack Printing Company, Easton, Pa.

Reviewed by PROFESSOR R. DE L. FRENCH, M.E.I.C.*

This book is accompanied by a circular which might be headed "Suggestions to Reviewers". The purpose of the book may be set forth by quoting from the circular:

"To encourage the . . . most suitable of the youth of our country to come into the engineering profession. . . To provide. . . for students. . . a treatise that will describe. . . the profession. . . To furnish. . . faculties with a fund of information about the profession. . . To give the. . . public an opportunity to correct the impression it has concerning the. . . profession. . . To keep the square pegs out of round holes and *vice versa*. . . To arouse a . . . greater enthusiasm for the engineering profession."

All engineers will agree that these are proper and laudable aims; most engineers will also doubt the possibility—at least, in a first edition—of reaching these objectives, no matter how experienced and distinguished the authors who undertake the task. Small wonder, then, that the sixty chapters which make up this book are of uneven quality.

Nineteen chapters deal with the major divisions of engineering and with such matters as mental capacity and natural talents, idealism, ethics, compensation and engineering literature. The remaining chapters cover the specialized branches of engineering. With the exception of seven for which the editors are responsible, the author of each chapter is a specialist in the subject of which it treats.

The American Association of Engineers deserves every commendation for the courage with which it has attacked a problem crying for solution, but this reviewer wonders if 500-odd pages is not a pretty big dose to prescribe for the high-school student, in the hope that it may help him to receive a correct impression of the life and work of the engineer. It would seem that the book is much more likely to serve well another purpose for which it was prepared, that of providing a foundation for lectures on the profession.

Perhaps in future editions the style of some chapters may be modified in favour of one more in keeping with the psychology of the young men to whom they are addressed. In this connection, one might commend to the editorial committee a perusal of Davis's "The Young Man in Business" or of Gow's two little books on humanistics.

* *Professor of Highway and Municipal Engineering, McGill University, Montreal.*

BULLETINS

Traffic signs—A 24-page booklet has been received from K. E. Erickson Co. Inc., Portland, Oregon, and Indianapolis, Ind., illustrating various types of traffic signs manufactured and sold by that company.

Rigid frame concrete bridges—A booklet has been received from the Portland Cement Association on the "Analysis of Rigid Frame Concrete Bridges," a subject in which remarkable progress has been made during the last few years. The methods outlined in the pamphlet are simplified as far as possible and are intended to facilitate the work of the engineer. The value of the booklet is increased by a bibliography of recent papers dealing with rigid frame analysis.

Resistances—A number of illustrated bulletins, amounting in all to 90 pages, have been received from the Zenith Electric Co. Ltd., London, England, which describe and illustrate various types of resistance units, their uses, dimensions and prices.

Compressors—Two 8-page folders describing 120 and 240 cubic feet displacement portable compressors, and one 16-page booklet, containing photographs and examples of compressors for refrigeration purposes, have been received from the Worthington Pump and Machinery Corporation, Harrison, N.J.

Feedwater Heaters—The Worthington Pump and Machinery Corporation, Harrison, N.J., have published a 4-page folder describing locomotive feedwater heater equipment.

Snub starters—An 8-page pamphlet has been received from Dominion Engineering Works, Ltd., Montreal, describing the principle of operation and applications of the Bethlehem snub starter.

Tractors—The Cleveland Tractor Company have published a 12-page booklet illustrating the various uses of their tractors for road making, with particular reference to road making in Medina county, Ohio.

Stainless clad steel—A 4-page leaflet has been received from the Ingersoll Steel and Disc Company, Chicago, Ill., illustrating a number of uses of Ingoclad stainless clad steel.

Pumps—A number of pamphlets have been received from the Viking Pump Company of Canada, Limited, Walkerville, Ont., illustrating the various types of pumps manufactured by this company to handle gasoline, kerosene, lube oil, etc.

C.E.S.A. Approval Specifications for Electrical Apparatus

The Canadian Engineering Standards Association announces that two new specifications have been issued under Part II of the Canadian Electrical Code: No. 7, Electric Portable Displays and Incandescent Lamp Signs, and No. 10, Electric Floor Surfacing and Cleaning Machines.

These specifications outline conditions which must be met to secure approval for the sale of those particular types of electrical apparatus in Canada.

Under recent arrangements which came into effect on January 31st, 1933, practically all electrical equipment manufactured in Canada is for the present being tested by the laboratory of the Hydro-Electric Power Commission at Toronto. These tests are based as far as possible on standards which are prepared by the Canadian Engineering Standards Association. The nine provinces of Canada have now officially adopted the Canadian Electrical Code and in practically all cases tne provincial inspection departments require approval by the laboratory mentioned.

The Manufacture of Sulphite Pulp

C. B. Davies, B.Sc.,

Sulphite Mill Superintendent, Sault Ste-Marie Division, Abitibi Power and Paper Co. Ltd., Sault Ste. Marie, Ont.

Paper presented before the Sault Ste. Marie Branch of The Engineering Institute of Canada, March 23rd, 1933.

Paper consists of cellulose fibres matted into a coherent sheet. The raw materials furnishing the fibre are wood pulp, cotton or linen rags, esparto, straw, hemp, flax, jute, etc. Old paper and the trimmings and waste from paper mills are also reworked into fresh paper.

In every case cellulose fibres must be freed from incrusting matter or treated in such a way as to reduce the substance to a state of minute subdivision and to isolate more or less completely the individual fibres.

There are two kinds of wood pulp, namely, mechanical and chemical. The three principal chemical processes are the soda, sulphate (or kraft), and the sulphite process. The product of the sulphite process is known as sulphite pulp.

Newsprint paper is made chiefly of a mixture of mechanical pulp (or groundwood) and sulphite pulp in the approximate proportions of 80 and 20 per cent respectively. Frequently a small amount of mineral matter (such as clay) is added to improve the surface of the sheet. Alum, various dyes, and sometimes resin size, are also added to the pulp mixture in small quantities.

In order that the function of the sulphite pulp may be more thoroughly understood, an outline of the groundwood process and a brief description of the paper machine proper may be given.

The Groundwood Process

Mechanical pulp is made by forcing a stick of wood against a revolving sandstone, or emery wheel, over which a jet of water plays continuously.

The resulting pulp is washed away by the water and passes several screens to remove insufficiently disintegrated particles. The pulp is then partly dewatered, or thickened, and pumped to the mixing room.

Obviously, groundwood pulp contains, in addition to the wood fibres, all the natural cementing materials, resins, sugars, etc., found in wood. The yield of pulp per cord of wood is therefore quite high, resulting in a comparatively low cost pulp. The fibres, however, are quite short and do not mat together well. The natural spruce wood fibre length is approximately ⅛ inch, and the average groundwood fibre is about 1/32 inch long. Such pulp can, therefore, be used only in conjunction with other longer fibres such as those which constitute a chemical pulp.

Figure 1 is a general flow diagram showing the relation of these various operations, and also a typical flow sheet for a newsprint machine.

The Paper Mill

This mixture is stored, then pumped through a flow regulator, diluted with water, thoroughly mixed and given a final screening, after which it enters the headbox of the paper machine.

The wet end of the type of machine used for newsprint manufacture is known as the Fourdrinier and consists essentially of an endless web of fine wire gauze travelling continuously in one direction and supported horizontally, or nearly horizontally, on a number of tube rolls. The slush stock is delivered on to this wire, the weight of the sheet being regulated by the supply of stock. As the water drains through the wire the pulp fibres are felted together, forming a continuous sheet of paper.

The web of wet paper is then transferred to a series of endless woollen felts and conducted through several press rolls which squeeze from the paper as much water as can be removed mechanically. The next step is to evaporate the balance of the water and this is accomplished by passing the sheet around a number of steam heated revolving drums, known as dryer rolls.

At the dry end of the machine, a smooth hard finish is obtained by running the paper through a stack of heavy steel rolls. The paper is then wound into a roll and later re-wound and slit into rolls of the desired length for shipment.

The Sulphite Mill

As already pointed out, sulphite pulp is mixed in newsprint slush in the approximate proportion of 20 per cent, principally to improve the sheet-forming properties of the slush and give to the finished sheet the necessary strength and character.

However, this is only one of the minor uses of sulphite pulp. It is the principal constituent of most book papers and many popular bond papers are 100 per cent sulphite. It is also the chief raw material used in the manufacture of rayon and cellophane and even the various forms of cellucotton which have grown so popular since the war, are 100 per cent sulphite.

The history of the sulphite process is comparatively short—only sixty-six years have elapsed since its discovery by Benjamin Tilghman, an American chemist. After patenting the process he abandoned its development due to equipment difficulties.

Major credit for further developments can be attributed to no one man, for much has depended upon the improvement of materials produced by other industries.

The process was first established on a successful commercial basis by a Swedish chemist, C. D. Ekman, in 1874. Later in 1880, another modification was developed to commercial success in Germany by A. Mitscherlich. The next fundamental improvement came in Austria where Eugen Ritter and Carl Keelner patented a basic modification, destined to become the most general practice on the American continent.

Commercial manufacture began in 1881 at Providence, Rhode Island, and the second mill on this continent was established at Merritton, Ontario, by Charles Riordon, in 1882.

The era of early discovery can be said to have ended by 1890. Then followed the successful production of acid resisting brick linings for digesters, and the discovery of acid resisting bronze alloys.

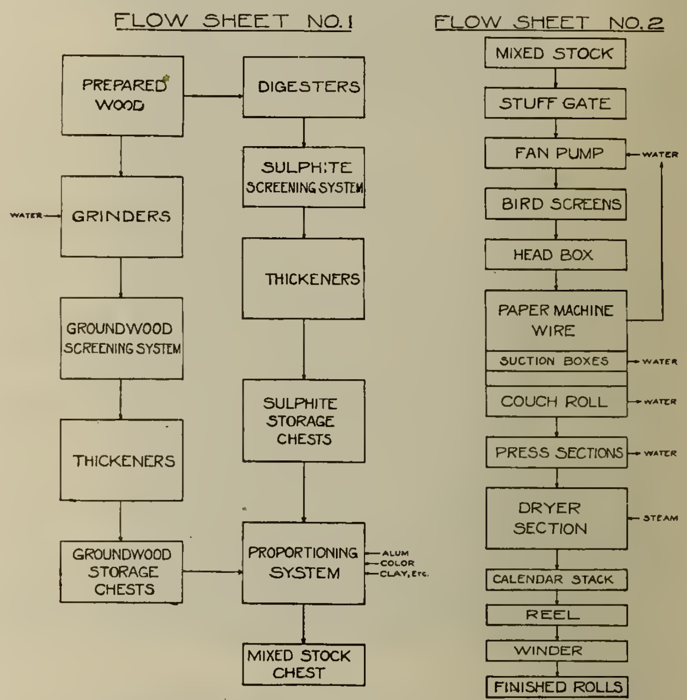

Fig. 1—Stock Flow Diagram for Paper Mill.

Though a mass of scientific and practical information was collected from experiment and observation, the process was little improved before 1915. Actually as late as 1922 the writer worked in a mill equipped with horizontal digesters.

It was general practice after each cook to send a crew of men into these digesters to shovel the pulp out through manholes at either end and later shovel chips from the ends into the centre of the digester. The cost of such practice would be prohibitive today.

The period since 1915 has seen the development of technical control in pulp and paper mill operation generally and in the sulphite mill in particular.

More recently the problems of digester operation have been seriously attacked, and through the application of chemical engineering principles some interesting developments have ensued.

Theory of the Sulphite Process

As already outlined, the sulphite process is a method of producing a fibrous pulp from wood prepared in a suitable form for treatment under pressure by a chemical solution.

The fibrous product is a mixture of various types of cellulose. In the wood, these cellulose fibres are held in chemical and physical combination with lignins, resins, starches and sugars. The following is a representative analysis of a Canadian pulpwood:—

Cellulose	50 per cent
Lignin	30 " "
Carbohydrates	16 " "
Resins, etc	3.3 " "

The function of the chemical treatment in the process is to separate the less soluble fibrous celluloses from the more soluble cementing materials by chemical action and dissolution, obtaining a product containing over 90 per cent cellulose.

This is accomplished in a large pressure vessel, or digester, which is filled with suitably prepared wood chips, and then pumped full of cooking acid, which is an aqueous solution of calcium or magnesium bisulphite carrying an excess of sulphurous acid. When charged, steam is introduced directly into the mixture of chips and acid through a suitable fitting at the bottom of the vessel. The digestion period varies from eight to sixteen hours, depending upon the quality of the pulp desired and other local conditions.

Lignins form the greatest part of the interfibrous binding of the cellulose and although the exact chemical structure of lignin is not definitely known, it is a generally accepted fact that the principal reactions which take place in the digester are:

1. Sulphonation of the solid lignin in the wood.
2. The subsequent removal of the lignosulphonate by hydrolysis.

Another function of the sulphite liquor is its attack on the non-cellulosic polysaccharides in the wood, converting them into simple sugars.

All of these reactions proceed very slowly at ordinary temperatures but speed up considerably at temperatures over 110 degrees C. Hence the necessity of digestion.

The waste liquor, containing approximately 55 per cent by weight of the wood in addition to the chemicals, is drained from the residual pulp in the blowpits after the digestion is completed.

Figure 2 gives a general diagram of the flow through the Sault Ste. Marie sulphite mill.

The Wood Room

The prepared wood referred to is from the same source as that supplied to the groundwood mill. For the manufacture of chemical pulp, it is necessary, in order that the cooking liquor may penetrate the wood, to reduce the blocks of wood to chips that are less than one inch long (measured with the grain)

The type of chipper used at this mill is a heavy steel disc, 82 inches in diameter, equipped with four heavy steel knives, and enclosed in a suitable housing. The disc is driven at approximately 200 r.p.m. The block of wood is fed, end first, against the revolving chipper disc at an angle of about 45 degrees. The knives slice off the end of the block as it projects beyond the bed knife and the chips thus produced are conveyed to a breaker which breaks up the larger discs, and are then elevated to shaker screens. The accepted chips are conveyed from the screens through a series of belt conveyors and bucket elevators to the chip storage bins over the digesters. The sawdust drops to a refuse conveyor and is sent to the boiler house to be burned as fuel, and the oversize chips and slivers are put through a rechipper and returned to the chip screen, thus closing up the system.

It takes approximately 34 cords of rough wood to produce one digester charge of chips, which necessitates a chip storage capacity of approximately 300 rough cords over the digesters. The chips flow by gravity from the chip bins into the digesters as required.

The Acid Plant

The raw materials used in the manufacture of sulphite acid are sulphur, limestone and water.

Sulphur as brimstone is now used almost exclusively on this continent because of comparative economy, purity and simplicity. A method of burning pyrites mine concentrates recently introduced in Canada has not yet reached a point where it may be considered to be beyond the experimental stage. There is also the possibility of a comparatively low cost sulphur dioxide supply in liquid form being obtained from smelter gases. The total annual value of sulphur consumed in Canada when newsprint production was at a peak in 1930 was about $3,700,000.

An abundant supply of cool water is also necessary for efficient acid plant operation. Due to warm water, many mills have been forced to resort to deep wells, and even refrigeration plants, during the summer months.

Sulphur is burned in rotary sulphur burners, the combustion to SO_2 being completed and controlled in combustion chambers. Although SO_2 is the main product formed when sulphur is burned in air, some SO_3 forms with an excess of air.

Therefore, the combustion must be carefully controlled. At this mill, a gas of approximately 18 per cent SO_2 content is most satisfactory.

The gas leaving the combustion chamber at a temperature of 1,800 degrees F. is conducted through cast iron pipes to a lead pipe cooler, where it is cooled to 25 degrees C. This cooling is necessitated by the fact that SO_2 is practically insoluble in water at higher temperatures.

Flow of gas is maintained through the acid system by a large lead blower situated between the coolers and the limestone towers.

At the Sault Ste. Marie mill there are four acid towers, each 100 feet high with an internal diameter of approximately six feet. These are of reinforced concrete construction with acid-resisting tile linings. Three are connected as strong acid towers and one as a weak tower. They are all kept full of limestone, one tower at a time being laid off and charged as necessary. Each tower holds approximately 165 tons.

The cooled gas is blown into the bottom of and upward through the strong towers where over 90 per cent of the SO_2 is absorbed. It is then conducted through lead pipes from the top of the strong towers into the bottom of the weak tower, finally discharging to the atmosphere from the top of the weak tower containing less than 0.02 per cent SO_2.

The flow of water which is counter-current to the gas flow may be followed through the flow sheet. (Fig. 2.) A steady and metered supply of water is pumped to the top of the weak tower, leaving as a weak acid to be pumped to the top of the strong tower.

The water flows down over the limestone, forming thin films on the surface of the rocks, and thus being brought into intimate contact with both the carbonate of the limestone and the SO_2 gas. Sulphur dioxide is absorbed by the water, and converted to sulphurous acid. This acid in turn reacts with the calcium carbonate of the limestone, producing calcium bisulphite.

The strong or raw acid leaving the strong towers is a solution of calcium bisulphite with an excess of dissolved sulphur dioxide or sulphurous acid, containing a total SO_2 content of approximately 4 per cent, of which about 0.75 per cent is free SO_2 and the balance combined as the acid salt of calcium.

This raw acid is then built up to a strength of over 6 per cent total SO_2 content as it passes through the recovery system. The recovery system consists of one tower and two tanks. The tower is constructed much the same as the limestone towers but is filled with wood blocks instead of limestone, and is only 75 feet high. The two tanks are of wood stave construction, 24 feet diameter by 22 feet high, each equipped with a lead spider at the bottom which distributes the relief gases and liquor throughout the acid in the tank.

Gas and liquor, relieved from the digesters for reasons which will be outlined later, is cooled and enters the recovery tanks through these spiders. Any unabsorbed gas is relieved from the tanks into the bottom of the recovery tower and any overgas from the top of the recovery tower is sent into the limestone towers with fresh burner gases.

The raw acid is pumped to the top of the recovery tower, flows downward over the wood block filling, absorbs some of the SO_2 gas, and flows from the bottom of the tower into the recovery tanks where it is further strengthened by absorption of fresh relief gas. The overflow from the recovery tanks is stored ready for use in the digesters. Two additional wood-stave tanks, each having 60,000 gallons capacity, serve as storage.

The strength of this cooking acid may be controlled partly by varying the rate of flow and temperature of water through the acid plant. However, as present digester operation effects a recovery of over 60 per cent of the sulphur dioxide pumped to the digester, it is evident that the recovery phase of acid making is most important, as a control of acid strength as well as from an economy standpoint.

Digester Operation

The process has now been followed through the wood room and through the acid plant to the digesters.

There are four digesters in the mill, each 17 feet diameter by 54 feet high, built of 1⅛-inch boiler plate with a suitable acid resisting lining. These linings consist of two courses of ceramic brick set in a litharge quartz cement. There is about one inch of ordinary cement grout between the two courses of brick, and also between the shell and back course, making a total lining thickness of approximately eight inches.

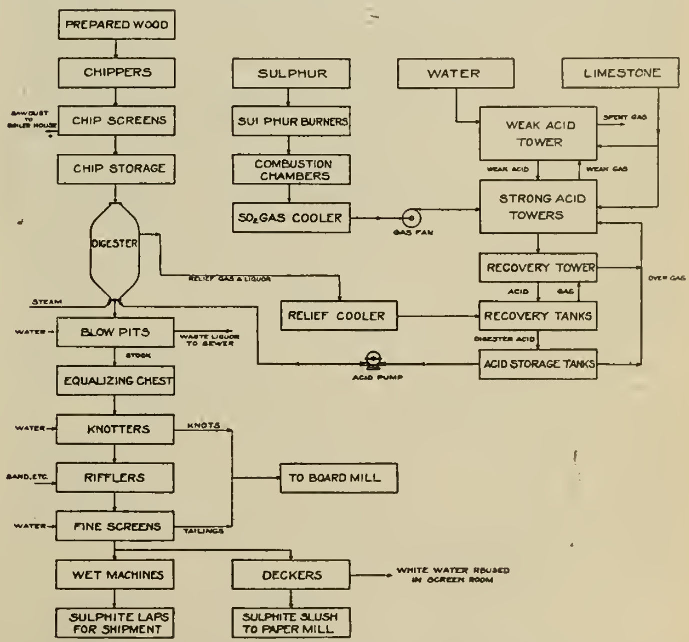

Fig. 2—Stock Flow Diagram for Sulphite Mill.

The digesters are cone-shaped, over 14 feet at the top and the bottom, having acid-resisting bronze fittings at each end. Bolted to the bottom flange is a large cross with necessary steam and acid pipe connections as well as a 12-inch blowoff connection. All digester fittings must be made of acid-resisting alloys, principally bronze.

Digester operation, or cooking as it is more generally known, is the most important and most interesting part of the sulphite process. It is here that the wood is reduced to a pulp and the quality of the final product is dependent upon the control of the cooking action.

The chip storage bins run the full length of the digester building, with openings over each digester. To fill a digester, the top cover is removed, and the chips allowed to flow into the digester until it is full. The prepared cooking acid is then pumped in through a connection in the bottom cross until the chips are completely covered. The digester now being fully charged, the top cover is bolted down, the steam valve cracked and the cook has begun.

Each digester is steamed through a 5-inch line equipped with a flowmeter, the control valve being located at the top floor. Steam is admitted at a predetermined rate, slowly during the first hour and gradually increasing. Experience has shown that the most economical cooking time under present conditions at this mill is thirteen hours, and, therefore, all rates of steaming, etc., referred to in this paper are based upon a standard thirteen-hour cook.

The rate of steaming is slow during the first hour in order to allow time for the acid to penetrate thoroughly into the chips before the temperature reaches 100 degrees C., at which point the cooking action begins to speed up. The function of the steam is, of course, to heat the contents of the digester. As the acid temperature is increased, the solubility of the SO_2 decreases and gas is freed from the solution. This gas collects at the top of the digester, causing a gas pressure. At about the third hour of the cook, the pressure at the top of the digester reaches 50 pounds and will continue to rise unless some of the gas is relieved. During the remainder of the cook, the digester pressure is controlled by varying the rate of relief. For this purpose, two 2-inch relief connections are located on the digester cover.

As the steam is introduced directly into the digester, the volume of the mass of chips and acid slowly increases until the level rises to the top of the digester at about 3½ hours and thereafter the relief is a mixture of gas and liquor. This mixture is cooled in the relief coolers and returned to the acid plant to be reclaimed as acid in the recovery system, as previously outlined.

When the digester starts to relieve liquor the steam flow is increased to approximately 16,000 pounds per hour and held at that point until the sixth hour. During this time the pressure is allowed to rise slowly until it reaches 65 pounds, where it is held until the twelfth hour. By the sixth hour the cooking action is well started. Since the velocity of the various reactions is dependent upon the temperature of the reagents, the digester temperatures must be carefully controlled. In order to avoid variations in the pulp produced from different cooks, a standard temperature rise must be followed closely during the balance of the cooking period. Therefore, after the sixth hour, the rate of steaming is governed by the temperature of the digester contents, as measured at the two thermometer fittings, one at the top of the cylindrical section and one at the bottom, and recorded on a two-pen temperature recorder on the operating floor.

In order to get good cooking conditions and hold the steam consumption to a minimum it is necessary to steam and relieve less actively during the last few hours of the cook. Then, in order to recover all the unconsumed SO_2 and maintain a low sulphur consumption, the digester must be relieved hard during the last hour of the cook. Should this gas be drawn off too soon, the acid strength in the digester may be reduced to a point where no further cooking action will take place in the digester and the whole charge may be ruined. For this reason, the quality of pulp depends to a great extent upon the judgment and skill of the digester operators. These men, known as sulphite cooks, hold the key positions in a sulphite mill.

Since it is impossible to get a representative sample of pulp out of a digester, the degree of digestion attained at any time must be judged by the colour, smell, and acid strength of samples of liquor drawn off through a digester side relief connection. When, in the judgment of the operator, the cooking action is nearly completed, both relief valves are opened wide and the digester pressure reduced slowly to approximately 45 pounds. thereby drawing off all the unspent SO_2 gas from the digester by the time the wood is thoroughly cooked.

The 12-inch blow-off valve at the bottom cross is then opened and the entire contents of the digester discharged into a large woodstave tank, known as the blowpit.

Washing and Screening Operations

The blowpit is equipped with a false wooden bottom, supported about 8 inches above the solid bottom of the pit. The spent acid drains away from the pulp, through the false bottom, and is run to the sewer. The residual pulp is thoroughly washed with water and then pumped to a large storage chest.

From this storage, the pulp is pumped as required to the screen room where all uncooked wood, knots, and slivers are removed. The screened stock is then thickened and stored in large chests ready for use at the paper machines.

Control of Operations

Control methods have for the most part been developed through the application of technical knowledge to the various problems, such control being nothing more than an attempt to standardize known processes.

Logically technical control should begin with the raw materials and the principal raw material is wood. Not enough work has been done, or what has been done has not been sufficiently popularized, along the line of grading pulpwood according to density, freedom from defects, etc. Lumber grading rules are well standardized but pulpwood grading has not kept pace. The old time attitude that "wood is wood" is much too prevalent in Canada, and is more noticeable at the mill slasher and blockpile than in the woods.

Most managements maintain that systematic grading and orderly piling of pulpwood is too costly and is not practical, because of the large quantities of wood handled. However, costly variations in paper quality and enormous wood losses will not be eliminated until technical control is applied to wood handling.

Control of wood preparation, barking, chipping, etc., where bark, sliver and sawdust losses often run into much money, also deserve more attention. The preparation of uniform chips with the lowest possible percentage of slivers and sawdust, from a uniform quality of wood, is a vital essential of low cost sulphite production.

Despite the variation in wood conditions there are many operations throughout the sulphite mill that may be standardized within certain limits. For this purpose a system of routine testing is maintained.

In the acid plant, the acid-maker runs hourly titrations to determine the strength of the weak acid, raw acid and digester acid being made. The water flow to the acid system is recorded by a flowmeter and the burner gas strength is recorded by a special instrument designed for the purpose.

Each digester is equipped with a recording steam flowmeter, a pressure recorder and a two-pen temperature recorder, and standard limits are set within which the conditions recorded by these meters must be maintained. To provide the operators with some information regarding the digester charge, chip moisture and wood density tests are run regularly and the acid pumped to each digester is carefully tested. Gauge glasses have recently been installed on each digester so that the operators may know the liquor level in the digester at any time during the cook.

Each blow is sampled and the pulp immediately tested for strength, bleachability, and tailings, so that the operators have a definite record of the quality of pulp produced. Throughout the screen room, stock consistencies, losses and production are accurately determined and recorded for the information of the screen operators and daily dirt counts made on the finished product. In the past, one of the most persistent causes of trouble in a paper mill was pitch from the sulphite pulp. Proper control of this has resulted in substantial savings in operating expense as well as improved paper mill operation and better quality newsprint.

This information is collected and summarized by the control department who issue daily, weekly and monthly statistical reports

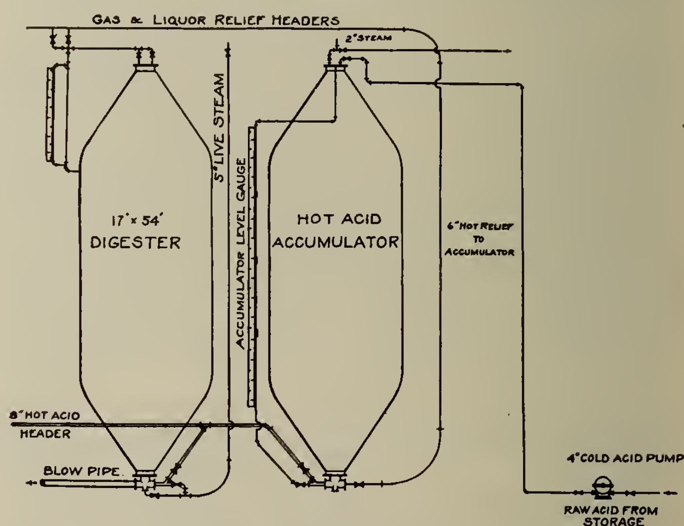

Fig. 3—Chemi-Pulp System for Sulphite Mill.

for the information and guidance of the operating staff. By following these reports closely, standardizing on as many conditions as possible, and linking up quality changes and operating difficulties with variations as shown by the control reports, cheaper production of a more uniform product has been made possible.

Chrome Nickel Steel

Since the successful development of the ceramic lining, the most valuable contribution made by any allied industry to the sulphite process is the development of acid-resisting, or so called stainless steels.

Chrome nickel steels were first introduced to the paper mills in this country about 1927 by manufacturers' agents who knew little about the properties of the alloys and nothing about their constitution. The result has been that most mills have had unfortunate experiences with these costly fittings and are very sceptical about the use of acid-resisting steels to-day.

However, the manufacturers have since made exhaustive studies regarding the application of these steels to the sulphite process and several interesting papers have recently been published.*

Although the alloys are sold under various trade names and with a variety of compositions, a good specification is as follows:

	A—for Castings	*B*—for Rolled Stock
Chromium	20-23 per cent	18 per cent
Nickel	9-10 " "	8 " "
Carbon	less than 0.2 per cent	.07 per cent max.
Molybdenum	3 to 4 per cent	3 to 4 per cent
Silicon	0.5 to 0.6	0.8 max.
Manganese	0.6 per cent max.	0.6 max.
Phosphorus and sulphur	.04 per cent max.	.04 per cent max.

All castings should be properly heat treated before machining and all fittings heat treated after machining, by heating to a temperature within the range of 1,950 to 2,150 degrees F. for two hours, followed by rapid cooling.

The materials formerly used for handling the sulphite liquors and gases were antimonial lead in cold lines and acid-resisting bronze where the temperatures are too high for lead. Due to the extremely corrosive nature of the hot liquors and gases the life of bronze fittings was quite short and operators were forced to adopt equipment that was simple and easily replaced.

However, with this restriction removed at least in part with the perfection of the chrome-nickel-iron alloys a new era of development has arrived for the sulphite process.

Chemi-Pulp System

In outlining digester operating methods the function of steam in heating the digester contents was mentioned, but the importance was not sufficiently stressed.

The steam consumption for a single cook under present operation is practically 100,000 pounds at 145 pounds pressure and 60 degrees F. superheat.

While injecting steam into the digesters at the rate of 16,000 pounds per hour the operator starts drawing relief from the digesters, and cooling that relief before sending it back to the recovery system. During an entire cook, approximately 86,500 pounds of liquor are relieved at an average temperature of 115 degrees C. and having a total heat content of approximately 21,000,000 B.t.u.'s; much of that heat is wasted in order to reduce the relief temperature to a point where satisfactory absorption can be obtained under atmospheric pressure.

Numerous attempts were made with partial success to devise methods of injecting hot relief from a hot digester into a colder one, but it was not until 1925 that a really efficient heat recovery system became an actuality.

This system, which was later patented, has become known as the chemi-pulp system. The principal operating feature is that instead of charging the digester with chips and cold acid at atmospheric pressure, it is charged with chips and hot cooking acid under pressure, the necessary heat being reclaimed from the relief.

Figure 3 is a simple diagram of a typical chemi-pulp installation. In this system as the normal relief is taken from a digester during the cooking operation, it is introduced without cooling into the bottom of an acid accumulator. The accumulator is a container similar in construction to a digester—as a matter of fact where the process is applied to an older mill, one of the digesters may be used for this purpose. By maintaining a pressure of 30 to 40 pounds in the accumulator, efficient recovery is effected at the higher temperatures due to increased solubility of SO_2 at higher pressures. The small amount of unabsorbed gas from the accumulator is relieved through the usual recovery system without cooling, thus maintaining a very efficient relief heat recovery and thereby saving at least 20 per cent of the steam consumption.

The promoters of this system claim, in addition to the steam savings, increased yields and better cooking conditions due to more rapid and uniform penetration of chips by the hot cooking acid.

Circulating Systems

One cannot make even hasty observations of sulphite cooking without noting the wide variations in the temperature in different sections of the digester, and being impressed by the importance of proper heat distribution.

The generally accepted picture is that though the large mass of chips remain stationary in the digester, the hot acid circulates up the centre and down around the cooler portion of the digester. In addition to this main movement of acid, gas currents and small convection streams play an important part in the heat distribution; also, variations in chip distribution, chip moisture, and other wood conditions and the acid strength, each exert so strong an influence on the velocity and direction of the larger currents that actual control of circulation is impossible.

For years forced circulation has been quite common in soda and sulphate mills, where the cooking liquors are not so corrosive, but attempts to apply these methods to sulphite failed due to corrosion of the acid-resisting bronze equipment. With the perfection of chrome nickel steels, however, many sulphite digesters have been equipped with circulating systems. The most recent of these combines forced circulation with indirect heating of the cooking liquors being circulated, and is shown in Fig. 4.

The equipment consists of a perforated pipe ring strainer situated near the base of the top cone of the digester. This strainer is connected to the suction of the circulating pump, which pumps the liquor through the heater and back into the digester through the bottom cross. The heater is of a two-pass design with one end of the tube bundle as a free floating head not attached in any way to the steam chest. Several new features are also embodied in the pump and strainer design in order to eliminate undue stresses and wear, as all parts are made of chrome nickel steel.

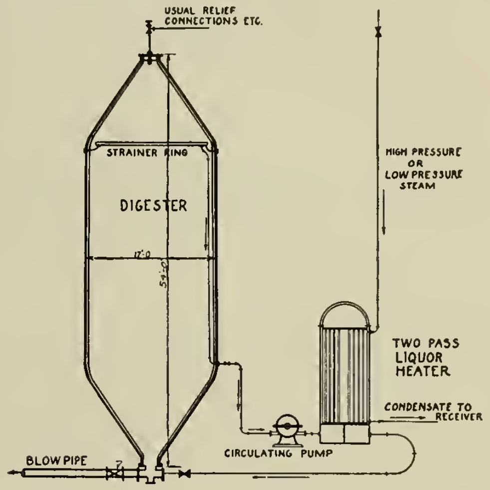

Fig. 4—Digester Circulating and Indirect Heating System.

The operation of such a system is very simple. The digester is charged as usual, the circulating pump started, and the circulated liquor heated as required. The pump is of sufficient capacity to provide a rate of turnover of the complete digester liquor charge every fifteen minutes, pumping out of the top and into the bottom in order that the movement may be aided by natural circulation. The digester is relieved back to the recovery system as usual. However, due to the fact that there is no condensed steam actually entering the digester, the liquor relief quantities are reduced from 86,700 pounds in the case of direct steaming to 19,000 pounds for the indirectly steamed cook. This, of course, means a saving of heat. Other advantages of the indirect heating feature include the possible use of low pressure steam from extraction turbines and the return of all condensate to the boiler house.

However, the main advantage of this system lies in the definite control of temperature distribution through the forced circulation feature. A probable yield increase of 5 per cent combined with a steam saving of 25 per cent through adoption of this system is estimated.

Combined Chemi-Pulp with Forced Circulation

By far the most attractive proposition of them all would be a combination of forced circulation with direct heating and the chemi-pulp system.

In addition to the cheaper operating cost, given a reasonably controlled supply of fresh wood it would be possible to produce in this mill a grade of pulp that could compete with the highest quality sulphite on the market. With such apparatus available, it is easy to forecast yields and sulphur consumption approaching the theoretical.

It should be noted that all estimates of savings, cost of equipment changes, etc., have not been accurately determined but are, in the opinion of the writer, sufficiently accurate to illustrate the immense possibilities of savings through the application of engineering principles to the sulphite industry.

* "Acid-Resisting Steels in the Sulphite Industry" read before the twentieth annual meeting of the Technical Section of the Canadian Pulp & Paper Association, January, 1933, by Mr. C. N. Carmichael, of Shawinigan Chemicals Limited, and published in the February, 1933, issue of *Pulp and Paper of Canada*.

Federal Department of Mines Issues Annual Report

A new high record in the value of gold output, and in the exports of copper, a search for gold more extensive than any heretofore undertaken; the erection of Canada's first radium extraction plant; and above all a further remarkable demonstration of the mineral industry's ability to cope with severe economic conditions, are described by Dr. Charles Camsell, M.E.I.C., as highlights of the mineral industry in 1932, in the annual report of the Department of Mines, Ottawa, for the fiscal year ending March 31st, 1933. "Canada's mining enterprises, industrialized as they are to a high degree, are in a strategic position to step into line with contemporary industries on the road to normal activity."

Copies of the annual report may be obtained from the Deputy Minister, Department of Mines, Ottawa.

An Electric Boiler Plant at Thorold, Ont.

W. L. Eliason, Electrical Engineer,
E. J. Calnan, Steam Control Engineer,
The Ontario Paper Company Limited, Thorold, Ont.

Paper presented before the Niagara Peninsula Branch of The Engineering Institute of Canada, April 26th, 1933.

The determining factor in the use of electric boilers has been the availability of power at a price comparable with the cost of fuels for the generation of steam. The fact that there was an excess of power available led The Ontario Paper Company to investigate the possibility of generating steam by electricity. It was found after careful investigation of costs that if a satisfactory agreement could be reached with the Hydro-Electric Power Commission, the generation of steam by electric power would be beneficial. Negotiations were started with the Commission, resulting in the signing of a power contract in September, 1932.

After exhaustive study of operating conditions, boiler designs and operations, heat balance equipment and the necessary accessories, the final station design was agreed upon and materials ordered.

Actual construction of the plant began early in November, 1932. With the co-operation of the Hydro-Electric Power Commission's engineers, their construction force and the equipment manufacturers, the plant was completed and in operation by February 3rd, 1933, a period of less than three months.

Boilers

The power is furnished by the Queenston plant of the Hydro-Electric Power Commission over a 110,000-volt transmission line to a bank of three 22,500-kv.a. single-phase 110,000/6,600-volt, 25-cycle transformers located adjacent to the steam boiler plant. There is also a fourth transformer installed as a spare.

The 110,000-volt service has only the main line breaker at Queenston to clear the line. The spur line into the Ontario Paper plant can be disconnected from the main line about a mile away where it joins the main transmission line.

The secondary bus feeds 6,600-volt power to each boiler through individual motor-operated 13,200-volt, 3,000-ampere oil circuit breakers having an interrupting capacity of 300,000 kv.a. at 12,000 volts. These breakers are relayed for feeder faults, boiler faults and failure of power on the boiler circulating pumps.

The boilers, which are of the Canadian General Electric Company's 30,000-kw. 6,600-volt, 3-phase single-tank type, are the largest of their type in the world to-day. The boilers are 11 feet 6 inches

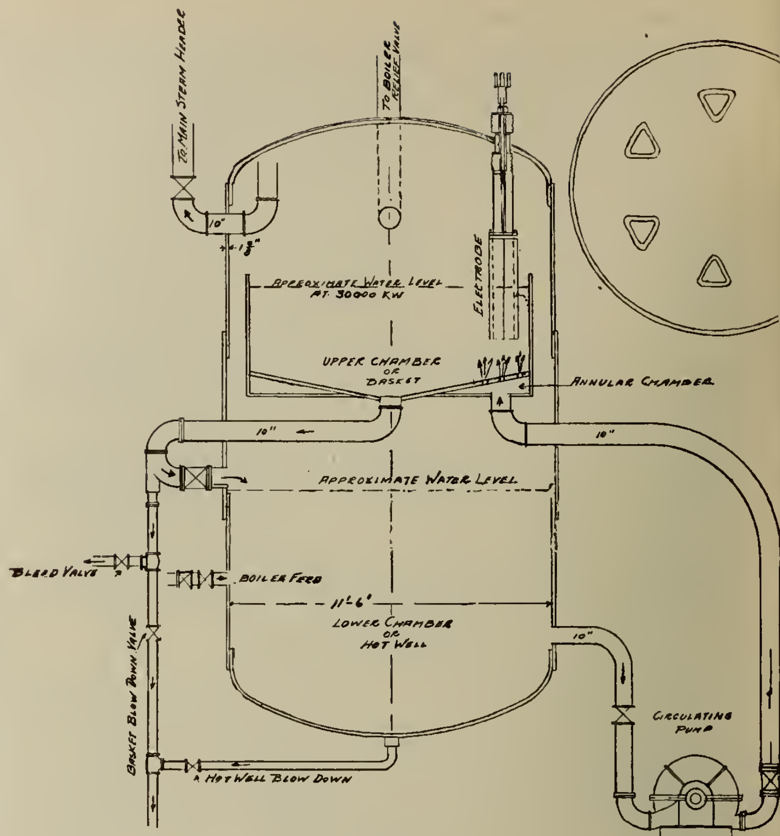

Fig. 1.

inside diameter and 25 feet high. The shell is 1⅜ inches thick and is made in three sections riveted together, the middle section being 2¾ inches larger in diameter than the two end sections. Top and bottom sections are 2-7/16 inches thick.

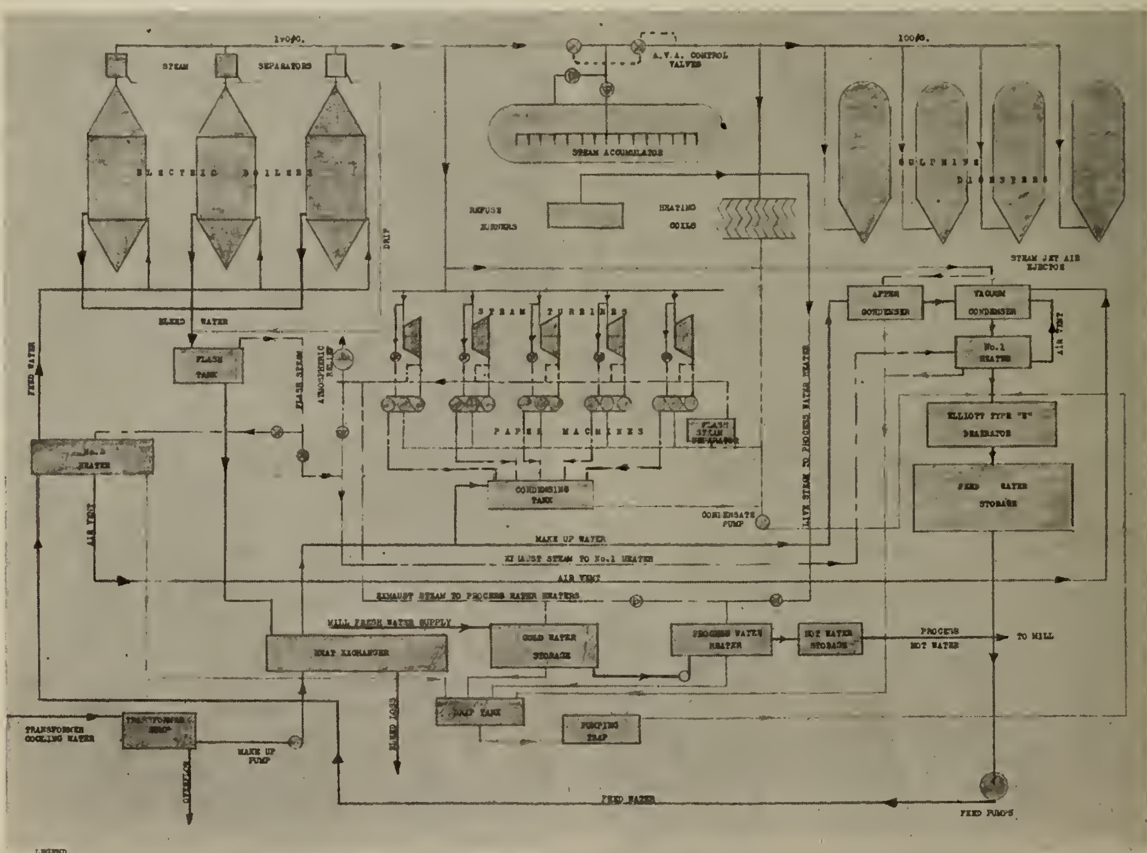

Fig. 2—Heat Balance Diagram.

The power is taken in through the top of the boiler by six electrodes, two for each phase. The electrodes are spaced 60 degrees apart on a circle and the phase electrodes are diametrically opposite. The electrodes consist of a main cast iron element or immersion section to which is bolted the adapter and into the top of the adapter a copper spindle is threaded and locked. These are assembled with porcelain insulating bushings in the boiler head or top. The main element or immersion section is triangular, having a narrow base curved to the curvature of the shell and the total weight of each electrode is 800 pounds.

The boiler design was based on boiler feed water consisting of 40 per cent make-up water and 60 per cent condensate, having a combined resistance of approximately 1,300 ohms per inch cube at 212 degrees F. In order to facilitate the design, samples of the make-up water and the condensate return water were sent to the boiler manufacturers.

Assembly and Operation

The electrodes project down in the boiler into the basket or upper chamber. The basket is an open end tank suspended so that the bottom is 16 inches below the bottom of the electrode. The bottom of the basket is hopper shaped, having an annular chamber into which the circulating water is discharged. The circulating water is then discharged into the basket proper through openings directly under each electrode so that a washing action tends to cleanse the electrode. (See Fig. 1).

The lower chamber or hot well is to maintain a supply of water for the boiler circulating pumps at approximately the same temperature as in the upper chamber. The level of water in the hot well is maintained either by hand or by a feed water regulator on the inlet from the boiler feed water pump. This amount of water in the hot well will permit 30 to 45 minutes operation of the boilers should the boiler feed pump fail for any reason.

Of the total amount of water pumped by the circulating pump 10 to 25 per cent is evaporated and 75 to 90 per cent returns to the hot well through external piping having a control valve. The object of returning the water to the hot well is to maintain a more uniform temperature and resistance of the water that is circulated under the electrodes in the upper chamber.

It was stated previously that 75 per cent of the water circulated was returned to the hot well. This is only partially true, as a portion of this is taken off the basket drain piping by bleed and blow down. An additional blow down is provided at extreme bottom of boiler.

The evaporation of the water causes a gradual increase of salt content, therefore a certain amount must be bled off and this loss supplied by boiler feed water. The amount necessary to maintain this balance is approximately 18 per cent of the water evaporated.

Heat Balance Scheme

The cooling water from the main transformers is returned to an overflow tank in the boiler house. From this tank sufficient make-up water for the system is pumped through the heat exchanger, after condenser, vacuum condenser, No. 1 heater to the deaerator where it is mixed with the condensate return water to remove the air and non-condensable gases before reaching the boiler feed water storage tanks. The boiler feed water is pumped from the storage tanks through No. 2 heater to the regulators on the boilers. (See Fig. 2.)

The make-up water is warmed approximately 15 degrees F. in passing through the transformer bank and leaves the heat exchanger with an additional 60 degrees F. rise, then a further rise of 55 degrees F. occurs in passing through the after condenser and vacuum condenser; continuing through the No. 1 heater the water reaches a temperature of 215 degrees F. before being mixed with the condensate return water.

The No. 1 heater uses the paper machine turbine exhaust when available and the amount of heat transferred to the make-up water depends upon the temperature of the water entering the heater. It will be noted that one quarter of the make-up water is diverted to the Farnsworth system after leaving the heat exchanger.

When there is no paper machine turbine exhaust steam, the No. 1 heater takes steam from the flash tank in the bleed water system. When the flash tank steam is not taken by No. 1 heater it goes to No. 2 heater which increases the temperature of the total feed water by approximately 15 degrees F.

The condensate return water after passing through the Farnsworth system, and being partially cooled by the diverted portion of make-up water, is pumped at a temperature of approximately 205 degrees F. direct to the deaerator by vertical pumps located in a pit in the machine room basement.

Bleed Water System

The bleed water and drip from the steam dryers on the boiler outlets goes through the flash tank where the pressure is reduced to 4 pounds gauge — the flash steam as previously mentioned going to either No. 1 or No. 2 heater and the water going to the heat exchanger at 225 degrees F. After passing through heat exchanger the bleed water goes to the sewer at a temperature 10 degrees F. above the entering make-up water temperature.

The mill supply of process hot water is taken from the mill fresh water system to the cold water storage tanks fitted with heating coils, which utilize the intermittent supply of paper machine turbine exhaust steam. This water, which may be either cold or partially heated, is pumped to the instantaneous process water heater at 100 pounds gauge pressure. If the water has not reached its final temperature of 180 degrees F. it is heated to this temperature by turbine exhaust steam when available, or by steam supplied through a reducing valve from the boilers. The supply of steam from the boilers is controlled by a thermostatic valve.

The drips from Nos. 1 and 2 heaters, after condenser, process water heaters and various points in exhaust-steam piping is returned to a collecting tank from which it is pumped by a pumping trap to the deaerator.

Accumulator

The Ruths Steam Storage accumulator of 15,000 pounds steam capacity is connected in the main steam header through control valves to supply steam to the digester header at 100 pounds gauge for sulphite cooking and heating. The installation permits the electric boilers to be operated at a comparatively uniform rate. The steam storage acts as an equalizer on the steam demand from the boilers. It permits sudden peak demands to be taken by the sulphite mill without materially changing boiler steaming rate.

Forty-Eighth
ANNUAL GENERAL MEETING
AT
MONTREAL
FEBRUARY 8th and 9th, 1934

In accordance with the By-laws, the Forty-Eighth Annual General Meeting of The Engineering Institute of Canada will be convened at Headquarters, 2050 Mansfield Street, Montreal, on Thursday, January 25th, 1934, for the reading of the minutes of the last Annual General Meeting and the appointment of Scrutineers, after which the meeting will be adjourned to reconvene on Thursday, February 8th, at the Windsor Hotel, Montreal, continuing on the following day.

As was the case last year, a two-day meeting will be held. The Montreal Branch, however, whose members are sponsoring the meeting, may always be relied upon to provide an exceptionally interesting programme.

Details of the arrangements will be announced in the December number of The Journal.

BRANCH NEWS

Calgary Branch

J. Dow, M.E.I.C., Secretary-Treasurer.
H. W. Tooker, A.M.E.I.C., Branch News Editor.

Through the courtesy of the management of the Earl Grey Golf Club, the privileges of the club were extended to the Calgary Branch on Saturday, September 2nd, where the members held their annual field day. Before beginning the battle for supremacy in the art of golf, a visit to the filtration plant of the new Glenmore Water Supply was arranged, and at 1.45 p.m. twenty-five of the members and their wives met at the site of the new dam and were conducted through the various buildings by guides provided by the city water works engineer, Mr. W. E. Robinson, and plant superintendent R. H. Hollis. This visit proved to be most interesting and illustrated the vast amount of study and thought necessary to construct such a plant and to provide a city with pure water.

At 3.00 p.m. the first of the members entering the golf tournament started from the first tee and as each succeeding foursome drove off, the keenness of the players was evident.

Finer weather could not have been desired, and combined with the wonderful views of the surrounding country, especially of the mountains, made each member feel that the event was worthwhile.

The refreshments provided by the ladies were presided over by Mrs. G. P. F. Boese, and all heartily agreed that they were most excellent.

The prizes presented by the chairman, H. J. McLean, A.M.E.I.C., were won by the following members:

Best net score—9 holes	1st	S. G. Coultis, M.E.I.C.
	2nd	R. L. Bonham, A.M.E.I.C.
Best gross score—9 holes	1st	H. B. Sherman, A.M.E.I.C.
	2nd	G. B. F. Boese, A.M.E.I.C.
Hidden hole (handicap)	1st	G. H. Patrick, A.M.E.I.C.
	2nd	R. C. Harris, M.E.I.C.
Putting (men)		E. N. Ridley, M.E.I.C.
Putting (ladies)	1st	Mrs. H. B. Sherman
	2nd	Mrs. S. G. Coultis

Hamilton Branch

Alex. Love, A.M.E.I.C., Secretary-Treasurer.
V. S. Thompson, A.M.E.I.C., Branch News Editor.

The Hamilton Branch of The Engineering Institute of Canada met in the grill room of the Royal Connaught hotel on the evening of September 12th. In the unavoidable absence of H. B. Stuart, A.M.E.I.C., J. Stodart, M.E.I.C., vice-chairman, occupied the chair and welcomed the large number of members and interested visitors, also a large delegation from the Hamilton Section Canadian Chemical Association who were guests for the evening.

The subject was "Radium," and the speaker Mr. J. D. Leitch, B.Sc., physicist, Department of Health, Province of Ontario—a recognized authority on this subject—was introduced to the gathering by the Secretary, Mr. Alex. Love.

Mr. Leitch, a former Hamiltonian, is a graduate of Glasgow University in electrical engineering, and after some experience in Canada was placed on the Radiological staff of the Ontario Department of Health. His research in equipment design and his wide knowledge of the use and extraction of the rare metals, have placed him in the foremost ranks of his chosen profession.

Radium

The lecture dealt with the general history, extraction, properties and use of radium. This element owes its discovery to the work of M. and Mme. Curie in 1898.

Preliminary work on radioactivity was begun long before M. and Mme. Curie accomplished their notable work. The real beginning, of course, was Ohm's law, propounded in 1825. Faraday and Crookes made valuable addition to electrolytic information, but the period between 1895 and 1900 was filled with the work of Becquerel, Rutherford, Thompson, Röntgen and the Curies.

The first really constructive work was done on fluorescence. Mr. Leitch ably illustrated this phenomenon by an experimental cathode ray equipment.

X-ray penetration is a variable dependent upon the voltage, gas pressure in the tube, and material of the anticathode. The hardness of the anticathode determines the penetration properties of the rays to a large extent. Modern X-ray tubes have heated filaments and operate at pressures of 200,000 volts. In New York, stated Mr. Leitch, there is one machine consuming pressures of 900,000 volts and here the X-rays partially overlap the wave length range of gamma rays—the radioactive element to which radium owes its penetration. It is not beyond the realm of reason to believe that it will be possible to build equipment to operate at 2,500,000 volts. When this point is reached we will have overlapped the gamma wave lengths and will have the equivalent penetration of 500 grams of radium—the total amount now obtainable in the whole world!

The discovery of radium opened new spheres for work along radioactivity lines. Laue found that he could actually photograph the structure of elements, while it remained for Rutherford in 1900 to actually separate alpha, beta and gamma rays, the three types emitted by radium. This process in the end was very simple, since by magnetic means alpha ray is deflected in one direction, beta ray, another soft, non-penetrating type, is deflected in the other, but gamma rays, being of a penetrating nature, were unaffected. Physicists 'pounced' on radioactivity to form their new theory of protons and electrons and the little 'solar systems' which we now understand as the basis of all elements.

The decay of uranium has a half-period of 4.67×10^9 years. By this tremendous figure is meant that period during which a given quantity of uranium loses electronic charges to become half-decayed to a new element—radium. Radium has a half-period of 1,690 years, while radium emission—a gas commonly called radon—has a period of 3.85 years. Radium, if hermetically sealed however, decays approximately 1 per cent in 25 years—an almost negligible figure.

The production of radium at Canada's Port Hope plant is carried on from Canadian ore. The ore is first ground to 35 mesh after being mine-cobbed. It is then treated with barium chloride and muriatic acid and converted to sulphates by sulphuric acid. A chemical 'trick' is used here, since it is known that barium and radium have very similar chemical properties and will separate readily together. The separation is so ready, however, that only by a long tedious process of fractional crystallization involving over 50 separate crystallizations and filtrations, is the radium separated from the barium as sulphate—the element of the needle radium of commerce. From this are produced the soluble forms of radium chloride and bromide.

The author opened a new realm of thought for his listeners by his description of cancer growth. The common methods of treatment cited were:

1. Radium needles.
2. Radium emission seeds.
3. Radium bombs.
4. Radium pads.

Radium needles carry about $125 worth of radium, and are inserted in the patient and are withdrawn after treatment. Radium seeds, however, which contain the gas resulting from radium chloride or bromide decay, are made of gold tubing, and since they are inactive after 30 days, may be left in the patient. Pads are applied for surface treatment while bombs—involving the use of up to 5 grams radium—are applied to the treatment of deep-seated growths.

Mr. Leitch described in detail his wonderful equipment for the preparation of the gold seeds in Toronto, and illustrated the wiring of his special equipment for the estimation of radium emission values.

At the close of the lecture there was considerable discussion. Mr. Powell, President of the Hamilton Section, Canadian Chemical Association, thanked the E.I.C. for the opportunity of attending such an interesting lecture, and on behalf of all present moved a vote of thanks to the speaker of the evening. This was enthusiastically endorsed by all present and the meeting adjourned. The attendance was 150.

Ottawa Branch

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

At the opening noon luncheon meeting of the 1933-34 term held at the Chateau Laurier on October 5th, the Ottawa Branch had the honour of listening to an address by Dr. O. O. Lefebvre, M.E.I.C., President of The Institute. Dr. Lefebvre spoke upon "Engineering Institute Affairs," his address being one of a number which he has been giving to various branches of The Institute.

Institute Affairs

Dr. Lefebvre, at the commencement of his address, referred to the aims and objects of The Institute as laid down in the constitution, and stated that although everyone had to admit that these objects had not been completely achieved in the past, still a very material proportion of them had. The membership of The Institute have maintained a high standard in the performance and actual practice of their professional duties. There had been very few engineering failures and it could truly be said that engineers have done their work well and conscientiously and if the country, as a consequence, is over developed, the fault is not theirs.

The Institute has also been most active in facilitating the interchange of knowledge and the results of the experience gained by engineers in undertaking new and various types of work. Much of this has been brought about by the different branches themselves.

Discussing the question as to whether these services could continue to the same extent in the future as in the past, Dr. Lefebvre outlined the difficulties at present facing The Institute, and stated that although everything possible had been done to reduce the cost of such services to the members there would still have to be a slight curtailment of them. He suggested that those who found it, on account of unemployment, impossible to pay their annual dues be put on a suspended list so that they would have no difficulty in being reinstated when they were re-employed.

Dr. Lefebvre outlined the history of The Institute particularly in connection with its relations with the various provincial associations of engineers. He reminded the members that the control of engineering practice cannot be exercised under the Dominion charter of The Institute. This is on account of the fact that under the British-North America act, the control of such practice is one of the prerogatives of provincial legislation.

There are now eight provincial associations in the nine provinces of Canada, Prince Edward Island alone being excepted. Dr. Lefebvre stated that eventually a uniformity of aims and purposes in the various associations in connection with legislation and requirements for admission would be brought about. Then it would become an easy matter to adjust The Institute requirements to those of the associations and in such a manner the speaker visualized The Institute as a Federal body for the profession, where all engineers throughout the Dominion would be members and all could devote their energies to the aims and objects for which The Institute at present stands. Such a development has taken place among some of our sister professions, the speaker instancing the case of the Royal Architectural Institute of Canada whereby an architect first of all becomes a provincial member and then a federal member.

The President also touched upon the work of the committee on development in their study of the possibility of revising the by-laws of The Institute. There was a difference of opinion amongst many members as to whether or not a revision is essential. However, a report will soon be in the hands of every member to which serious consideration should be given.

Group Captain E. W. Stedman, M.E.I.C., chairman of the local Branch, presided, and in addition to the chairman and the speaker head table guests included: Hon. Alfred Duranleau; Mr. E. R. E. Chevrier, M.P.; Maj.-Gen. A. G. L. McNaughton, M.E.I.C.; Col. A. E. Dubuc, M.E.I.C.; Dr. Chas. Camsell, M.E.I.C.; J. B. Hunter; Watson Sellar; K. M. Cameron, M.E.I.C.; J. E. St. Laurent, M.E.I.C.; Capt. F. Anderson, M.E.I.C.; C. McL. Pitts, A.M.E.I.C.; G. J. Desbarats, M.E.I.C.; John McLeish, M.E.I.C., and E. J. Lemaire.

Peterborough Branch

H. R. Sills, Jr.E.I.C., Secretary.
W. T. Fanjoy, Jr.E.I.C., Branch News Editor.

ANNUAL OUTING

The annual outing of the Branch this year took the form of a visit on Saturday afternoon, October 7th, to the plant of the Deloro Smelting and Refining Company at Deloro, Ont. Some twenty-two members and friends made the trip from Peterborough to the plant, where Mr. S. B. Wright, general manager, took charge, and a thorough inspection was made. An excellent insight into the operation of the plant was obtained by everyone.

The tour started with the raw material of which the principal product is cobalt although silver and arsenic are contained in the ore and extracted and refined as by-products. A special metal called Stellite is also produced. The ore is obtained from the mines at Cobalt and shipped by rail to the smelting plant in a partially crushed and concentrated state. The tour of the plant included the crushing and blast furnace divisions, the arsenic chambers, the silver refinery, the cobalt treating plant, the Stellite section and the laboratories.

Following the inspection tour, supper was held at the Royal hotel, Marmora, after which Mr. R. A. Elliott, plant superintendent, gave a talk covering the plant history and processes.

In 1903 during the building of a railway by the Ontario government from North Bay to Temiskaming, a pink material was uncovered in a rock cut which was later recognized as cobalt bloom. This was the origin of the mining centre of Cobalt. The word is derived from the German word "cobold," meaning evil spirit, because miners were poisoned by this ore, and as it turned out the poison was arsenic associated with the cobalt.

Mr. Elliott went on to say that Deloro was originally received through a Crown grant, and in 1868 three shafts were sunk by the Deloro and Madoc Company, but did not prosper.

After further attempts, in 1882 the buildings which are incorporated in the present plant were built, and from 1896 to 1902 the Canadian Gold Fields Company had charge of the property. In 1902 operations ceased, however, because the percentage of ore was getting leaner and the arsenic greater.

With the discovery of cobalt in 1903, M. J. O'Brien obtained a claim in Cobalt, and the first ore went to the United States for smelting the silver, but the presence of arsenic resulted in a heavy penalty. In 1906 the Deloro plant was purchased by the O'Brien Company and put into operation.

It was not until 1910, however, that the process of extracting cobalt was worked out and the commercial production of the black oxide of cobalt was started in 1911.

Mr. Elliott said that Deloro is the only producer of cobalt on the North American continent.

In processing, the ore is first crushed to the fineness of bulk sugar for sampling purposes, and is then treated in a blast furnace using coke as a fuel. Three products are obtained: arsenic, slag and "speiss." The arsenic takes the form of fumes of sublimed arsenic which are caught in cooling chambers. The slag goes to the dump and the speiss which consists of arsenic, cobalt, nickel, silver and iron, is poured off, and cooled in cone shaped buggies. When treating high silver content ores, the speiss becomes saturated with silver which settles to the bottom of the cone and when cool can be knocked off and sent to the silver refining division.

The speiss is reground and roasted which eliminates the rest of the arsenic which is collected in the same chambers mentioned above. The residue is heated with aluminum dust and chloridized salt which breaks down and the chlorine unites with the silver to form silver chloride. This is cyanided and agitated which dissolves out the silver and the solution is then treated with caustic soda to precipitate the silver. This is cast in bars and shipped to England.

The arsenic is refined by resubliming and is ground and packed in kegs to be used in the glass industry as a degasifier and also as an insecticide in combination with calcium.

Members of Peterborough Branch at Deloro, Ont.

The residue from the cyanide treatment goes to the cobalt plant where it is treated with sulphuric acid to form a pink sulphate. This material is then dissolved in water and neutralized with lime which gives a precipitate leaving the cobalt in solution.

This solution is treated with chlorine gas, soda ash, caustic soda and sodium hypochlorite and the resulting cobalt oxide obtained is sold. It is used principally in the ceramic industry in the production of blue colour and in the enamelling trade as a dryer for paints.

Metallic cobalt is also produced by reducing the oxide in a furnace with charcoal at 1,200 degrees C., and is used principally in making "Stellite."

The speaker went on to describe Stellite, which is an alloy of metallic cobalt, chromium, tungsten and carbon, and is used for high speed cutting tools. It is made in three grades called Nos. 4, 10 and 40.

Mr. Elliott also touched on safety work at the plant which, by means of a suggestion system with money prizes, an inspection committee, a publicity committee and campaign and relief committees, had reduced accidents from six hundred and forty-three man days in 1923 to none in 1929 and 1933.

Saguenay Branch

J. W. Ward, A.M.E.I.C., Secretary-Treasurer.

On the evening of October 12th, 1933, H. B. Pelletier, A.M.E.I.C., addressed a meeting of the Saguenay Branch on the subject of "The Chicoutimi Harbour Development," which proved very interesting to the forty members and friends present. The speaker began by tracing the history of the harbour from the earliest known records and finished with a description of the plans and construction of the present development. A synopsis of the address follows:

THE CHICOUTIMI HARBOUR DEVELOPMENT

The first known report on the possibilities of the Saguenay river was made by Father Jean de Quen who was in charge of a mission located at Tadoussac, at the junction of the Saguenay and St. Lawrence rivers. He led a party of Indians up the Saguenay, in 1641, to Lake St. John, a distance of one hundred miles, and established a mission there.

In 1810 William Price, an Englishman sent by the British government to get masts for the navy, found excellent pine in the Saguenay valley. In 1840 he returned and started a lumber business at Grand Bay.

In 1874 a wooden dock was built at Chicoutimi which is still in use.

The Saguenay is a tidal river as far up as the mouth of the Shipshaw, about six miles above Chicoutimi. At Chicoutimi the maximum difference in water levels due to the tides is twenty feet. For a distance of about eight miles down stream the river is too shallow to allow any but small boats to pass at low tide. In about 1900 efforts were made to have the government dredge this channel deep enough for sea-going ships, but these efforts were without success.

Mr. J. E. A. DuBuc, the local member of parliament, led a group of enthusiasts who convinced the Federal government that a modern harbour would justify itself, so in 1926 authority was given to have plans drawn up. Those for the new harbour were submitted in 1927 by A. D. Swan and Associates and it was decided to dredge the channel to a minimum depth of sixteen feet and the harbour itself to a depth of thirty feet at low tide.

The plans as submitted called for a dock four thousand feet long facing the river. For the present the dock is to be only twenty-six hundred feet long. The main dock face consists of a concrete wall sixteen feet wide at the bottom and three feet at the top. This is built on stone-filled timber cribs which rest on the clay bottom of the river. The area of the river bed enclosed by the dock walls and the shore line is about fifty acres. The first fill next to the front wall and for a distance of forty feet back was gravel. The remaining fill consists of clay pumped from the river bed by a suction dredge. A total of 1,850,000 cubic yards of fill was placed by the dredge. As an unemployment relief measure, 150,000 cubic yards of earth were conveyed to the harbour by means of carts, waggons and trucks. This material was obtained from cuts made to reduce grades on certain streets in Chicoutimi.

At the conclusion of the discussion of the address the speaker was given a hearty vote of thanks.

Before the close of the meeting the Harbour Commissioners extended an invitation to all present to inspect the development, which invitation was readily accepted. On the following Saturday afternoon twenty-two members and visitors were shown around the harbour by the President, Mr. J. C. Gagne, and Commissioners Messrs. M. R. Kane and L. P. Girard, whose courtesy was very much appreciated. The new bridge connecting St. Anne and Chicoutimi which is nearly complete was also inspected. An added attraction was a visit to the French gunboat "Ville d'Ys" which was in the harbour at the time.

Saskatchewan Branch

S. Young, A.M.E.I.C., Secretary-Treasurer.

The regular monthly meeting of the Branch was held in the Hotel Champlain, Regina, on Friday evening, October 20th, 1933, being preceded by a dinner at which nineteen were present. The chair was occupied by P. C. Perry, A.M.E.I.C.

S. R. Muirhead, A.M.E.I.C., reported for the Papers and Library Committee, stating that L. A. Thornton, M.E.I.C., would address the November meeting on the proposed power development on the Saskatchewan river, east of Prince Albert. With respect to the December meeting arrangements have been completed for an address by E. B. Webster, A.M.E.I.C., on the possibilities of the mineral resources of Saskatchewan.

At the conclusion of the regular business the chairman called on E. A. Duschak, A.M.E.I.C., for his paper on "Developments in Petroleum Refining."

After describing the several types of crude petroleum, namely paraffin base, asphalt base and mixed base, Mr. Duschak proceeded to outline the process of separation, describing the equipment used.

In general there are three refining processes:

1. By distillation, carried out at atmospheric pressure.
2. The cracking process, carried out under pressure with increased heat.
3. The vacuum process.

The cracking process, the most recent development, came into being as a result of the greatly increased demands for higher returns of gasoline from crude petroleum; this demand in turn being due to the greatly increased use of the combustion engine for motor transport.

The paper was provocative of much interested discussion, a vote of thanks being regularly moved and tendered to Mr. Duschak.

Vancouver Branch

A. I. E. Gordon, Jr.E.I.C., Secretary-Treasurer.

First Narrows Pressure Tunnel

The first meeting of the 1933 Fall season was held on Tuesday, October 10th, 1933, at 8 o'clock p.m., in the Medical-Dental building, when an audience of fifty-four members and friends, including several ladies, heard an interesting illustrated talk on "First Narrows Pressure Tunnel" by W. H. Powell, M.E.I.C., engineer to the Greater Vancouver Water District.

The speaker was introduced by P. H. Buchan, A.M.E.I.C., chairman of the Branch. Mr. Powell traced the history of the tunnel from its conception, through the different stages of investigation and construction to completion in the summer of 1933.

Investigation was chiefly geological in character and numerous test-holes were sunk. The average depth to bedrock was 100 to 150 feet and the structure consisted of sandstones underlain by shales and conglomerates. The beds dipped at about 15 degrees to the south and a line was eventually chosen about 400 feet beneath the surface of the Narrows which lay entirely in these sedimentary rocks. The distance between shafts was chosen as 3,108 feet.

Construction began early in 1931 after the contract had been awarded to the Northern Construction Company and J. W. Stewart, Limited of Vancouver. The south shaft was in solid rock and presented no problem, but the north shaft was in gravel and was sunk by a caisson and open dredging until finally seated on good foundation at a depth of 130 feet. The caisson was 24 feet in outside diameter and 14 feet inside, and the shaft 9 feet 8 inches diameter from the caisson down the same as the south shaft.

Bonna pipe was used to line both shafts and tunnel. In sound rock the equivalent of a ⅝-inch steel pipe was used and in poor rock the equivalent of one inch was used. The inside diameter of the tunnel was 7 feet 6 inches and of the shafts 8 feet. The pipes were placed by a special cantilever car and concrete was blown into place around them. The shaft caps at both ends are heavy castings divided into four outlets. The water from one of these is now supplying Vancouver through a 70-inch main and the other three now sealed will eventually feed an 84-inch main. A 60-inch main feeds the north shaft and others will be built as required. Provision has been made to unwater the shaft if necessary.

Considerable discussion ensued led by Messrs. Robinson, Cowley, Buchan and Price. A vote of thanks was moved by C. Brakenridge, M.E.I.C., and following mention of a few items of business by the chairman the meeting adjourned.

Winnipeg Branch

E. W. M. James, A.M.E.I.C., Secretary-Treasurer.
E. V. Caton, M.E.I.C., Branch News Editor.

Self-Liquidating Public Works

At the first meeting of the season, held at the University of Manitoba, an address was given by Major Northwood on "Self-liquidating Public Works." Major Northwood, one of the leading architects in Winnipeg, was for some time the Winnipeg representative of the Federal Relief Commission and was particularly qualified to deal with this subject.

In defining "self-liquidating works" the speaker pointed out that this did not necessarily mean financially self-liquidating but liquidating in the benefits directly and indirectly afforded the community and in the money indirectly saved or created by their construction. He divided such works into those immediately remunerative, those ultimately remunerative, those filling the present need, and those filling the future need, pointing out that in many cases the return in service rather than in cash was the liquidating feature.

He emphasized the economic and moral waste of the present direct relief upon the community, not only from the heavy expense which produced nothing but also from the deteriorating effect upon the recipient.

In his opinion until the building trades could be revived no permanent improvement in conditions could take place, and submitted a list of possible buildings and construction work for the district.

In support of his advocation of increased building construction he quoted Sir Arthur Salter as stating that the building industry was the key point in recovery, and referred to charts showing the relation of the building industry to national welfare, stating that the building industry was the largest direct employer of labour and that for every $100 spent on a building over $80 actually went in wages for building trades or on labour in the material used.

In his opinion the cost of relief by self-liquidating public works should not in any case cost more than twice the present direct relief and would immensely benefit the country.

He advocated the immediate erection of a beet sugar factory and new farm building, which would give an immense impetus to the back-to-the-land movement besides providing employment. The beet sugar factory would directly and indirectly employ approximately 1,100 men and give three months employment each year to 3,000 farm and factory workers and furnish to farmers a cash market for a crop work as high as $46 an acre.

He pleaded that the government should declare its policy in advance so that men now on relief might have at least some definite hope of work to which they could look forward.

After the address a long discussion took place in which many of the members expressed themselves strongly in favour of some definite programme of construction work being taken at an early date.

Canada's Metal Production

Canada's metals hold a position in world markets of greater relative importance than her wheat. This fact was brought home to Canadians for the first time by the emphatic statement of Premier Bennett recently in Toronto. Figures explaining this reversal of a commonly accepted idea have been given by Dr. Charles Camsell, M.E.I.C., Deputy Minister of Mines at Ottawa.

During the past ten years the Canadian output of copper, lead and zinc has been increased from 100,000 tons a year to 400,000 tons. As our domestic consumption is less than the former figure, 300,000 tons of these metals must be marketed abroad.

Under the present Empire tariff agreements, Great Britain affords the readiest market for a part of the Canadian surplus of these metals, and the amount sold there has been increased greatly during the past year. But even when the greatest amount possible of our metals has been absorbed in the British market, there is a substantial part remaining that must be sold in foreign countries. Further, our mines, smelters and refineries have a capacity largely in excess of their present production and any increase in output is therefore almost completely dependent upon selling the metals in foreign countries.

Thus Dr. Camsell is fully justified in stating that "we are confronted with the necessity, as a matter of national business interest, of giving the most intensive study to the way in which international trade in metals is organized, to the trend of tariff legislation, quota requirements, and other measures which directly affect the ability of Canadian metals to find an entry into the principal markets."

Air Transportation

Aviation until now has been primarily an engineering industry. However, along with those engineering problems which still press upon the industry, air transportation is now confronted with the task of educating the public to ride in planes and ship commodities by air.

Of special importance to the industry at present are the following subjects:

(*a*) Influence of speed and regularity of service.
(*b*) Trend of construction of transport planes.
(*c*) Avigation aids which are adding efficiency to flight.
(*d*) Operating costs and problems.
(*e*) Traffic promotion.

(*a*) The summer of 1933 marks the greatest increase in speed in the history of air transportation. From 1925 to 1927, typical cruising speed of commercial airplanes was around 100 m.p.h. By 1932 this had increased to approximately 115 m.p.h. This summer there are in service multi-motored passenger transports capable of a cruising speed as high as 165 m.p.h.

The speed of transport planes depends chiefly on type of design and construction, efficiency of the power plant, and the degree to which comfort features—which add weight to the plane and influence its design—are considered. In the new Boeing high speed, multi-motored transports, the engineers allowed 170 pounds for each passenger and then added 107 pounds allowance per passenger. This included 30 pounds of baggage, 19 pounds for the upholstered seat and belt, 4.4 pounds for laminated window glass, 16.3 pounds for soundproofing and cabin lining, 4.4. pounds for the heating and ventilating system, and 14 pounds for miscellaneous items. Carrying a stewardess and her equipment, as the third member of the crews, meant 19 pounds weight allowance per passenger.

(*b*) The demand for speed is reflected in the design and construction of the planes being brought out in 1933. Biplanes have lost ground and the low wing monoplane seems to be taking rank over high wing monoplanes. The tubular steel fuselage, fabric covered and with wood and fabric wing construction, is giving way rapidly to all-metal construction.

Likewise it is probable that combination mail-express-passenger land transports in the next few years will be medium sized, carrying from eight to twelve passengers and cargo instead of the thirty- and forty-passenger planes predicted in some quarters a few years ago. The medium sized plane has several advantages, including high speed, lower operating costs, easier landings in case of emergency than the superland plane, and they lend themselves to flexible schedules.

(*c*) Definite progress has been made in increasing propeller efficiency. United Air Lines recently installed controllable pitch propellers on its multi-motored passenger transports and the take-off time and run was reduced 20 per cent, rate of climb increased 22 per cent and cruising speed increased 5 m.p.h. The wide disparity between take-off and maximum speeds and between cruising and top speeds was minimized.

Another constructive side of the picture is the progress made to increase the dependability of air transportation. The element of uncertainty has been substantially minimized through development and adoption of aids to avigation, weather observing and reporting, airway developing and lighting and radio telephone.

Noteworthy advances have also been made during recent years in the matter of aircraft instruments, and such devices as the artificial horizon, the directional gyro, the sensitive altimeter and the like have placed air navigation upon a higher level of accuracy.

(*d*) Air transportation has moved from the stage of development of equipment and facilities to a period in which traffic growth must be a paramount factor if air transportation is to justify itself. The following figures show how the rate per mile being received for carrying air mail is not much more than half to-day of what it was in 1929:

Fiscal year	Rate of pay per mile
1929	$1.09
1930	.97
1931	.79
1932	.62
January, 1933	.55

It has been the expansion of air mail service, not the rate of pay to the carriers, which has held the air mail appropriations at the level of recent years. The average rate of passenger fare in the United States has been reduced from eleven cents a mile in 1928 to approximately six cents in 1933.

Airport facilities costing approximately $125,000,000 have been provided. Most of these terminals are municipally owned.

Each dollar of expenditure of all air mail-passenger carriers according to Post Office reports, is divided approximately as follows:

Depreciation and obsolescence	20 cents
Repairs and overhaul	16 "
Pay of pilots and assistant pilots	13 "
Gasoline and oil	9 "
Advertising and traffic	8 "
Maintenance and operation of ground facilities	20½"
Insurance	6½"
General office expense and administration	7 "

The passenger traffic, while increasing, is not in itself sufficient as yet to put air transportation on a paying basis. However, it is reasonable to expect that in a comparatively short term of years a logically set up air mail network serving those cities which develop sufficient air mail poundage to warrant the route, can bring in enough revenue to the government to approximate the amounts paid by the government to the air lines for transporting the mail.

(*e*) The air lines recognize they must go out and develop new passenger and express business. It is noteworthy that during a period of business depression the air lines flew more miles and carried more passengers and express last year than any time in their history.

American commerce and industry are making greater use of air transportation because they recognize the savings to be effected in travelling, corresponding and shipping by air.

Abridged from a paper presented at the International Automotive Engineering Congress, Chicago, September 4th, 1933, by Mr. P. G. Johnson.

Softwood Distillation

The softwood distillation or naval stores industry in America has centred almost entirely in the southeastern states of the United States. The southern pines of that district are rich in turpentine, resin, pine oil, pine tar, pitch, etc., and this fact together with favourable climatic conditions and an abundance of cheap labour has permitted production there at very low costs.

The use of Canadian woods for such purposes, and especially the use of sawdust and other mill waste, however, has been and continues to be an interesting possibility, concerning which the Forest Products Laboratories of Canada, Forest Service, Department of the Interior, receive numerous requests for information. Comparatively little research in this direction has been carried out in Canada, but a great deal of information is available from Europe and the United States. The Laboratories recently made a review of such information and have just issued a report entitled, "Review of the literature on softwood distillation," in order that such information might be available to those interested in this subject. This review brings together data regarding the history of the industry, resin content and available supplies of Canadian softwoods, processes, yields and products in softwood distillation, plant and operating costs, statistics, Canadian imports, etc. An extensive bibliography is given for those interested in pursuing the subject further.

Copies of this review are available on request to the Forest Products Laboratories, Ottawa.

An Experiment in Road Engineering

An interesting experiment in road engineering is at present in progress in Dundee. Its main feature is the use of jute cloth as part of the surface for roadways. A street is being laid with an ordinary macadam base 4 inches deep, and one portion is to be finished with the usual asphalt surfacing. The other portion has a jute hessian cloth laid on the base, and on the top of the jute lengths, which extend from kerb to kerb, there is laid a carpet of sand-asphalt about an inch thick. A coating of chippings is then put on to roughen the surface so as to give a foothold for horse traffic and to prevent the skidding of motor vehicles. The main object of the jute cloth is to facilitate stripping off the surface when repairs are required. It is believed that with the presence of the cloth it will be necessary to remove only the top surface of an inch instead of renewing the roadway to a greater depth. The experiment is also expected to show whether the jute cloth will reinforce the surface so as to make it more lasting.

The Times Trade and Engineering Supplement.

McGill University Travelling Library

Although the McGill University travelling library is a well-known institution, there are many people living in isolated places who are unaware of the opportunities this offers.

For an expenditure of $4.00, all transportation charges paid by the University, a library of from thirty to forty books is available, the only restriction being that it may not contain more than one-half fiction. This may be kept for four months and renewed if desired. The Department contains over 14,000 books, covering a wide range of subjects which include biography, travel, history, science, music, art, etc. If desired a catalogue will be sent from which personal selection may be made.

This service has been made possible through the generosity of a well-known Montreal family, and this year the McGill Graduates Society made a grant of $500 for the purchase of new books.

It is the intention that as many graduates as possible should benefit from the service, but the libraries may be obtained by any group living in districts where there are no library facilities. Further information may be obtained from the Travelling Library Department, McGill University, Montreal.

Preliminary Notice

of Applications for Admission and for Transfer

October 23rd, 1933

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, 1933.

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

CADE—JOHN EDWIN, of Edmundston, N.B., Born at Brussels, Belgium, May 6th, 1889; Educ., 1909-12, South Kensington School of Science; Night classes during pupilage at Dover Technical School and special coach on theory of structures; 1906-09, pupil, shops and drawing office, Messrs. S. Pearson & Son, Dover Admiralty Harbour Works, England; 1912-17, constrn. supt., Hollinger Cons. Gold Mines, Timmins, Ont.; 1924-25, elect'l. and mech'l. design, Canadian Vickers, Montreal; 1925-28, engr. designer, Canada Sugar Refining Co., Montreal; 1928 to date, asst. chief engr., Fraser Companies Limited, Edmundston, N.B.

References: F. O. White, K. G. Cameron, C. O. Thomas, D. H. James, S. Hogg.

COLBORNE—ORVILLE L., of 531 N. Norah St., Fort William, Ont., Born at Bridgen, Ont., Dec. 17th, 1898; Educ., Blenheim Continuation School, 1905-15; London Technical School, evenings; 1919-21, ap'ticeship with G. Murray, architect, London, Ont.; 1921-23, tracer, dftsman and asst. engr., C. D. Howe & Co., Port Arthur, Ont.; 1924-29, asst. supt., city of Cranbrook, B.C.; 1930-31, supt. of constrn. for A. H. Green & Co., engrs. and contractors, Nelson, B.C.; 1931-32, with Cons. Mining & Smelting Co., Trail, B.C., as supt. of constrn. of company's hospital at Trail; 1931-33, city engr., Rossland, B.C. At present unemployed.

References: P. E. Doncaster, C. D. Howe, R. B. Chandler, G. P. Brophy, A. E. Wright, W. M. Reynolds, A. B. Ritchie.

FARROW—RICHARD CHARLES, of Victoria, B.C., Born in Middlesex, England, Aug. 11th, 1892; Educ., Public and High Schools, Vancouver, and private study; Regd. Prof. Engr. and B.C. Land Surveyor; 1912-14, levelling, dfting and computing; transitman; 1914-15, private practice, minor engrg. work and logging rly. installns.; 1915-19, overseas; 1919-23, private practice, misc. engrg.; 1923, Southern California Edison Co. (hydro-electric) as computor; 1924-27, in charge of checking dept., Civil Divn. of Engrg. Dept., and 1927-28, i/c of Civil Divn. office for same company; 1928-32, with Water Rights Branch, Dept. of Lands, Victoria, B.C., as follows: 1928-30, i/c of power investigations; 1931, misc. hydraulic engrg.; 1932, hydrometric work, Cariboo. At present in private practice, William Lake, B.C., principally hydraulic work for mining companies.

References: J. C. Macdonald, E. Davis, F. W. Knewstubb, S. H. Frame, C. E. Webb.

HATFIELD—GORDON WALLACE, of Saint John, N.B., Born at Saint John, July 27th, 1908; Educ., B.Sc. (Chem.), McGill Univ., 1931; 1925-26, lab. asst., Atlantic Sugar Ref. Ltd., Saint John; 1928 (Summer), switch operator, Saint John Hydro Commission; 1929 (Summer), control survey, International Paper Co., Campbellton, N.B.; 1930 (Summer), asst. chemist, Aluminum Co. of Canada, Arvida; 1931-32, asst. engr., and from March 1932 to date, asst. chemist, Atlantic Sugar Refineries, Ltd., Saint John, N.B.

References: W. J. Johnston, C. M. McKergow, A. Sutherland, C. C. Langstroth, F. G. Green.

McLENNAN—ALLAN JOHN, of 50 Eighth Ave., Pointe aux Trembles, Que., Born at Melbourne, Victoria, Australia, April 21st, 1905; Educ., B.Sc., 1930, M.Sc., 1932, Mass. Inst. of Tech.; 1924-28, tester, and for last two years special tester with the Melbourne Electric Supply Co., work involved tests on meters, instruments, relays, transformers; 1930-31, test course, General Electric Company; 1931-32, research asst. in electr'l. engrg. dept., Mass. Inst. Tech.; Feb. 1933 to date, plant electr'n., in charge of electr'l. work, instruments, and control apparatus at the Shell refinery, Shell Company of Canada.

References: H. Milliken, C. V. Christie, A. D. Ross, R. E. Smythe, G. H. Pittaway, S. Mitcheson, H. H. Snyder.

PANGMAN—ARTHUR HENRY, of 112 St. Joseph St., Dorval, Que., Born at Montreal, July 1st, 1905; Educ., B.Sc. (Chem.), McGill Univ., 1930; Summers 1926 and 1928, chem. and engrg. work with Redpath Sugar Refinery and J. T. Donald Co. Ltd., respectively; 1929-31, with the Murphy Varnish Co., and from 1931 to date, control chemist with C. E. Frosst & Co., pharmaceutical chemists, Montreal.

References: F. P. Shearwood, J. R. Donald, R. DeL. French, C. S. Gzowski, F. W. Taylor-Bailey.

FOR TRANSFER FROM THE CLASS OF ASSOCIATE MEMBER TO THAT OF MEMBER

HEARTZ—RICHARD EDGAR, of 208 Portland Avenue, Town of Mount Royal, Que., Born at Marshfield, P.E.I., Aug. 18th, 1895; Educ., B.Sc., McGill Univ., 1917; 1917 (Summer), St. Maurice Constrn. Co., field and office work at Gouin dam; 1917-19, R.F.C., commissioned and appointed Flying Instructor, May 1918; 1919-20, Fraser Brace & Co., field and office work on Big Eddy Dam at Turbine, Ont.; 1920-25, with Shawinigan Engineering Co. Ltd., as follows: 1920-22, field and office work during constrn. of No. 2 power house extension at Shawinigan Falls, Que.; 1922-24, res. engr., on La Gabelle development, in charge of field and office work at power site; 1924-25, res. engr. on St. Narcisse development; 1925 to date, with Power Engineering Company as follows: 1925-27, study of various hydro-electric projects, including preliminary design; 1927-28, res. engr. (Power Engrg. Co.), during constrn. of Paugan Falls development; 1929 to date, gen. supervision of work, involving change over of high and low tension systems of the Laurentide and No. 2 Shawinigan power plants. Design, layout and specifications of constrn. plant for, and general procedure of Mattawin River storage dam, Rapide Blanc and Poisson Blanc developments, including general supervision of these developments. Investigations and reports on misc. projects. (*S. 1917, A.M. 1926.*)

References: S. Svenningson, P. S. Gregory, J. A. McCrory, O. O. Lefebvre, J. H. Brace, E. Brown.

TRIMINGHAM—JAMES HARVEY, of Montreal, Que., Born at Bermuda, Aug. 14th, 1886; Educ., B.Sc., 1908, M.Sc., 1920, McGill Univ.; 1908-11, demonstrator, elect'l. dept., McGill Univ.; 1916-17, sub. lieut., 1917-19, lieut., R.N.V.R.; 1911-13, manager, Bermuda Electric Light Company; 1913-16, supt. of power, Sherbrooke Rly. & Power Company; 1919 to date, chief engineer, Power Corporation of Canada, Montreal, Que. (*St. 1907, A.M. 1913.*)

References: J. S. H. Wurtele, A. G. L. McNaughton, L. A. Kenyon, C. N. Mitchell, G. H. Kohl, J. Palmer, J. Morse.

FOR TRANSFER FROM THE CLASS OF JUNIOR

DESBARATS—GEORGE H., of Low, Quebec, Born at Ottawa, Ont., Nov. 20th, 1900; Educ., B.Sc., McGill Univ., 1922. Engr. Lt. Commdr., R.C.N.V.R.; 1919 (6 mos.), midshipman, R.C.N.; 1920 (3 mos.), junior radio engr.; 1921 (3 mos.), student, Montreal Tramways; 1922 (6 mos.), test floor engr., English Electric Co.; 1922-25, ap'tice. Canadian Westinghouse Company; 1926 (3 mos.), electr'n., Fraser Brace Co.; 1926 (6 mos.), electr'n., Canadian Comstock Co.; 1924 (2 mos.), Engr. Lieut., H.M.C.S. "Patriot"; 1925 (6 mos.), Engr. Lieut., H.M.S. "Capetown"; 1926-27, electr'l. foreman, Canadian Comstock Co.; 1927 (5 mos.), shift foreman; 1927-28, supt. of Farmers power house, and 1928 to date, supt. of Paugan power house for Gatineau Power Company. (*St. 1919, Jr. 1926.*)

References: G. G. Gale, C. P. Edwards, J. Murphy, C. V. Christie, E. W. Stedman.

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 Wanted

ELECTRICAL AND RADIO ENGINEER, B.Sc., '28. Experience in the design and testing of broadcast radio receivers, including latest superheterodyne practice, and capable of constructing apparatus for testing same. Also familiar with telephone and telephone repeater engineering. Thorough experience in design, and construction and inspection of municipal power conduits. Apply to Box No. 12-W.

MECHANICAL ENGINEER, Canadian, with technical training and executive experience in both Canadian and American industries, particularly plant layout, equipment, planning and production control methods, is open for employment with company desirous of improving manufacturing methods, lowering costs and preparing for business expansion. Apply to Box No. 35-W.

MECHANICAL ENGINEER, A.M.E.I.C. Married. Experience in machine shops, erection and maintenance of industrial plant mechanical and structural design. Reads German, French, Dutch and Spanish. Seeks any suitable position. Apply to Box No. 84-W.

YOUNG ENGINEER, B.A., B.SC., A.M.E.I.C., R.P.E., Ont. Competent draughtsman and surveyor. Eight years experience including design, superintendence and layout of pulp and paper mills, hydro-electric projects and general construction. Limited experience in mechanical design and industrial plant maintenance. Apply to Box No. 150-W.

PURCHASING ENGINEER, graduate mechanical engineer, Canadian, married, 34 years of age, with 13 years' experience in the industrial field, including design, construction and operation, 8 years of which had to do with the development of specifications and ordering of equipment and materials for plant extensions and maintenance; one year engaged on sale of surplus construction equipment. Full details upon request. Apply to Box No. 161-W.

CIVIL ENGINEER, age 44, open for employment anywhere, experience covers about 20 years' active work, including 7 years on municipal engineering, 2 years as Town Manager, 3 years on railway construction, 3 years on the staff of a provincial highway department, 2 years as contractor's superintendent on pavement construction. Apply to Box No. 216-W.

REINFORCED CONCRETE ENGINEER, B.SC., P.E.Q., eight years experience in construction design of industrial buildings, office buildings, apartment houses, etc. Age 30. Married. Apply to Box No. 257-W.

MECHANICAL ENGINEER, B.Sc., McGill '19, A.M.E.I.C. Married. Twelve years experience including oil refinery power plant, structural and reinforced concrete design, factory maintenance, steam generation and distribution problems, heating and ventilating. Available at once. Location immaterial. Apply to Box No. 265-W.

ELECTRICAL ENGINEER, B.SC., '28, Canadian. Age 25. Experience includes two summers with power company; thirteen months test course with C.G.E. Co.; telephone engineering, and the past thirty months with a large power company in operation and maintenance engineering. Location immaterial and available immediately. Apply to Box No. 266-W.

PLANE-TABLE TOPOGRAPHER, B.SC., in C.E. Thoroughly experienced in modern field mapping methods including ground control for aerial surveys. Fast and efficient in surveys for construction, hydro-electric and geological investigations. Apply to Box No. 431-W.

ELECTRICAL ENGINEER, B.SC., A.M.E.I.C., AM.A.I.E.E., age 30, single. Eight years experience H.E. and steam power plants, substations, etc., shop layouts, steel and concrete design. Location immaterial. Available immediately. Apply to Box No. 435-W.

CIVIL ENGINEER, B.A.SC., and C.E., A.M.E.I.C., age 30, married. Experience over the last ten years covers construction on hydro-electric and railway work as instrumentman and resident engineer. Also office work on teaching and design, investigations and hydraulic works, reinforced concrete, bridge foundations and caissons. Location immaterial. Available at once. Apply to Box No. 447-W.

CIVIL ENGINEER, B.SC., A.M.E.I.C., with six years experience in paper mill and hydro-electric work, desires position in western Canada. Capable of handling reinforced concrete and steel design, paper mill equipment and piping layout, estimates, field surveys, or acting as resident engineer on construction. Now on west coast and available at once. Apply to Box No. 482-W.

Situations Wanted

CIVIL ENGINEER, Canadian, married, twenty-five years' technical and executive experience, specialized knowledge of industrial housing problems and the administration of industrial towns, also town planning and municipal engineering, desires new connection. Available on reasonable notice. Personal interview sought. Apply to Box No. 544-W.

ELECTRICAL AND MECHANICAL ENGINEER, B.SC., A.M.E.I.C. Experience includes C.G.E. Students Test Course and six years in engrg. dept. of same company on design of electrical equipment. Four summers as instrumentman on surveying and highway construction. Recently completed course in mechanical engineering. Available at once. Location preferred Ontario, Quebec, or Maritimes. Apply to Box No. 564-W.

CIVIL ENGINEER, age 25, single, graduate. Creditable record on responsible hydro and railroad work in both Eastern and Western Canada. Apply to Box No. 567-W.

MECHANICAL ENGINEER, A.M.E.I.C., with twenty years experience on mechanical and structural design, desires connection. Available at once. Apply to Box No. 571-W.

Employment Service Bureau

This bureau is maintained by The Engineering Institute of Canada for the benefit of members and organizations employing technically trained men.

An enquiry addressed to 2050 Mansfield Street, Montreal, will bring full information concerning the services offered. Details can also be obtained from Branch secretaries who are located in the larger centres throughout Canada.

Brief announcements of men available and positions vacant will be published without charge in The Engineering Journal and the Bulletin. Replies addressed in care of the required box number will be forwarded to the advertiser without delay.

An additional service also offered those who are unemployed or wish to change their positions, is the opportunity of placing their names and records on file at 2050 Mansfield Street for consideration by employers wishing to employ engineers. This is of great assistance as many employers will not advertise or wish to locate a suitable man on short notice. If desired the information contained in these records can be kept confidential.

Forms for registration purposes may be obtained from The Institute Headquarters or Branch secretaries.

MECHANICAL ENGINEER, B.A.SC., '30, desires position to gain experience, and which offers opportunity for advancement. Experience in pulp and paper mill and one year in mechanical department of large electrical company. Location immaterial. Available immediately Apply to Box No. 577-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.

MECHANICAL ENGINEER, Canadian, technically trained; eighteen years experience as foreman, superintendent and engineer in manufacturing, repair work of all kinds, maintenance and special machinery building. Location immaterial. Available at once. Apply to Box No. 601-W.

CHEMICAL ENGINEER, S.E.I.C., B.SC., University of Alberta, '30. Age 31. Single. Six seasons' practical laboratory experience, three as chief chemist and three as assistant chemist in cement plant; one year's p.g. work in physical chemistry; three years' experience teaching. Desires position in any industry with chemical control. Available immediately. Apply to Box No. 609-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.

CIVIL ENGINEER, A.M.E.I.C., R.P.E., Ontario; three years construction engineer on industrial plants; fourteen years in charge of construction of hydraulic power developments, tower lines, sub-stations, etc.; four years as executive in charge of construction and development of harbours, including railways, docks, warehouses, hydraulic dredging, land reclamation, etc. Apply to Box No. 647-W.

Situations Wanted

MECHANICAL ENGINEER, A.M.E.I.C., Canadian, technically trained; six years drawing office. Office experience, including general design and plant layout. Also two years general shop work, including machine, pattern and foundry experience, desires position with industrial firm in capacity of production engineer or estimator. Available on short notice. Apply to Box No. 676-W.

ELECTRICAL AND CIVIL ENGINEER, B.SC., Elec., '29, B.SC., Civil '33. Age 27. JR.E.I.C. Undergraduate experience in surveying and concrete foundations; also four months with Canadian General Electric Co. Thirty-three months in engineering office of a large electrical manufacturing company since graduation. Good experience in layouts, switching diagrams, specifications and pricing. Best of references. Available immediately. Apply to Box No. 693-W.

MECHANICAL ENGINEER, B.SC., '27, JR.E.I.C. Four years maintenance of high speed Diesel engines units, 200 to 1,300 h.p. Also maintenance of D.C. and A.C. electrical systems and machinery. Draughting experience. Westinghouse apprenticeship course. Practical mechanical and electrical engineer with a special study of high speed Diesel engine design, application and operation. Location in western or eastern Canada immaterial. Apply to Box No. 703-W.

COMBUSTION ENGINEER, R.P.E., Manitoba, A.M.E.I.C. Wide experience with all classes of fuels. Expert designer and draughtsman on modern steam power plants. Experienced in publicity work. Well known throughout the west. Location, Winnipeg or the west. Available at once. Apply to Box No. 713-W.

YOUNG ENGINEER, B.A.SC., (Univ. Toronto '27), JR.E.I.C. Four years practical experience, buildings, bridges, roadways, as inspector and instrumentman. Available at once. Present location, Montreal. Apply to Box No. 714-W.

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

MECHANICAL ENGINEER, age 41, married. Eleven years designing experience with project of outstanding magnitude. Machinery layouts, checking, estimating and inspecting. Twelve years previous engineering, including draughting, machine shop and two years chemical laboratory. Highest references. Apply to Box No. 723-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.

DESIGNING ENGINEER, M.SC. (McGill Univ.), D.L.S., A.M.E.I.C., P.E.Q. Experience in design and construction of water power plants, transmission lines, field investigations of storage, hydraulic calculations and reports. Also paper mill construction, railways, highways, and in design and construction of bridges and buildings. Available at once. Apply to Box No. 729-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.

CIVIL ENGINEER, M.SC., 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.

ELECTRICAL AND RADIO ENGINEER, B.SC. '31, S.E.I.C. Age 25. Nine months experience on installation of power and lighting equipment. Eight months on extensive survey layouts. Two summers installing telephone equipment. Specialized in radio servicing and merchandising. Available at once. Location immaterial. Apply to Box No. 740-W.

CIVIL ENGINEER, graduate '29. Married. One year building construction, one year hydro-electric construction in South America, fourteen months resident engineer on road construction. Working knowledge of Spanish. Apply to Box No. 744-W.

SALES ENGINEER, B.SC., McGill, 1923, A.M.E.I.C. Age 33. Married Extensive experience in building construction. Thoroughly familiar with steel building products; last five years in charge of structural and reinforcing steel sales for company in New York state. Available at once. Located in Canada. Apply to Box No. 749-W.

DESIGNING ENGINEER, graduate Univ. Toronto '26. Thoroughly experienced in the design of a broad range of structures, desires responsible position. Apply to Box No. 761-W.

MECHANICAL ENGINEER, graduate, '23, A.M.E.I.C., P.E.Q., age 32, married. (English and French.) Two years shop, foundry and draughting experience; one year mechanical supt. on construction; six years designing draughtsman in consulting engineers' offices (mechanical equipment of buildings, heating, sanitation, ventilation, power plant equipment, etc.). Present location Montreal. Available immediately. Montreal or Toronto preferred. Apply to Box No. 766-W.

Situations Wanted

ELECTRICAL ENGINEER, B.Sc. (McGill Univ. '29), S.E.I.C. Married. Experience in pulp and paper mill mechanical maintenance, estimates and costs and machine shop practice. Desires position with industrial or manufacturing concern. Location immaterial. Available on short notice. References. Apply to Box No. 770-W.

CIVIL ENGINEER, S.E.I.C., B.Sc. Queen's Univ '29. Age 25. Married. Three years experience as construction supt. and estimator for contracting firm. Experience includes general building, bridges, sewer work, concrete, boiler settings, sand blasting of bridges and spray painting. Available at once. Apply to Box No. 776-W.

CIVIL ENGINEER, B.Sc., '25, JR.E.I.C., P.E.Q., married. Desires position, preferably with construction firm. Experience includes railway, monument and mill building construction. Available immediately. Apply to Box No 780-W.

DRAUGHTSMAN, experience in civil engineering, forestry engineering, land surveying and house construction. Good references. Apply to Box No. 781-W.

ELECTRICAL AND SALES ENGINEER, S.E.I.C., grad. '28. Experience includes one year test course, one year switchboard design and two years switchboard and switching equipment sales with large electrical manufacturing company. Three summers Pilot Officer with R.C.A.F. Available at once. Apply to Box No. 788-W.

SALES REPRESENTATIVE. Electrical engineer with ten years experience in power field interested in representing established firm for electrical or mechanical product in Montreal territory. Excellent connections Apply to Box No. 795-W.

CIVIL ENGINEER, S.E.I.C., graduate '30, age 23, single. Experience includes mining surveys, assistant on highway location and construction, and assistant on large construction work. Steel and concrete layout and design. Apply to Box No. 809-W.

CIVIL ENGINEER, college graduate, age 27, single. Experience includes surveying, draughting concrete construction and design, street paving both asphalt and concrete. Available at once; will consider anything and go anywhere. Apply to Box No. 816-W.

CIVIL ENGINEER, B.E. (Sask. Univ. '32), S.E.I.C. Single. Experience in city street improvements; sewer and water extensions. Good draughtsman. References. Available at once. Location immaterial. Apply to Box No. 818-W.

CIVIL ENGINEER, S.E.I.C., B.Sc. (Queen's '32), age 21. Three summers surveying in northern Quebec. Interested in hydraulics and reinforced concrete. Available at once. Location immaterial. Apply to Box No. 822-W.

CIVIL ENGINEER, B.Sc., A.M.E.I.C., with fifteen years experience mostly in pulp and paper mill work, reinforced concrete and structural steel design, field surveys, layout of mechanical equipment, piping. Available at once. Apply to Box No. 825-W.

ELECTRICAL ENGINEER, S.E.I.C., grad '29, age 24, married; experience includes one year Students Test Course, sixteen months in distribution transformer design and eight months as assistant foreman in charge of industrial control and switchgear tests. Location immaterial. Available at once. Apply to Box No. 828-W.

CIVIL ENGINEER, B.A.Sc., D.L.S., O.L.S., A.M.E.I.C., age 46, married. Twelve years experience in charge of legal field surveys. Owns own surveying equipment. Eight years on technical, administrative, and editorial office work. Experienced in writing. Desires position on survey work, assisting in or in charge of preparation of house organ, on staff of technical or semi-technical magazine, or on publicity, editorial or administrative office work. Available at once. Will consider any salary, and any location. Apply to Box No. 831-W.

CIVIL ENGINEER, M.Sc., B.P.E. (Sask.). Age 27. Experience in location and drainage surveys, highways and paving, bridge design and construction city and municipal developments, power and telephone construction work. Available on short notice. Apply to Box No. 839-W

CIVIL ENGINEER, S.E.I.C., B.Sc. '32 (Univ. of N.B.). Age 25, married. Two years experience in power line construction and maintenance; one year of highway construction; one summer surveying for power plant site, location and spur railway line construction. Available at once. Location immaterial. Apply to Box No 840-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.

CIVIL ENGINEER, B.Sc. (Alta. '31), S.E.I.C., age 24. Experience, three summers on railroad maintenance, and seven months on highway location as instrumentman. Willing to do anything, anywhere, but would prefer connection with designing or construction firm on structural works. Available immediately. Apply to Box No. 846-W.

MECHANICAL ENGINEER, JR.E.I.C., technical graduate, bilingual, age 30. Two years as designing heating draughtsman with one of the largest firms of its kind on this continent handling heating materials; three years designing draughtsman in consulting engineers' office, mechanical equipment of buildings, heating, ventilation, sanitation, power plant equipment, writing of specifications, etc. Present location Montreal. Available at once. Apply to Box No. 850-W.

Situations Wanted

BRIDGE AND STRUCTURAL ENGINEER, A.M.E.I.C., McGill. Twenty-five years' experience on bridge and structural staffs. Until recently employed. Familiar with all late designs, construction, and practices in all Canadian fabricating plants. Desirous of employment in any responsible position, sales, fabrication or construction. Apply to Box No. 851-W.

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MECHANICAL ENGINEER, Canadian, age 25, B.Sc. (Queen's '32). Since graduation on supervision of large building construction. Undergraduate experience in electrical, plumbing and heating, and locomotive trades. Available at once. Apply to Box No. 903-W.

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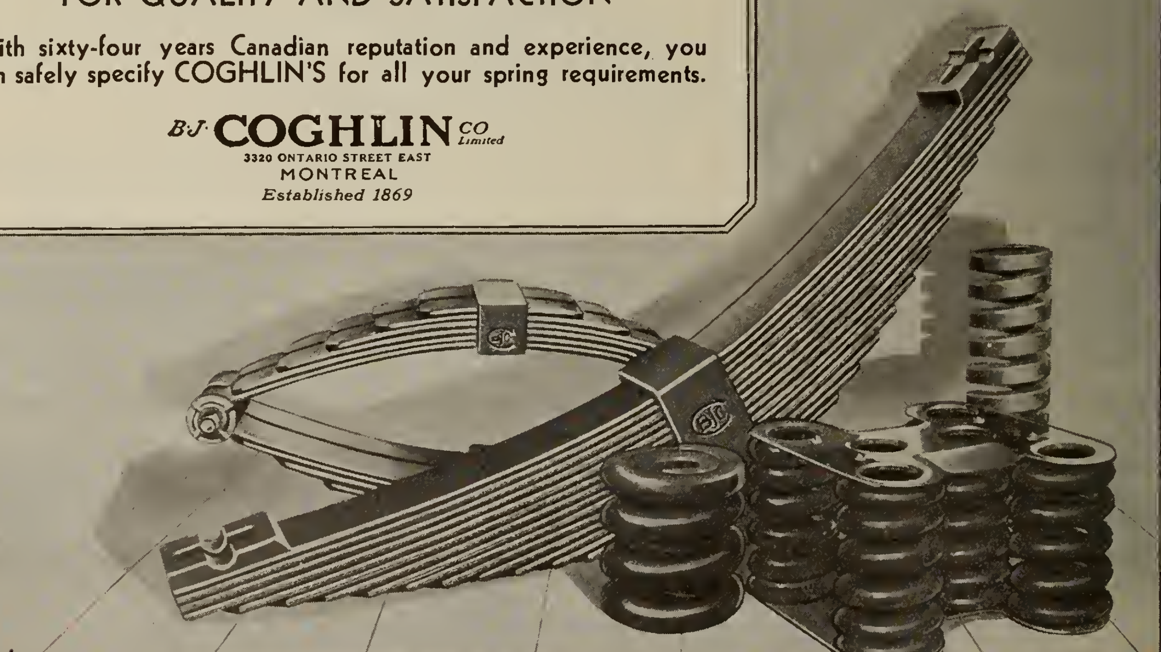

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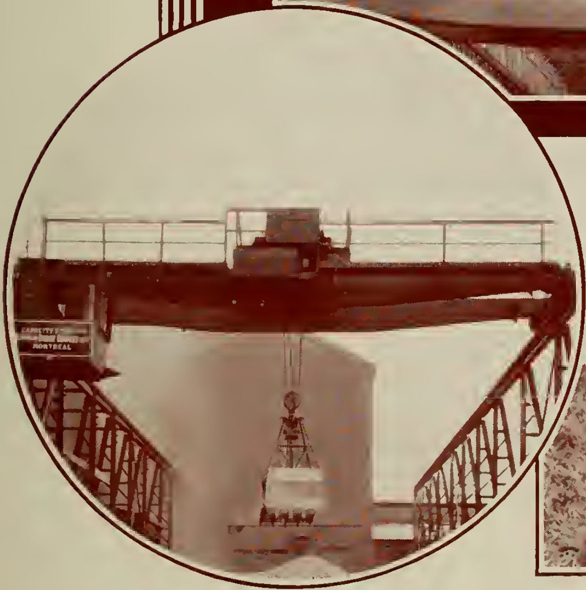

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No. 12

DECEMBER
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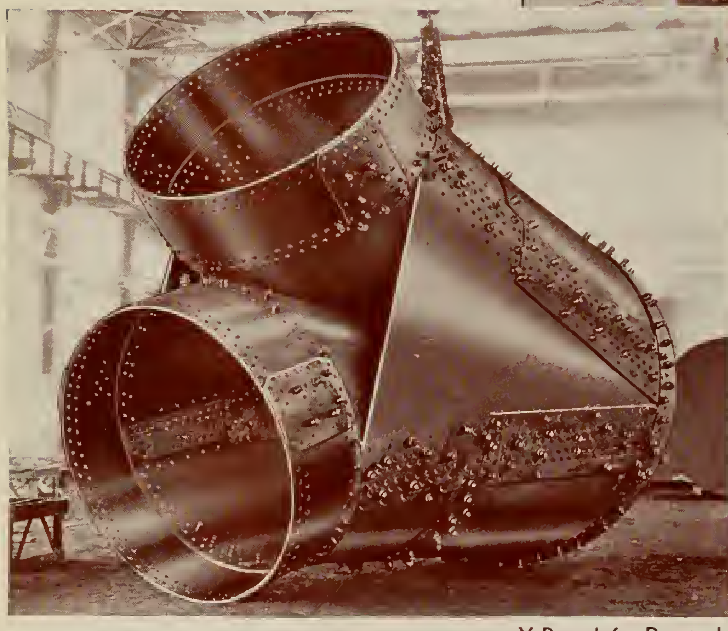

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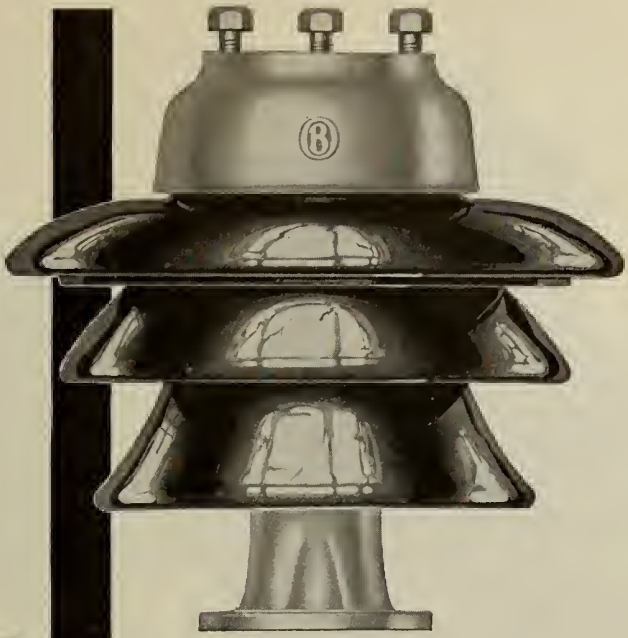

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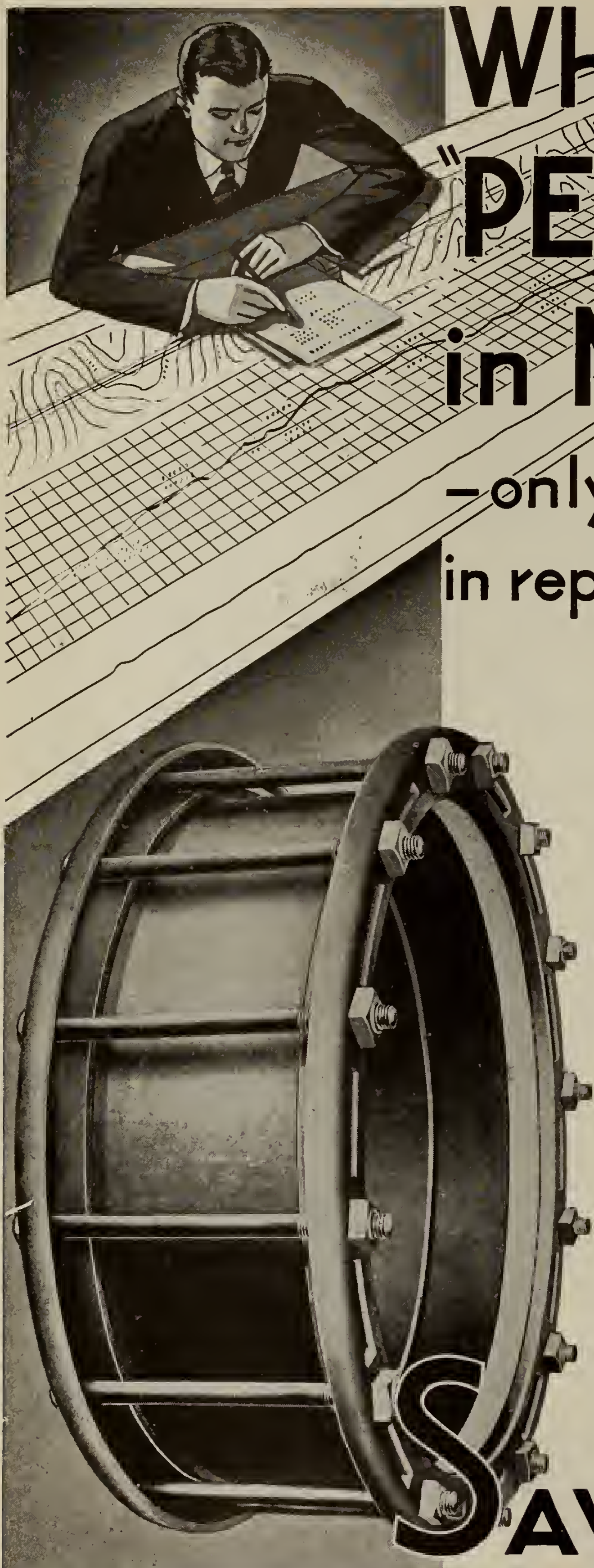

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The Utilization of Magnesian Carbonates

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Paper to be presented at the General Professional Meeting of The Engineering Institute of Canada, Montreal, Que., February 8th and 9th, 1934.

SUMMARY.—Outlining the history of the magnesian refractories industry in Canada during the last thirty years, the paper explains the development of a method of eliminating silica and lime from the magnesite rock obtained near Grenville, Que. This was necessary in order to permit the economical production of a satisfactory refractory lining for open hearth steel furnaces, refractory brick, plastic magnesia for flooring and stucco and material for other purposes. The result of this work, which has been carried out by the National Research Council with the co-operation of the industry, has been a gratifying increase in demand due to the improvement in the quality of the products named.

This paper outlines a metallurgical problem presented to the National Research Council of Canada in 1925, the several investigations carried out in an effort to solve that problem, and the results obtained. The paper may be considered as one of a series, the others of which will deal in some detail with either the laboratory studies or the commercial application of the products developed in these investigations.

The Problem

In the year 1900 large deposits of mixed magnesium and calcium carbonates were found about 15 miles north of the town of Grenville, Quebec. A few small shipments were made from time to time during the succeeding years, but no extensive mining operations were undertaken until 1914, when, because of the war, supplies of magnesite from Europe were cut off. In 1916 the deposits were examined by M. E. Wilson,* who estimated that there were then in sight on the various properties about 1,200,000 tons of mixed carbonates, of which a little more than half contained under 12 per cent of CaO (equal to a dolomite content of about 40 per cent). In these deposits $MgCO_3$ and $CaCO_3.MgCO_3$ are so intimately mixed that a good separation by hand-sorting is impossible. The carbonates are usually, but not always, coarsely crystalline. Associated with and disseminated through the carbonate rock is considerable serpentine in varying amount, as a result of which all rock mined contains an appreciable amount of silica.

A considerable development of these deposits took place during the war. At first only crude rock was shipped, but subsequently kilns were installed on the property and a dead-burned product (clinker) was made. In 1918, total shipments amounted to 39,365 tons, valued at $1,016,765. The greater part of this product went to the United States for use as a refractory in open-hearth steel furnaces.

When the war was over the situation was completely changed. European dead-burned magnesite clinker, practically free from lime, again became available. Due to the exchange situation then existing this magnesite was offered at a very low price. Most of the steel makers considered it unequalled for service and were glad to resume its use. In a short time the Canadian producers of magnesian refractories had completely lost the United States market and were seriously threatened even in Canada. The situation was further aggravated by the depression in the steel industry itself.

For several years the Canadian producers endeavoured to meet the situation by improved business methods. The more important producers arranged for the co-operative working of their quarries and kilns and instituted an energetic sales campaign. It soon became evident, however, that these methods alone would not effectively meet the situation, and in 1925 the companies appealed to the Dominion government for assistance. The government gave them a sympathetic hearing and assigned to the National Research Council the task of investigating the companies' technical problems. (It may be noted here that before the amount appropriated by the Dominion government for this investigation had been expended the co-operating companies were in a position to support the work financially and were so doing.)

Following this assignment of the problem a committee was formed under the chairmanship of Dr. H. M. Tory, President of the National Research Council, qualified metallurgists were secured, and an investigation was begun in co-operation with technical officers of the operating companies and of the Department of Mines, in whose ceramic laboratory one phase of the investigation has been carried out. The technical supervision of the investigation was assigned to the author, who instituted a series of frequent conferences of all the technical men directly concerned. The members of this group have planned all except the early stages of the investigation and are jointly responsible for the progress made.

*Memoir 98, Department of Mines, Canada, 1917.

Steel makers did not wish to use the refractory marketed by the Canadian companies on account of its high lime and silica content. In an effort to meet the purchasers' wishes the companies were endeavouring to reduce the percentages of these constituents by sorting the crushed rock on picking belts, but owing to the uniform dissemination of the impurities it was impossible to make a product which on the basis of chemical composition could compete

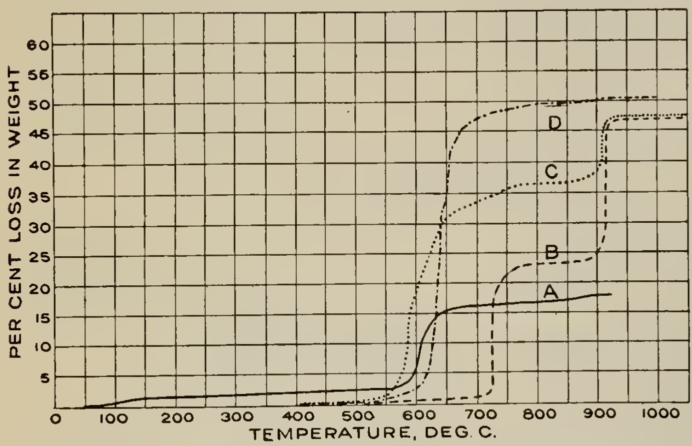

Fig. 1. Thermal decomposition of:
A. Serpentine.
B. Dolomite.
C. Magnesitic dolomite from the Grenville district.
D. Washington magnesite.

with European magnesite. Further, the extensive sorting resulted in the rejection of some 70 per cent of the rock mined, with a correspondingly high production cost.

The immediate problem therefore consisted in devising methods for the elimination of the impurities associated with the magnesia, thus increasing the percentage of rock utilized and improving the quality of the companies' sole product, a dead-burned magnesian refractory. From the beginning there was also borne in mind the possibility of developing new products, especially refractory brick and plastic magnesia. Unsuccessful attempts to manufacture these products had previously been made.

Elimination of Lime and Silica

A study was made of the properties of the chief mineral constituents of the rock, in order if possible to discover differences upon which mechanical or chemical methods for the partial or complete elimination of lime and silica might be based.

Curves for the decomposition of the three principal minerals found in the deposit are shown in Fig. 1, and corresponding analyses in Table I. Serpentine under the

Table I

Composition of Samples Subjected to Thermal Decomposition Tests (Fig. 1)

Sample	*Insol.	†R_2O_3	CaO	Loss on Ign.	MgO (by diff.)
A. Serpentine	36.4	1.5	4.3	19.2	38.6
B. Dolomite	0.4	0.4	30.9	46.6	21.7
C. Magnesitic dolomite	3.1	0.6	14.7	46.3	35.3
D. Washington magnesite	2.4	1.2	1.3	50.5	44.6

*The insoluble matter is practically pure silica.
†Essentially Fe_2O_3 and Al_2O_3.

conditions of the experiment was found to lose most of its water of hydration in the neighbourhood of 600 degrees C. After decomposition it still retained much of its original mechanical strength. Dolomite decomposed in two stages. The first stage, at about 725 degrees, consisted in the separation of the molecules of $MgCO_3$ and $CaCO_3$, with the immediate decomposition of the former, which was already above its normal decomposition temperature. The second stage, at 910 degrees, was the decomposition of the remaining $CaCO_3$. The temperature of decomposition of magnesium carbonate varies somewhat with the source of the mineral. Pure magnesite from the State of Washington decomposed at 625 degrees. The selected Grenville rock, whose decomposition curve is shown in Fig. 1 (Curve *C*), contained considerable lime in the form of dolomite; its magnesitic constituent broke up at 575-640 degrees; the $MgCO_3$ of the dolomite between 650 and 750 degrees and the $CaCO_3$ of the dolomite at 900-910 degrees. The latter temperature represents the decomposition point of pure calcite, a curve for which has not been shown, as this mineral is not present in appreciable quantity in the Grenville rock. The oxides produced from the low-temperature decomposition of the carbonates were all relatively soft, especially the magnesia. Advantage of this fact was taken in the development of a process of separation.

The decomposition tests immediately suggested the possibility of calcination at a temperature between the decomposition temperatures of magnesite and dolomite, in order to leave both the dolomite and serpentine in a relatively hard condition. A light crushing operation on the calcine would pulverize the soft magnesia and leave the impurities relatively coarse, permitting their separation by a current of air or by a simple screening operation. Further, such a method would have the advantage of separating the magnesia from both impurities at once.

When tried in the laboratory the method was found to possess merit and conditions were soon discovered whereby a good separation could be obtained. Table II gives the results of one test in which several screens were used to show the various products which could be made. In this case, had all the sizes passing a 20-mesh screen been combined and dead-burned, the product would have comprised 70.2 per cent of the weight and would have contained 3.8 per cent insol., 14.3 per cent CaO and 79.1 per cent MgO, a result which would have been considered highly gratifying if obtained in practice at that time, while the reject after similar treatment would have comprised 29.8 per cent of the total weight and would have contained 13.9 per cent insol., 31.1 per cent CaO and 52.4 per cent MgO, the last being present in large part as dolomite.

Table II

Results of Calcination, Light Crushing, and Screening

Screen Mesh	Per cent Weight	Insol.	CaO	MgO	Ign. Loss
+ 8	12.7	10.6	23.8	36.0	27.6
+20	20.2	9.7	21.7	40.1	26.4
+35	11.9	8.1	20.6	43.1	26.1
+65	12.0	4.2	15.8	57.4	20.4
−65	43.2	1.6	8.8	75.5	11.6

A process* developed after much experimentation was tried on a commercial scale in one of the kilns used for the production of dead-burned clinker. The use of powdered coal as fuel at such a low temperature made necessary an external combustion chamber in order to insure proper ignition, but by its use the temperature could be maintained at any desired point. The calcine was later crushed by being tumbled in a rotary cooler, and a single screening operation yielded, as in the laboratory, coarse and fine products as a reject and as a material for dead-burning, respectively. The process was thus proved technically

*Canadian Patent No. 278,774 to F. E. Lathe and D. W. Stewart.

feasible. Its commercial application, however, was rendered unnecessary by the results of another series of laboratory experiments carried on concurrently.

Preparation of a Basic Furnace Refractory

The experiments just referred to were preceded by a study of the requirements of open-hearth steel furnaces. When a relatively pure magnesite clinker is used in burning-in the bottoms of steel furnaces, or in patching as holes are formed, it is common practice to mix with it a considerable proportion of material of relatively low melting point, since magnesite has not the property of "setting" alone at ordinary furnace temperatures. Open-hearth slag is generally used for this purpose, its function being to melt and bind together the highly refractory particles of magnesia. Such a hearth, however, requires a very long period to burn-in, and is at best a heterogeneous mixture. It appeared that an ideal refractory for use in open-hearth steel furnaces should possess the following properties:

1. It should "set" rapidly at ordinary furnace temperatures.
2. It should not require the addition of extraneous fluxes.
3. It should form a truly monolithic mass.
4. It should be physically and chemically resistant to the action of steel and slag.
5. It should be sufficiently refractory at the maximum temperatures of steel furnace operation.
6. In storage it should remain stable indefinitely, whether wet or dry.

Accordingly, a long series of experiments was undertaken in an effort to develop a product which would satisfy these requirements. It was found practicable to retain a considerable percentage of silica in the refractory, provided that the proportion of lime to silica was kept well above that corresponding to the composition of dicalcium silicate ($2CaO.SiO_2$). This compound on cooling shows marked expansion at 675 degrees C., where transformation occurs, as a result of which those products containing it in quantity frequently fall to a powder. Some of the difficulties previously encountered in practice were due to the fact that the lime was actually too low in proportion to the silica present.

Advantage was also taken of the well-known effect of iron oxide in rendering the lime inactive chemically. Iron oxide appears to hasten the transformation of magnesia to dense, inert periclase; it combines with some of the magnesia to form a ferrite; it hinders the transformation of dicalcium silicate. It was determined that by maintaining the right proportions of lime, silica and iron oxide, the properties of stability and rapid setting could be secured without either materially reducing the melting point of the product or rendering it more susceptible to the action of open-hearth slags.

The laboratory experiments were carried out by A. C. Halferdahl in a small rotary kiln designed by himself. The kiln was fired by ordinary city gas and air, with the addition of a little oxygen for temperatures above 1,600 degrees C. The furnace was lined with periclase brick. It was used not only for the clinkering experiments with some one hundred and forty different mixes, but also to determine the time and temperature required for the "setting" of the products.

A large number of chemicals were tried in various combinations with magnesia. None of them, however, gave as much promise as lime, iron oxide and silica, and the composition decided upon for the commercial product* was therefore confined to these three, with minor quantities of alumina and other accessory constituents. As the laboratory experiments progressed the results were applied to commercial operations, the final product having approximately the following composition: CaO, 17.5 to 21.5 per cent; iron oxide (calc. to Fe_2O_3), 6.5 to 7.5 per cent; SiO_2, 5.5. to 7.0 per cent; MgO, 63 to 68 per cent.

Extensive plant improvements accompanied the application of the laboratory results to commercial operations. In present practice the higher percentage of lime and silica results in the utilization of a greatly increased proportion of the rock mined. The picking belts have been discarded and the only sorting is done at the quarry, where a small amount of waste rock is rejected at low cost. A large stock pile of crushed kiln feed is maintained, thus facilitating thorough mixing. After coarse crushing the rock passes with iron oxide to ball and tube mills, in which these constituents are intimately mixed and finely ground. A higher burning temperature is maintained than formerly, but finer pulverizing of coal fuel, an increase in primary air, better draught control and accurate regulation of the temperature and composition of stack gases have nevertheless been the means of considerably reducing coal consumption. The production per kiln has been increased and a better burned product has resulted. Transportation facilities have been improved to handle the greatly increased output, a standard gauge railroad having replaced the narrow-gauge mountain road connecting the mine and plant with the Canadian Pacific Railway near Grenville.

The dead-burned refractory now produced differs radically, not only in chemical composition but also in physical properties, from both the foreign magnesite clinker and the burned dolomite now on the market. In it are realized the objectives originally stated, the properties of setting rapidly at ordinary open-hearth furnace temperatures without the admixture of slag or other flux, adequate refractoriness, resistance to the physical and chemical action of the bath, and stability in the presence of moisture. Steel makers skilled in its use are saving time in burning-in bottoms and in patching between heats—savings sufficient

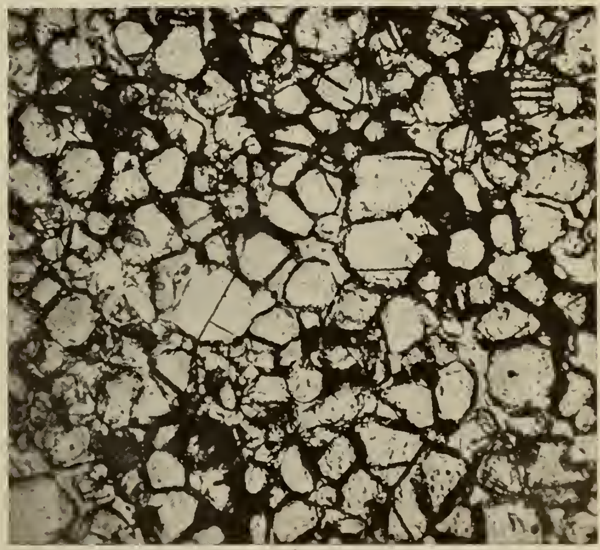

Fig. 2—Thin Section of Open Hearth Furnace Bottom. Magnification approximately 50.

in some cases to pay the whole cost of the refractory—are securing more permanent installations, and, in addition, are reducing the cost of refractory per ton of steel. The best proof that these advantages are real is found in the fact that this product is being purchased in some districts at a cost, including freight, well above that of dead-burned magnesite. It is finding a ready market in Canada, the United States and Great Britain. This record is the more noteworthy in

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*Canadian Patent No. 305,757 to G. M. Carrie and A. C. Halferdahl.

that it has been made during a severe depression in the steel industry.

Figure 2 shows a thin section of an open-hearth furnace bottom which was resurfaced with this refractory and upon which three hundred and thirteen heats had subsequently been made. The bottom is revealed as a mass of periclase grains below 0.008 inch in diameter, cemented together with silicates and ferrites. Grey polygonal areas are periclase,

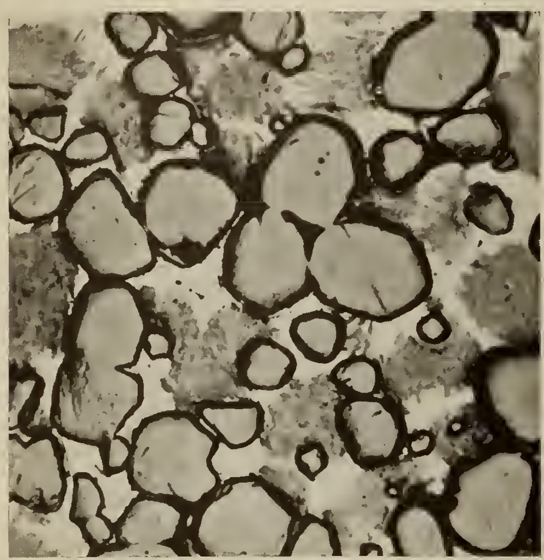

Fig. 3—Section of Open Hearth Furnace Bottom by Reflected Light. Magnification approximately 400.

irregular grey areas between periclase grains are silicates and similar black areas are ferrites. In the absence of slag as a binder such a bottom furnishes a minimum opportunity for physical or chemical attack.

Figure 3 illustrates the same refractory under reflected light, the specimen being from an open-hearth furnace bottom put in wholly of Canadian clinker. Grey grains of periclase are surrounded by irregular patches of grey silicates and white magnesiaferrite. The grey periclase grains, still smaller than in Fig. 2, are believed to consist of practically pure MgO.

Recently this material has been applied in a new field. In March, 1931, Noranda Mines, Limited, at Noranda, Quebec, was having trouble with a new anode furnace bottom, and, after consultation regarding the advantages of monolithic construction, decided to have a bottom burned-in with this special basic refractory plus iron oxide. This was done shortly afterwards. A few holes developed after a period of operation but these were successfully patched with the same material and the whole bottom is now in excellent condition after more than two-and-one-half years of constant service. Details of construction were given in a paper by Boggs and Anderson* of the Noranda company.

The investigation of other possible outlets for this clinker is still under way, but commercial application is already being made of a finely ground basic cement for general use with basic refractories, and a chemically bonded basic refractory which may be rammed into place as a furnace lining. Further developments are anticipated.

Refractory Brick

Early experiments in brick manufacture were conducted with the clinker produced some years ago. Some troubles were experienced due to the action on the clinker of water used in tempering, which caused it to partially slake, and to the presence of dicalcium silicate, the transformation of which formed numerous dust spots, but these troubles were entirely eliminated by the use of the improved clinker. The brick produced from the new clinker were of good mechanical strength, but had high shrinkage, deformed readily, and proved quite inferior in spalling resistance. Another fault was their short firing range, that is, the shortness of the temperature range in which the brick were neither underburned nor overburned.

Unfortunately, the development of new clinker appeared to be in some respects a move in the wrong direction, in so far as brick manufacture is concerned. Although for furnace work a quick-setting material is desired, which will form a hard, impervious mass, the manufacture of brick requires a refractory the particles of which can be bonded together over a long firing range without appreciable shrinkage. For a time it was felt that it might be necessary to develop a different clinker for the manufacture of brick, and much effort was expended in so modifying it as to overcome the difficulties encountered. A large number of mixes were tried, but for a long time no brick were obtained which could be considered commercial possibilities.

Chromic oxide had been tried in early experiments without much encouragement, but subsequently commercial chrome ore was used in larger quantity and it was found that shrinkage decreased with an increase in the proportion of chromite until, at 30 per cent chromite, shrinkage had been almost completely eliminated. This is illustrated by Fig. 4, in which brick Nos. 1, 2, 3 and 4 show a gradual decrease in linear shrinkage from 7.6 to 1.2 per cent, with chromite contents of 0, 15, 25 and 30 per cent, respectively.

It was hoped that the elimination of shrinkage would also improve the resistance of the brick to spalling, but unfortunately such was not the case. A further series of experiments was therefore undertaken with the specific object of increasing spalling resistance through the determination of the optimum grain sizes of the constituents. Success was eventually attained by using coarse chromite and fine clinker.

The physical and chemical composition of some of the experimental brick are shown in Table III, together with their resistance to spalling. In spalling tests each heating

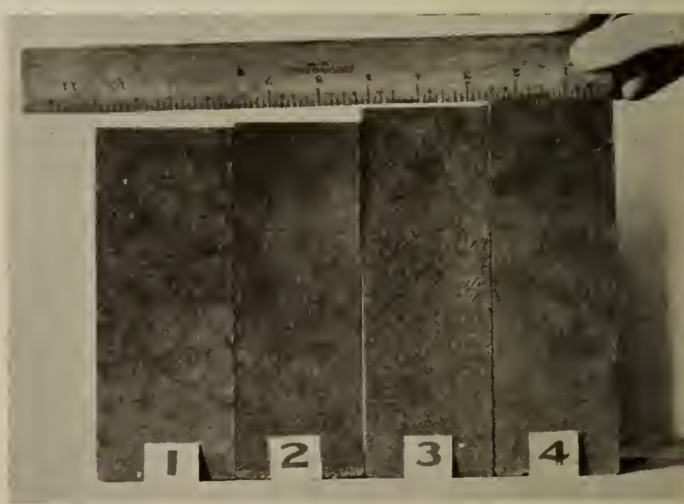

Fig. 4—Brick Showing Decreasing Shrinkage with Increase in Chromite Content from 0 to 30 per cent.

and cooling cycle consists of fifty minutes of heating a brick in the front of a direct-fire gas furnace at 1,200 degrees C., followed by cooling in the laboratory under a current of air from an electric fan for ten minutes, at the end of which time the brick is again heated. It will be noted that ordinary magnesite and chrome brick, as purchased on the open market, spalled in the first cycle, whereas two types of the experimental brick were intact after 30 cycles, when the test was discontinued. It may

*Can. Min. and Met. Bull., April, 1932, pp. 127-161.

be added that early spalling tests were made at 950 degrees C., but in later work the temperature was raised to 1,200 degrees to give the brick a more severe test. One cycle at 1,200 degrees was found equal to 5-10 cycles at the lower temperature. Various stages in the development of spalling resistance are shown in Fig. 5.

Table III
Spalling Tests on Refractory Brick

No.	Constituents	Grain size, meshes per linear inch					Spalling test, number of cycle in which spalling began
		−8 +10	−10 +14	−14 +28	−28 +48	−48	
1	Chromite, per cent	15	15	..	..	..	*30
	Magnesitic clinker, per cent	15	15	10	10	20	
2	Chromite, per cent	..	..	33.3	..	..	24
	Magnesitic clinker, per cent	..	..	..	33.3	33.3	
3	Chromite, per cent	15	15	..	..	..	*30
	Magnesitic clinker, per cent	..	..	17.5	17.5	35	
4	Commercial magnesite brick, burned						1
5	Commercial unburned magnesite brick...						1
6	Commercial chromite brick						1

*Not spalled after 30 cycles.

Following the laboratory tests steps were taken with a view to the commercial manufacture and use of the special type of brick† developed. Brick were made in commercial kilns of different types and were installed for service trial in various metallurgical furnaces. The laboratory results having been confirmed in actual practice, arrangements were made for commercial manufacture, the early trials being carried out under the direction of the laboratory staff. These brick are now on the market in England and it is believed that, because of their unusual spalling resistance and other valuable properties, they will find commercial application in a wide field. Most of the laboratory work and commercial trials have been carried out by J. W. Craig.

Plastic Magnesia

The success of the low-temperature calcination of Grenville rock in the experiments already described, and in particular the easy temperature control, revived interest in the production of plastic magnesia. A review of the situation revealed the fact that although Sorel or oxychloride cement had been made for years from plastic magnesia, magnesium chloride solution and various aggregates, its use had never become very general. Reasons for this were sought and it was concluded that the application of this material had been limited both by the nature of the plastic itself and by the conditions under which it was used.

†Patents applied for in all principal countries in the names of G. M. Carrie, J. W. Craig, A. C. Halferdahl, and F. E. Lathe.

Plastic magnesia is ordinarily produced from magnesite containing a little lime, which is burned at a temperature sufficiently high to decompose practically all the carbonates present, so that the lime is rendered free. This adversely affects the quality of the plastic. Further, plastic magnesia is very hygroscopic, and much of the material on the market has already absorbed sufficient moisture to impair its quality.

It was also observed that, although considerable work had been done on the use of plastic magnesia in oxychloride cement—notably by the Dow Chemical Company—the permanence of the product was by no means assured. Many successful installations had indeed been made, but inexperienced men frequently had failures, with the result that contractors and architects would not, as a rule, specify magnesia composition flooring or stucco.

It was therefore decided to investigate both the production of plastic magnesia and its commercial application.

In work done by the co-operating companies previous to this investigation it had been found impossible to calcine the Grenville rock properly without the production of a considerable quantity of free lime, but with an external combustion chamber, referred to above, this operation proved comparatively easy. The optimum temperature and time of calcination were both determined. The small amount of free lime produced in burning was neutralized by the addition of magnesium sulphate, and thus rendered harmless. No separation of dolomite or serpentine was undertaken, since these remained in the plastic as an inert filler and thus merely replaced aggregate always required for commercial application.

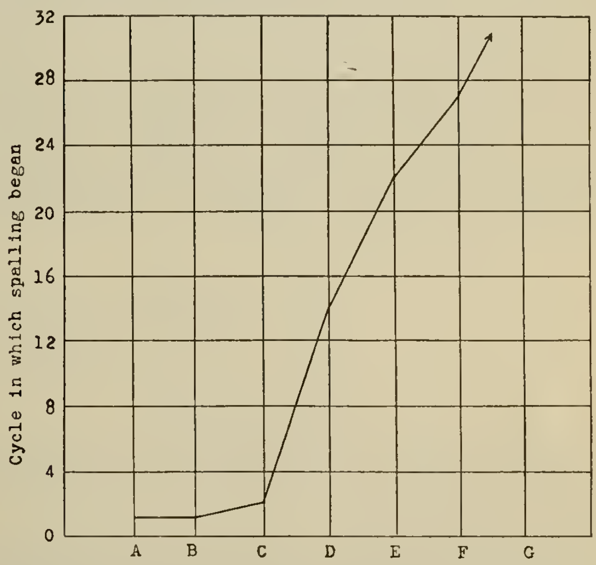

Fig. 5—Stages in the development of Spalling Resistance:
A. Improved clinker, first successful brick.
B. Clinker with chromite addition, reduced shrinkage.
C. Clinker with sized chromite, fine-grained brick.
D. Fine clinker with coarse chromite, low-temperature firing.
E. Fine clinker with coarse chromite, high-temperature firing.
F. Improved grain sizing.
G. Commercially made brick.

The plastic magnesia produced was found to be considerably more active chemically than the ordinary material on the market, due to the lower temperature at which it was made. This resulted in a quicker set, which, however, is not necessarily a disadvantage.

The chief trouble encountered in the use of magnesia cements is volume change. This may be either expansion or contraction, or both. The former is observed when the cement is wet, and is frequently caused by the presence of free lime in the plastic; the latter may be due to the loss of moisture, at low atmospheric humidity, by the cement constituents, notably magnesium chloride and wood flour. As mentioned above, free lime has been neutralized in the Canadian plastic, so that appreciable expansion does not occur. To secure an accelerated test of contraction, all test bars were exposed to a temperature of 40 degrees C. over calcium chloride, conditions much more severe than ever encountered in practice. After a series of experiments extending over a period of several years, shrinkage has been almost eliminated by properly proportioning the constituents and the grain sizes of the aggregates.

In 1929 a trial floor of 20,000 square feet of magnesia composition flooring was laid in the temporary laboratories of the National Research Council, and this installation proved so satisfactory that a floor of 130,000 square feet has been laid in the new National Research Laboratories recently erected at Ottawa. Both the manufacture of the plastic and the laying of the floors were carried out with the close supervision of the Council's staff, under A. F. Gill.

Canadian plastic magnesia has now been on the market for some time and its use for floors is on the increase. Other possible applications are being studied.

Magnesium Bisulphite Liquor

The utilization of magnesian carbonates in the manufacture of sulphite pulp was a problem undertaken jointly by the Forest Products Laboratory of the Department of the Interior and the National Research Council, the former endeavouring to determine the advantages of magnesia in sulphite cooking operations and the latter to work out a method for the production of magnesium bisulphite liquor in towers.

In the Research Council's investigation it was determined that the relative rates of solution of the minerals calcite, dolomite and magnesite in sulphurous acid of a strength commercially used in the paper industry are about as 117:13:1. From this it was obvious that dolomite or magnesite could not be substituted for limestone in ordinary towers without a great increase in tower capacity. Further, if any two of the minerals were present in disseminated form the one having the slower rate of solution might be left in the form of a sludge. That this would occur was easily demonstrated in a small laboratory tower. Attention was therefore directed to methods of increasing the rate of solution of the magnesian carbonates.

Two methods appeared to offer commercial possibilities—calcination and fine grinding. The rates of solution of magnesia and lime produced by low-temperature calcination were demonstrated to be even more rapid than that of limestone. If, by slaking or grinding, the calcine were reduced to a fine state of division, it was obvious that its rate of solution would be so increased by the enormously larger surface area of its particles as to render coarse limestone slowly soluble by comparison. With these facts as a basis a process was worked out in the laboratory whereby magnesia or mixed magnesia and lime slaked with water are added to the top of a tower filled with coarse limestone for the production of a bisulphite liquor containing magnesia in any reasonable proportion. Not only is magnesia in the liquor believed to be advantageous but better control of sulphite acid composition may also be maintained by this process, especially in cold weather.

The process* has been tried commercially by one of the large paper companies and its technical feasibility has been demonstrated.

Results

The direct result of this investigation has been a very gratifying expansion of the magnesian products industry during a particularly difficult period. It is also of interest to note certain indirect results, which from the national point of view are of at least equal value. These include much additional freight for the railroads, increased consumption of Canadian coal, increased exports and decreased imports of refractories, and improved products for the metallurgical and construction industries.

*Canadian Patent No. 291,599, U.S. Patent No. 1,828,690, to D. W. Stewart. See also Pulp and Paper Mag., vol. 26, p. 1013, 1928.

Field Control of Concrete

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Paper presented before the Saint John Branch of The Engineering Institute of Canada, November 24th, 1932.

SUMMARY.—The author describes the method employed for the field control of concrete in the construction of the new pier and quay wall at West Saint John, a work of which a brief general description is given. The paper deals with the classes of concrete used, the tests and methods of grading for the aggregate and the precautions taken in placing, testing and curing the concrete. Reference is also made to the measures taken to ensure satisfactory placing under winter conditions.

This paper deals solely with one feature of the construction of the new pier and quay wall at West Saint John, N.B., namely the field control over mixing and placing of the 85,000 cubic yards of concrete used in the work.

Description of Work

A brief outline of the whole undertaking will enable the reader better to visualize the extent of the project and to understand the necessity for the precautions taken, as described later.

The pier is 700 feet long by 300 feet wide and the quay wall is 858 feet long. The slip on the north side of the pier is 300 feet wide at the bulkhead, and that on the south side is 200 feet, with provision to extend to 300 feet at such time as a future pier is constructed. The depth of water is 35 feet below low water at extreme low tide. The three walls are founded on rock throughout their full length at a depth of 37 feet below low water. The coping level is 32.5 feet above low water.

Due to the fact that it was necessary to remove nearly half a million cubic yards of solid rock, and that wall construction can be done much more cheaply in the dry, it was decided to construct a cofferdam, completely surrounding the pier and quay wall. This cofferdam is 5,900 feet long and encloses an area of 43 acres.

Two steel transit sheds, each 600 feet long by 95 wide, will be constructed on the north and south sides of the pier, served by five tracks between the sheds, and one track between each shed and the wharf face. A transit shed 740 feet long by 95 feet wide will also be constructed on the quay wall and will be served by tracks in a similar manner to the pier.

A million and a half bushel grain elevator has been constructed at the head of the south berth, provision having been made to extend to three million bushels if required in the future. This elevator will receive grain through a car dumping house, and will ship grain over every berth in the West Side Harbour, including the three new berths.

Concrete

After investigations over a period of years into the effect on concrete exposed to the special conditions found locally, a tidal range of the harbour waters of 28 feet at the maximum, together with severe frost action, it was decided that every precaution would have to be taken in the mixing

Fig. 1—View of New Concrete Dock at West Saint John, N.B.

and placing of the concrete in order to ensure that the highest possible resistance was obtained.

Concrete was specified in three classes, according to cement content, as follows:—

No. 1 concrete to contain 658 pounds cement per cubic yard of concrete
No. 2 concrete to contain 564 pounds cement per cubic yard of concrete
No. 3 concrete to contain 470 pounds cement per cubic yard of concrete

The mixtures were as follows:—

No. 1 concrete 1-1.5-2.4 dry rodded
Field mix 1-1.8-2.6 allowing for bulking
Average water 3.6 Imp. gallons per bag of cement

No. 2 concrete 1-1.9-3.1 dry rodded
Field mix 1-2.3-3.4 allowing for bulking
Average water 4.0 Imp. gallons per bag of cement

No. 3 concrete 1-2.3-3.7 dry rodded
Field mix 1-2.7-4.0 allowing for bulking
Average water 4.4 Imp. gallons per bag of cement

No. 1 concrete was used on the face of the walls from low water to coping level, the thickness being 18 inches, and in all arch slabs above low water. No. 2 concrete was used in all other work with the exception of the heavy mass wall in front of the elevator. In this No. 3 concrete was used up to low water level.

The provision of the richer mix on the wall in the tidal range is for density. It is hoped that this dense concrete will prevent or delay disintegration on the face due to frost and salt water action.

Cement

All cement was delivered to the work in 94-pound bags, each car being sampled and tested before shipment. The usual cement tests were made, the C.E.S.A. specification for cement being the standard used.

Aggregates

At the time the contract for this work was let, it was proposed to use sand and gravel from the Bay Shore for concrete aggregates. In order to establish the quality of these materials, samples were sent for testing to the Public Works laboratory at Ottawa. These tests indicated that both sand and gravel were quite satisfactory from the standpoint of cleanness and strength. The following are the results of the strength tests:—

The standard briquette tensile tests on sand showed Bay Shore sand 130.7 per cent of the strength of standard Ottawa sand in seven days, and 123.5 per cent in twenty-eight days.

The standard 2-inch by 4-inch cylinder compressive test showed Bay Shore sand 147.5 per cent of the strength of Ottawa sand in seven days.

It was specified that fine aggregate should be at least equal in strength to Ottawa sand.

Sand and gravel were supplied by the two companies operating at Bay Shore. As it was specified that fine and coarse aggregate should be kept separate on the work, screens were set up on the beach and all sand and gravel passed over these screens before loading the trucks for delivery.

Fine Aggregate

Fine aggregate specifications were as follows:—

Passing ⅜ inch sieve 100 per cent
Passing No. 4 sieve 85 per cent
Passing No. 50 sieve—not more than 30 per cent

The following grading of sand was accepted as being within the specification, and was used as the standard with which all sand delivered to the work was compared:—

⅜ inch	sieve	100 per cent passing*		
No. 4	"	85 to 100 per cent passing	.185	inch
No. 16	"	45 to 80 " "	.046	"
No. 50	"	10 to 20 " "	.0116	"
No. 100	"	0 to 3 " "	.0058	"

At the beginning of the work the sand was obtained from natural clear sand deposits and did not require to be screened. This measured up very well to the above standard. But these deposits were soon worked out and it was necessary to separate the gravel from the sand. It was found when sand and gravel were separated, particularly when working over an area containing a large percentage of fine gravel from ¾ inch down, that a large amount of fine gravel passed through both the ⅜ inch and ¼ inch screens. The result was a very harsh sand, greatly lacking in fines, as shown by the following typical analysis:—

⅜ inch	sieve	100.0	per cent passing*
¼ inch	"	95.4	" "
No. 4	"	90.5	" "
No. 8	"	71.8	" "
No. 16	"	37.8	" "
No. 30	"	11.8	" "
No. 50	"	3.2	" "
No. 100	"	0.1	" "

Fineness modulus 3.85

Fig. 2—View showing Coffer Dam being Removed.

*Mesh sizes according to the Tyler standard screen scales:
No. 4—.185 inch.
No. 8—.093 "
No. 16—.046 "
No. 30—.0232 "
No. 50—.0116 "
No. 100—.0058 "

It was necessary, therefore, to build up a sand with the proper amount of fines to produce a well graded sand. Fortunately a deposit of fine sand was found at low water mark, near one of the screening plants. A sample of this was taken into the laboratory and resulted in the following analysis:—

⅜ inch	sieve	100.0	per cent passing
¼ inch	"	99.8	" "
No. 4	"	99.5	" "
No. 8	"	98.7	" "
No. 16	"	97.2	" "
No. 30	"	94.3	" "
No. 50	"	44.1	" "
No. 100	"	1.0	" "

Fineness modulus 1.65

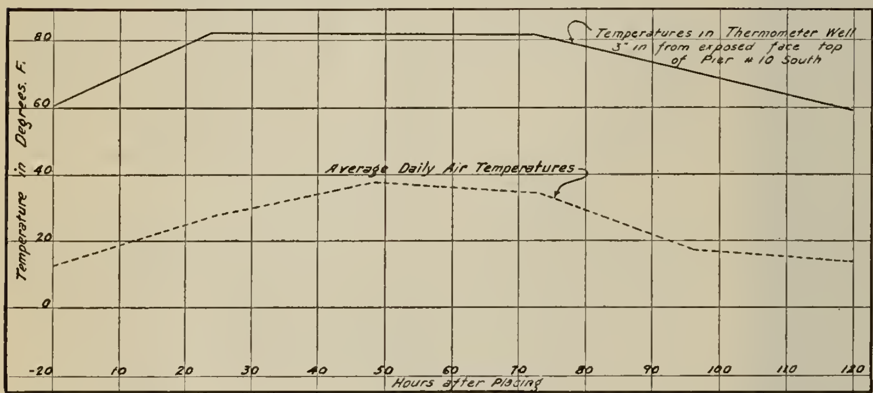

Fig. 3—Chart showing Record of Temperatures of Concrete at Various Hours after Placing. February 10th to 15th, 1932.

It can readily be seen that the deposit contained a large percentage of fines with little or no silt. The particles were sound and clean. With this it was then possible to work out a combination of coarse and fine sand which, when mixed, gave the following result:—

⅜ inch	sieve	100.0	per cent passing
¼ inch	"	96.5	" "
No. 4	"	89.8	" "
No. 8	"	72.7	" "
No. 16	"	47.5	" "
No. 30	"	28.6	" "
No. 50	"	18.2	" "
No. 100	"	1.2	" "

Fineness modulus 3.42
Weight per cubic foot 115 pounds

This grading gave a very satisfactory sand with sufficient fines to make the mix plastic and smooth.

In order to obtain this desirable combination, trucks at the screening plant were loaded with the proper amounts of fines and coarse. This was accomplished by having a stock pile of fine sand at the screening plant and one man detailed to see that the proper amount of fine sand was added in such a way as to have the entire load uniform.

Colour tests were frequently made, particularly when there was a change in location.

Coarse Aggregate

Coarse aggregate specifications were as follows:—

2 inch sieve 100 per cent passing
1 inch sieve 40 to 75 per cent passing
No. 4 sieve—not more than 15 per cent
No. 8 sieve—not more than 5 per cent

The intention was to arrive at an average gravel of which the following analysis is an example:—

2½ inch	sieve	100.0	per cent passing
2 "	"	97.4	" "
1½ "	"	84.0	" "
1 "	"	62.5	" "
¾ "	"	42.5	" "
½ "	"	32.8	" "
⅜ "	"	18.9	" "
¼ "	"	6.9	" "
No. 4	"	0.9	" "
No. 8	"	0.0	" "

Fineness modulus 7.54
Weight per cubic foot 116 pounds

The inspector at the mixer looked after the loading of wheelbarrows and kept as nearly as possible to an average gravel.

An average bulking in the stock pile was found to be about 20 per cent for sand and 7 per cent for gravel, between dry rodded and wet loose.

Measurement

All materials were measured at the mixers by volume. Wheelbarrows were carefully measured and the loading inspector saw that proper quantities were used. In this regard the men loading the wheelbarrows took great interest in judging the amounts necessary, once they understood what was required. Receiving hoppers and buggies were also measured, so that it was possible to check the yield as required.

Just to demonstrate the accuracy of the above method it was possible to check the place measurement figures to within .6 of 1 per cent in 53,000 cubic yards.

The water for each batch was accurately measured in containers, no variation being allowed except by special instructions. It was necessary, of course, to vary the water from time to time if the aggregates were dry or wet, but only sufficient water was used to produce a plastic and workable mixture.

Placing and Curing

The placing of the concrete was under the supervision of inspectors in the forms. These inspectors were required to see that the foundations were properly cleaned, that the forms were in good order, and that the concrete was properly placed and tamped, and were carefully instructed along these lines.

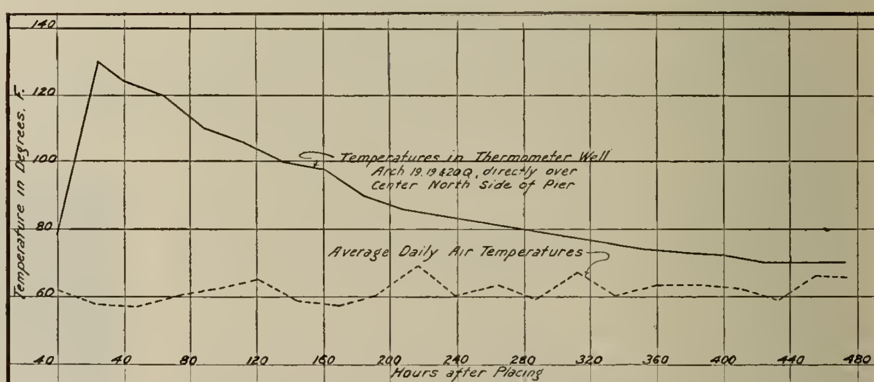

Fig. 4—Chart showing Record of Temperatures of Concrete at Various Hours after Placing. July 16th to August 5th, 1932.

Before placing concrete over concrete previously placed and set up, great care was taken in cleaning the old surface. It was then thoroughly washed down with water and covered with a thin layer of 1 to 2 mortar of the consistency of thick cream, care being taken to work this mortar into the surface of the old concrete. The new con-

TABLE I

CONCRETE COMPRESSION TESTS—NORTH AND SOUTH SIDE OF PIER

Class of Concrete	Cement Bags per cu. yd.	Test No. of Days	Pounds per sq. in.			Average Water Imp.gals.
			Highest	Lowest	Average	
No. 1	7	7	4980	3250	4027	3.6
" 1	7	28	5685	3340	4708	3.6
" 2	6	7	5055	2120	3806	4.0
" 2	6	28	5810	3260	4820	4.0
" 3	5	7	3820	2850	3526	4.4
" 3	5	28	5055	4275	4653	4.4

TABLE II

CONCRETE COMPRESSION TESTS—7 DAYS TO 1 YEAR
Four 6"×12" Cylinders from Same Batch

Class of Concrete	Cement per cu. yd. 94lb. Bags	Imperial gals. per Bag	Pounds per sq. in.			
			7 Days	28 Days	6 Months	1 Year
No. 1	7	3.5	4160	....	6240	6040
" 1	7	3.5	4325	5640	4870	5990
" 2	6	3.7	4910	5265	5870	6610
" 2	6	4.3	4240	4765	5755	6010
" 2	6	4.9	3780	4650	4790	4925
" 2	6	3.7	4165	5260	4800	6320
" 3	5	4.7	3710	4800	6185	6720

crete was then placed. As soon as a section of concrete was placed and sufficiently set, the top surface was carefully scraped and broomed off with wire brushes, in order to remove laitance.

Over-tamping was not permitted, particularly at the face of the forms, as this method has a tendency to bring the fines to the face and would result in a porous, non-wearing surface.

After the forms were removed, the concrete was saturated with water at least twice daily. As a matter of fact it was usually washed down twice in the morning and twice in the afternoon, for a period of not less than seven days.

WINTER CONCRETE

During the winter months, the usual methods of placing concrete under such conditions were followed. The water and sand were heated with live steam, but gravel was only heated when coated with ice, or in a frozen condition. The forms and surface of old concrete were treated with live steam immediately before fresh concrete was placed against them. The usual methods of placing then followed. At the conclusion of each pour, the top of the concrete was covered with tarpaulins under which live steam jets were placed.

The steam and tarpaulins were kept on for a minimum of eighteen hours, depending on the outside temperature.

Temperature charts were maintained throughout the winter. These charts indicated the maximum and minimum outside temperatures each day and night, also the temperature of the concrete as placed in the forms. It was possible to maintain during the winter an average temperature above 50 degrees F. for all concrete as it was placed in the forms.

Thermometer wells made of ¾-inch iron pipe three feet long and sealed with wooden plugs at both ends, were set in freshly placed concrete at various locations. Figures 3 and 4 show record of temperatures taken in this manner.

CONCRETE COMPRESSION AND PERMEABILITY TESTS

Concrete compression tests of 6-inch by 12-inch cylinders were carried on twice weekly or as required from August 1931 to May 1932. A summary of these tests is shown in Tables I and II.

Comparative compression tests were made to ascertain what strength and resistance concrete would have with from one to five days curing and then exposed to frost, to compare with duplicate specimens cured for different periods in the laboratory. The tests were originally made to govern form removal. Forms were allowed to be removed in four days in mild winter weather, but if colder they were kept on for a minimum of five days. Table III demonstrates how tests were made.

Permeability tests were made with specimens of the different classes of concrete. These specimens were made on the work, cured for definite periods and then shipped to Montreal. The results of the tests showed in the majority of cases that under pressures of from 20 to 50 pounds per square inch for from twenty-four to seventy-two hours water did not penetrate the ground surface of the specimen, with the exception that where coarse, poorly graded sand was used water did penetrate to a depth of 1½ inches.

TABLE III

COMPARATIVE COMPRESSION TESTS

No. of cylinder	Class of concrete	Cement per cu. yd. 94-lb. bags	Imperial gals. per bag	No. of days curing then out-of-doors	No. of days curing then room cured	Outside temperatures during test				Pounds per sq. in. 28 days
						Min. temp. 1st 24 hrs.	Highest	Lowest	Average	
1-C }	No. 2	6	4.07	5		24°	58°	0°	29°	4450
2-C }	No. 2	6	4.07		28					3485
3-C }	No. 2	6	3.98	5		41°	58°	−2°	26°	4595
4-C }	No. 2	6	3.98		28					4440
6-C }	No. 1	7	3.54	4		6°	48°	4°	22°	4825
7-C }	No. 1	7	3.54		4					5145
8-C }	No. 2	6	3.97	3		6°	48°	4°	22°	4010
9-C }	No. 2	6	3.97		3					4850
10-C }	No. 2	6	4.00	2		6°	48°	4°	23°	5620
11-C }	No. 2	6	4.00		2					*5145
12-C }	No. 2	6	3.76	1		6°	48°	−4°	24°	3950
13-C }	No. 2	6	3.76		1					4410

*Large pebble in centre of this cylinder after fracture indicated cause of reducing strength.

Dependence for permanence of the structure was not placed on admixtures of waterproofing compounds, but on sound aggregates, properly proportioned, thoroughly mixed, carefully placed and sufficiently cured. The cement content of the mixtures has been such as to give great strength and density.

The following quotation from an article by R. B. Young, M.E.I.C.,* is of interest in this connection:

"Concrete has many enemies in nature, but by far the most important is the combined action of water and frost. One has only to make a tour from north to south, examining concrete along the way, to discover the part that frost plays in the deterioration of concrete. Below the frost belt, even the poorest concrete will give service for years without appreciable deterioration, and only when used in a reinforced concrete structure where corrosion of the embedded steel causes spalling, will its poor quality become conspicuous. One finds many structures in Florida and along the Gulf of Mexico that are ten or more years old and in first class condition, which if north of the Ohio river would, in the same period, have required extensive repairs or replacement."

"It should be remembered in dealing with the action of frost that it is not the freezing of the concrete itself that is harmful, but the freezing of water that is present in the concrete. Dry concrete, no matter what its quality, is not destroyed by alternate freezing and thawing, but let the pores of that concrete be filled with water to such an extent that no space is available to take care of the expansion that inevitably takes place when water changes to ice, and disruption must occur unless the concrete is strong enough to resist the large stresses set up. If one considers that concrete is relatively weak in tension, one sees the reason why, in making concrete resistant to frost action, impermeability is so much more important than strength."

"Prevent the penetration of water into concrete and at once it becomes a building material highly resistant to all ordinary destructive agencies."

From this it can readily be seen why such care was taken to place concrete to withstand its most important enemy, the combined action of water and frost.

The work was under the supervision of Alexander Gray, M.E.I.C., chief engineer and general manager of the Saint John Harbour Commissioners.

The Atlas Construction Co. and Standard Dredging Co., were general contractors, J. C. Horgan, superintendent.

Brodrick Bros., were sub-contractors on excavation.

Chas. Warnock & Co., Montreal, were consultants on laboratory tests.

In conclusion the author would like to express to the inspectors his appreciation of their untiring efforts through fair weather and foul to see that the concrete was properly placed, and to S. B. Beaton, his laboratory assistant, for the efficient manner in which he so ably assisted in compiling records and the making of tests.

*See "More Lessons from Concrete Structures in Service," The Journal of The American Concrete Institute, May 1931.

Construction of La Quiebra Tunnel, Colombia, S.A.

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Paper presented before the Montreal Branch of The Engineering Institute of Canada, November 17th, 1932.

SUMMARY.—The tunnel referred to passes through the central range of the Andes in the Republic of Colombia at an elevation of slightly over 4,000 feet, and has a length of 12,250 feet. The paper gives a general description of the climate and topography of the district, the problems arising in transporting men and equipment and the labour situation as affecting the work of the contractor. Particulars are given as to the construction equipment and the 1,000 kv.-a. hydro-electric plant which it was necessary to construct. The author concludes with a detailed account of the methods adopted in driving the tunnel and in timbering and lining it.

A description of the construction of La Quiebra tunnel in the Republic of Colombia necessitates an explanation first of all of the conditions under which the tunnel had to be built, and of the difficulty of assembling the necessary personnel, equipment, spare parts and materials in time to complete the tunnel in three years in such a remote locality.

The La Quiebra tunnel was driven for the Ferrocarril de Antioquia, or the Antioquian Railway, to connect two previously built portions of the railway which operates between the city of Medellin, capital of the state of Antioquia, and Puerto Berrio, situated on the Magdalena river.

The Republic of Colombia covers an area of approximately 463,000 square miles (slightly larger than the province of Ontario) and lies between latitude 12 degrees 24 minutes north and 4 degrees 17 minutes south. Its northern extremity is about 1,900 nautical miles south of New York city.

The territory was finally conquered by Spain in 1537 and remained under Spanish domination until independence was achieved in 1810-1820, the present Republic of Colombia being established in 1886. It was originally populated by Indians, some of them resembling the Incas of Peru or the Aztecs of Mexico. After the conquest, a great many Spanish migrated to Colombia and negro slaves were imported to the coast regions from Africa. At the present time only about ten per cent of the population is of pure Spanish descent, the great majority being a mixture of Indian and Spanish.

The language spoken throughout the modernized part of the country is Spanish, but many of the higher officials and business men also speak English and French.

The prominent topographical feature of the country is the Andean mountain system, consisting of three ranges running north and south and uniting at the Ecuadorian boundary. These are known as the western, central and eastern Cordillera.

The existence of these ranges affects all conditions of life and commerce in Colombia. Most of the population live in the high country where the climate is superior to that of the coast regions. Transportation is extremely difficult and costly and this has hindered the economic progress of the nation considerably.

The Magdalena is the principal river; it is 1,060 miles long and lies between the eastern and central mountain ranges. It originates in the high table lands south of the city of Bogota and empties into the Caribbean sea at Barranquilla. The next most important is the Cauca, separating the central and western ranges and flowing into the Magdalena about 200 miles up from its mouth. Both rivers for the most part flow through a dense tropical jungle and carry an enormous quantity of silt, also they are infested with crocodiles.

The Cauca is navigable for 3-foot draught, stern paddle wheel vessels of the Mississippi type for about 220 miles from its junction with the Magdalena. The Magdalena is navigated by the same type of boats but with 6-foot draught from its mouth at Barranquilla to

La Dorada—a distance of about 615 miles. Between La Dorada and Beltran the river is too shallow and rapid for boats and a railway connects the two places—a distance of about 77 miles. For the next 57 miles the river is again navigable for small steamers to Girardot. From Girardot there is a narrow gauge railway to Bogota, situated at an elevation of about 8,600 feet.

Practically speaking, the entire commerce of the interior of the country is dependent on the two rivers. In time of severe drought even the smallest river boats have a hard time to get up the Magdalena river as far as Puerto Berrio—about 500 miles—and inbound freight has been known to be tied up at Barranquilla for as long as six months. Even with normal river conditions, shipping freight up river is a question of getting on the good side of company officials and boat captains besides paying the regular river tariff. After all this the importer's troubles may not be at an end as not infrequently the boats run aground and goods, particularly heavy articles, are unloaded on the river bank to be picked up by another steamer weeks or months later. A passenger up the river may get to La Dorada in seven days, or if conditions are adverse, it may take anywhere between ten days to four weeks.

A good aeroplane service operating regularly twice a week both ways has recently been inaugurated. The planes carry mail and passengers but only fourteen pounds of baggage is permitted.

The Republic has spent all the money it could find on transportation without affording much relief. Scattered sections of railroads have been built, enormously expensive because of the steepness of the ground, but no through line has been accomplished. An attempt was made to improve navigation on the Magdalena, but it is obvious that this task is far beyond the resources of the country.

Bogota, the capital of Colombia, has a population of nearly 200,000 and is the largest and most important city.

Medellin, the second city, is the capital of the Department of Antioquia, and has a population of about 80,000. This department covers an area of 24,400 square miles, is a mass of mountains and hills with small valleys in between, and has a population of about 800,000.

Medellin is situated on the western slope of the central range of the Andes mountains at an elevation of about five thousand feet. The climate is almost ideal, the temperature rarely going above 85 degrees and seldom below 70 degrees. The torrential rains of the two rainy seasons per annum (169 inches September 1927-September 1928) include a number of short daily periods of rain instead of continuous days of wet weather. Coffee and gold are the principal exports of the district. The gold is found in the gravel of the river beds which is being extensively mined by the hydraulic method and by dredging.

The city of Medellin is healthy, clean, well paved, has an excellent and plentiful water supply, fairly good electric light and telephone systems and an excellent tramways system.

Access to the city from all points of the compass is by way of the Magdalena river to Puerto Berrio and thence by railway for a distance of 190 kilometres, including the traversing of La Quiebra pass. Previous to the construction of the railroad the only access was across exceedingly rough country on mule or horseback through dense tropical forests for the greater part of the distance.

In 1874, Francisco J. Cisneros, a Cuban engineer and the pioneer railway builder of Antioquia, began the construction of the narrow gauge railway from Puerto Berrio toward Medellin. By 1885, 48 kilometres had been constructed and from that time it has been steadily extended until now there is a through line to Medellin and about 130 kilometres beyond to the banks of the Cauca river. (See Fig. 1.)

The broken and hilly character of the country makes railroading extremely difficult. Grades of slightly over 2 per cent are quite common with a maximum of $4\frac{1}{4}$ per cent. The minimum radius of curve is 71 metres or nearly a $24\frac{1}{2}$ degree curve. The side hill slopes are steep and when the natural surface is broken, landslides are common occurrences, especially in wet weather. The road bed is well kept. The gauge is 36 inches with 60-pound rails, the track is rock ballasted and native hardwoods are used for ties.

Leaving Puerto Berrio, the railway follows the valley of the Malena river, then crosses a divide with a grade of about 4 per cent into the Nus valley. At the upper end of the Nus valley, however, the main divide between the Magdalena and Cauca watersheds proved an insuperable obstacle. Construction of the eastern portion of the line was stopped for some years while the western section from the divide to Medellin was built. The gap at the divide was diminished until between the two terminals of the railway there remained about $2\frac{1}{2}$ miles—horizontal distance—and the top of the pass was about 1,350 feet in elevation above the temporary railroad terminals.

Fig. 1—Map of Republic of Colombia (Railways and Automobile Roads indicated).

As a temporary expedient to overcome the difficulty, a rough wagon road was first built over the La Quiebra pass and over this road all passengers and freight were hauled. Later, a motor highway was built connecting the two terminals and this road, cut into the side of the mountain and surfaced with oil bound macadam, is well built. It is 11 kilometres in length with a ruling grade of about 6 per cent and many exceedingly sharp curves.

Passengers were transported between the terminals by automobiles and buses while heavy trucks were employed to transport freight. The charge for freight was two dollars per ton without insurance.

With the advent of the railway the interior developed rapidly and by 1926 it was found that freight traffic had

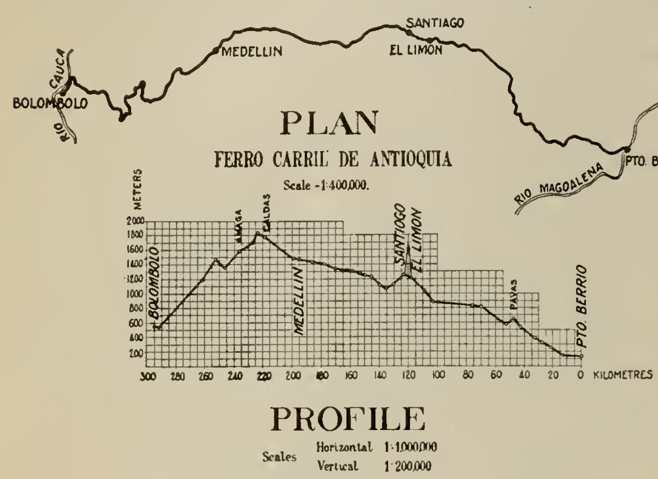

Fig. 2.

increased so much—from 60,841 tons in 1920 to 131,625 tons in 1926—that the tunnel under the La Quiebra pass became imperative.

The author first became acquainted with the possibilities of a tunnel there in 1923 when the Ferrocarril started an active discussion of costs, hoping to get the work done for about a million dollars.

In August 1926 the Ferrocarril de Antioquia awarded to the author's company the contract for driving a tunnel under the La Quiebra pass, a distance of 3,740 metres or 12,250 feet, to connect the then existing railway terminals of El Limon and Santiago.

Construction Equipment

The length of time required to obtain construction equipment was the first and one of the serious problems of the contract. Owing to the enormous freight charges between Montreal or New York and the site of the work, it was impossible to consider returning the plant to North America. For this reason all equipment was purchased new at the cost of the Ferrocarril and it remained in Antioquia at the completion of the work.

The work was started with no other equipment than picks and shovels and two-foot gauge industrial cars and track borrowed from the railway. These were supplemented after a couple of months by two gasoline-driven air compressors and a few jack-hammer drills.

The equipment eventually purchased included blowers, cars, compressors, crushing plant, derricks and hoists, drills, engines, generators and motors, hydro-electric plant, ice plant, locomotives, machine shop equipment, mixers, muckers, pumps, and saw mill equipment.

The storage battery locomotives as used in the tunnel for hauling the cars are a great improvement over the mule but they are fairly expensive. In a country where mules are, or were at the time, very expensive, and where it developed they were trained only to carry and not to pull, some mechanical means for hauling the cars was a necessity. In such a small bore tunnel of considerable length, gasoline locomotives were out of the question due to the fumes. The author is not prepared to argue that those selected are better than trolley locomotives but in this instance they had the advantage of being able to run out on the main line railroad tracks which were 36-inch gauge, the same as the tunnel equipment.

Small power-shovels known as mucking machines were used, as these can be operated in a very narrow tunnel due to the fact that they do not revolve but discharge their buckets into a conveyor mounted on the rear of the shovel and this conveyor dumps the spoil into tunnel cars attached temporarily, one at a time, to the rear end of the shovels. This car when loaded had to be removed by the locomotive and an empty car raised by an air lift trolley was swung into position behind the shovel. The bucket can be swung only very slightly to the right or left and it is forced into the muck face only by means of the tractive power of the shovel itself. The shovel operates on 36-inch gauge track which had to be laid down in front of it in short sections. It is equipped with a single 50-h.p. motor which operates the bucket, the conveyor and the traction wheels.

The use of the mucking machines speeded up the removal of muck to such an extent that it was possible to use horizontal or lifting holes right down to subgrade with consequent great saving in excess excavation below subgrade. The performance of a mucking machine at La Quiebra amounted to the loading of about 120 cubic yards of loose rock in approximately eight hours. Only one mucking machine operated at a time in each heading but it broke down sometimes and had to be replaced by the spare shovel.

At La Quiebra gelatine dynamite was used and when shooting the full face of the tunnel in hard rock, seven successive rounds were fired all of which were actuated by a single flash of electric current. To use the delay fuses successfully in this manner required very careful work in the drilling and loading of the holes.

The decision to purchase expensive mucking machines for use in a country where hand labour is traditionally cheap was reached after a long consideration of all the factors. In the first place the wage of common labour, due to the large expenditure for public works which were proceeding at that time, had been increased to the sum of approximately 1.20 pesos per shift (peso equals about 97⅓ cents U.S.), but in addition to this

Fig. 3—Mucking Machine.

rate the men were allowed seven days' pay for six days' work provided they had not been absent during six successive days. They were also allowed a daily ration for sustenance at a cost of about twenty cents per man per day and this represented a certain loss to the railway company. Allowance was also made for paying the men on certain feast days so that virtually the price of common labour in the tunnel was about 2 pesos per day of ten hours. Further, the native labourers are not efficient in mucking out a tunnel and it is certain that the mucking could never have been completed on time even if the hand mucking had been economical from the point of view of cost per cubic yard. The mucking machines cost about $8,000 each and they required foreign operators. As will be explained elsewhere, the importation of each foreign employee represented an expenditure of about a thousand dollars in addition to paying his high rate of wages and travelling time.

The contractors introduced the first sawmill into the Department of Antioquia and possibly the first in the Republic of Colombia. Previous to this date, all lumber had been sawn by hand, a saw pit being used with two men operating the saw. Wood is expensive by reason of the enormous cost of getting it out, and though the extent of the forests is very impressive only one tree in several acres is worth cutting for the production of lumber. The result is that the common method of obtaining timber is to send gangs into the forests, cut down these choice trees and carry out the logs on the backs of mules. For transportation by mule back the pieces must be cut very short. As an example of the great cost of this method it may be noted that the Ferrocarril was paying 1.80 pesos each for ties for its 36-inch gauge track. These ties, of course, were of the best species of wood, known as "comino." Comino ties laid in the track twenty years ago are still sound. The wood is rather a striking yellow colour and is readily workable. The shavings look like pure gold and for interior work the wood is readily polished and presents a beautiful finish. In the appendix is a report on local woods prepared by Mr. Martin F. O'Day.

The cost of logs at the outset of the work was about 180 pesos per thousand feet b.m., but this was later reduced to about 80 pesos. The cost of the small scraps of wood used universally for cooking worked out to about 60 pesos per cord.

The stone crushing plant installed for the tunnel and erected near the El Limon portal was regarded as a piece of permanent railroad equipment. Previously, the Ferrocarril de Antioquia had drilled all its quarries by hand and had broken the stone with hand hammers. The quarries were served by very small steel side dump V-cars running on 24-inch gauge industrial track; the cars and track were of European manufacture. The plant as erected had no novel features from the point of view of North American engineers.

An outstanding feature of the job was the installation of a small ice machine and cold storage room, ice being a real luxury. Throughout most of Colombia fresh meats are consumed on the day of the killing and ice where obtainable is used in beverages only.

For every article of equipment, a long list of spare parts was imported along with the machine. The consideration and selection of this list was a very important item in the management of the work.

Combining the problems of motive power for driving the tunnel and the possibility of the use of electric locomotives in the operation, it was decided to construct a small hydro-electric development at the El Limon portal, developing sufficient power for the driving of both headings; but because of the length of time required for the investigation, design and construction of the hydro-electric plant, it was decided to install for the beginning of tunnelling operations, Diesel engines of sufficient capacity to operate two-thirds of the entire compressor capacity. Oil engines were selected because of the availability of fuel oil which was obtainable from the refinery of the Tropical Oil Company situated at Barranca Bermeja about eighty miles down stream from Puerto Berrio on the Magdalena river.

Small temporary generators also had to be installed to serve until the hydro-electric plant was finished. This electrical equipment was all installed at the El Limon portal but furnished power for both portals, a light steel pole transmission line (6,600 volts) having been constructed across the pass. This installation was barely large enough to permit operation of the mucking machines and the charging of locomotive batteries before the completion of the hydro-development.

This provision of small generators with oil engines as well as engines for the compressors will appear to be a duplication of construction equipment requirements but they were installed as the oil engines and small generators would not only serve as spares to the hydro-electric equipment during part of the tunnel construction, but later would serve a useful purpose in the railway shops a short distance outside of the city of Medellin.

The feasibility of operating steam locomotives through the tunnel had been studied previously. During the earliest operation of the eastern end of the railway, wood fuel had been used, but for many years the locomotives on the Porce or western division of the railway burned coal which was mined at a point about 20 kilometres west of the city of Medellin. Soon after the development of the Colombian oil fields the locomotives on the Nus or eastern section of the railway were equipped to burn oil instead of wood. It was finally concluded that these oil burning locomotives could safely be operated through the tunnel until such time as the growth of traffic would develop a ventilation problem serious enough to justify the expense of installing electrical operation for the tunnel.

Chorrera Hydro-Electric Development

The decision to construct a hydro-electric development was reached in the fall of 1926. This was based on a very meagre survey and the information supplemented by a personal inspection of the site of the dam and the proposed location of the low pressure pipe, penstock, surge tank and power house.*

The Department of Antioquia abounds in small hydro-electric sites and with an annual rainfall of over 160 inches, with high mountains and steep valleys, conditions are ideal for impulse wheel developments. These developments are mainly useful for small operations such

Fig. 4—Downstream View of Dam on Chorrera River.

as mining, and for the lighting of small towns and villages. If, however, a large prime power requirement is to be taken care of, the selection of a site is quite difficult. The valleys are so steep that seasonal storage is virtually out of the question as a dam one hundred feet high will flood only a

*The plant is described in an article published in "The Canadian Engineer" in its issue of May 14, 1929. This article was prepared by Mr. L. A. Osterhoudt, resident engineer on construction of the plant.

small acreage and there occur low water months with a rainfall of only 19/100ths of an inch.

The requirements at La Quiebra were severe because prime power was a necessity both for the construction work and for the requirements of the Ferrocarril de Antioquia in the way of village lighting and for the future electrical operation of the tunnel. The stream selected for the development was the Chorrera, the water falling

Fig. 5—View of Chorrera Falls and Penstock from El Limon.

over a cliff and sliding down a steep granite face for a height of four or five hundred feet.

The Chorrera is one of the principal tributaries of the Nus river and flows directly past the El Limon portal. A suitable dam site was soon found within a mile of the portal giving an available head of 1,380 feet. Above this site there is a short flat section of the valley of about 6 acres, so that by constructing a dam 9 metres high and 35 metres long, it was possible to impound about 30 acre feet of available storage.

The main features of the development were decided upon in advance of any gauge readings but a weir was constructed which showed that at the end of a seven months dry season a minimum flow of about 7 second feet was available. The average flow over a year was about 17 second feet. A storm amounting to almost a cloud-burst occurred after construction of the dam, resulting in a flow of more than 2,000 cubic feet per second for about half an hour. The dam contained only about 700 cubic yards of concrete. The penstock consisted of a low pressure section starting at the dam and extending for 438 metres along the mountain-side following the line of an old miner's canal which had a capacity of about 2 feet per second. The grade of the old canal, about 1 per cent, was suitable for the low pressure pipe line. The pipe line, however, is carried on trestles built of old railroad rails across two ravines while the old canal worked its way around the ravines with considerable additional length and curvature. This low pressure pipe had a diameter of about 18 inches but this was varied sufficiently to permit the nesting of the pipe so that three lengths occupied the space of one and accomplished a saving in ocean freight. Loose flanges for the joints were also adopted for this reason. The surge tank was constructed at the top of a steep grade. It is built of reinforced concrete, is 8 metres high and is 2.9 metres inside diameter. The high pressure penstock descends the steep slope of the hillside for a distance of 1,090 metres measured along the slope and finally crosses the head waters of the Nus river immediately adjacent to the El Limon portal where the rubble masonry power station was built.

The construction of the high pressure pipe line was the most difficult feature of the hydro-electric development. The pipe, beginning at the surge tank, had a diameter of 450 millimetres for one third of the distance down the slope, the middle third was 400 millimetres and the bottom third 350 millimetres. The thickness increased gradually from 5 millimetres at the top to 12 millimetres at the bottom of the hill. The flange joints were riveted on by the manufacturer. In order to maintain a uniform temperature in the pipe and thus avoid the use of expansion joints, the pipe was buried in a trench about 3 feet deep which was backfilled with earth. Masonry anchorages were built along the line at all angle points and at other places where necessary. An automatic butterfly valve was installed in the high pressure line just below the surge tank. This valve closes when for any reason the velocity of the water in the pipe rises above maximum demand. The water pressure acts upon a lever or scoop extending into the pipe and moves it enough to trip a heavy weight which closes the valve. Operation of the valve is automatic, manual, or by electric circuit from the power house.

The penstock line crossing of the River Nus was accomplished by constructing heavy masonry piers in and on both sides of the stream. The discharge from the power house returns directly to the stream below the power house. The discharge of an impulse wheel is entirely free, with no draught tube problems, but it involves a waste of perhaps 15 feet of head. This is immaterial in the case of developments with heads of hundreds of feet. In spite of quite elaborate inspection, the pipe proved to be somewhat brittle at the longitudinal welds with the result that breaks occurred in the rough handling of pipe into position in the line, and several occurred in the early operation of the plant. Fortunately, a few extra lengths of each size of pipe had been ordered, and by using a welding outfit on the job, repairs and substitutions were accomplished without serious delay. During construction this pipe was reinforced by steel bands made on the site.

The Pelton wheels were two in number, each designed to develop 600 h.p. at a head of 420 metres or 1,380 feet.

The generators for the Chorrera development consisted of two 500-kv.-a. direct-connected generators, each with direct connected exciter. These operated at 900 r.p.m. and generated power at 480 volts.

The power house is situated directly adjacent to the El Limon portal. For the purpose of transmitting power to Santiago portal and subsequently to the town of Santiago, a transmission line 4½ kilometres long, on steel poles, was built over the pass. The current was stepped up to 6,600 volts through a bank of three 150 kv.-a. transformers in an outdoor sub-station near the power house. It was afterwards stepped down to 480 volts through a similar bank of transformers at Santiago. The steel poles of the transmission line were 30 feet high with angle cross arms and pin type insulators. At the ends and at the strain points, strain insulators were employed.

The automatic oil regulating governors operate a needle valve which will shut off the flow in the penstock in about forty-five seconds when a reduction of load occurs; but there is another governing feature of the units which acts more quickly; it merely diverts the jet, or part of it, away from the buckets and this type is generally in use in Antioquia without the needle valve—the waste of water being less serious than a shock to the penstock.

From the placing of the first order for equipment until the hydro plant was actually in operation, was a period of eleven months. This is not unduly long when it is considered that the first equipment to arrive was received six months after the placing of the order. The remoteness of the work, as already stated, constituted the chief difficulty. Errors in shipments and breakage in handling during transportation and damage by wetting necessitated numerous expedients and hurry-up shipments before the plant could be put into permanent operation. Four lengths of the high pressure pipe line were lost in transit, one being dropped overboard during unloading from the ship at Puerto Colombia while the other three lengths just mysteriously vanished.

The materials and supplies necessary for constructing the dam and intake structure were mostly carried on mule-back over trails which took off from the motor highway in the vicinity of the portal. The heavy pipe sections were hauled up the slope on a narrow gauge track by means of flexible wire cables operated by gasoline hoists mounted on the steep slope of the penstock location. The 9-metre length of the high pressure pipe line was adopted to reduce the number of joints, as these were the most expensive feature of the line. This resulted in the heaviest section of pipe weighing about a ton and a quarter—which proved quite heavy enough in view of the means by which it had to be handled. The slopes of the high pressure penstock line averaged 41.8 per cent with a maximum of 69.5 per cent.

Surveys and design for the plant were started in November 1926. The equipment was all ordered by March 1927 and began to arrive on the site in September 1927. Construction of dam was started in August 1927 and the plant was in operation in January 1928.

Personnel

The locating of satisfactory personnel for the execution of the contract proved to be a difficult problem. The contractors were a Canadian corporation, but it developed that no practical tunnel men could be hired in Canada. Office organization, general foremen and mechanics were sent from Canada but the tunnel men were nearly all from the United States. The conditions of employment were set forth in a contract which provided:

That Fraser, Brace, Limited was the employing agent for the Junta Directiva of the Ferrocarril de Antioquia.

That a fixed salary would be paid per month beginning from the date of sailing from New York, San Francisco or New Orleans.

That an allowance of $450 would be paid for travelling expenses to the work, to include cost of passport, physical examination, vaccination and visa of passport.

That should the man's services be satisfactory and should he remain on the work for two years or until his services were no longer required he would receive (*a*) a bonus of $50 per month for his time on the job, (*b*) an allowance of three weeks' salary for time of returning home and (*c*) an allowance of $425 for return travelling expenses.

That, if his services proved to be not satisfactory for any reason or for the immoderate use of alcohol, the employer might cancel the contract at any time and pay none of the allowances provided for above in respect to the termination of employment.

That the employee agree to appeal only to the laws of Colombia in the event of injury or damage claims of any kind.

The contractor carried a special insurance policy for the compensation in gold of all important foreign employees in case of death or injury while on the work. The premium on this policy was paid as part of the cost of the contract.

The wages and salaries paid to the contract men were about 50 per cent above their home rates.

About eighty-seven men from North America were sent down for purposes of the contract. In addition to this about fifty foreigners or non-Colombians showed up at the site asking for employment and were put to work, but they did not sign the special contract above referred to.

The finding of satisfactory miners or tunnel men was always a problem throughout the contract period, particularly because the men had to have experience in both hard and soft ground tunnelling.

In the early stages of the work an attempt was made to have one heading foreman operate four drills with the help of eight Colombians. The Colombians proved so slow at learning, however, that it became necessary to put two foreign miners on four machines. The mucking machines operated on the average two shifts per day and as understudies had to be provided, this meant that two operators and two understudies had to be available at each end of the tunnel. The supply of miners, mechanics, electricians, etc., had to be kept above the net requirements at all times in order that the progress of the work could be maintained on schedule in spite of occasional absences or loss of personnel. Construction work was booming in both United States and Canada during the years when the tunnel was constructed and this increased the difficulty of finding satisfactory men to go so far from home.

The cost of travelling expenses for importing foreign help was over $85,000.

The turnover in native labour was high, because at the rate of wages paid a man soon accumulated so much money that he had to stop work in order to spend it.

The Sunday and feast day wages paid, that is, wages paid for days when the men did not actually work, amounted to nearly 128,000 pesos for the job.

At the time that three eight-hour shifts were adopted, that is—about December 1928—a bonus payable to all the heading men, mucking crews and mechanical forces was given for all footage over 75 feet of tunnel per week. This bonus system had a great moral effect and the footage was increased considerably.

Tunnel Driving

The contract was on the cost plus fixed fee basis and there were penalty and bonus clauses for completion of the work within the agreed estimate and within the contract time. However, the cost of lining the tunnel was not included in this fixed estimate as it was quite impossible to guess in advance how much of the tunnel would require masonry lining. A substantial bonus was earned in each case, the cost of driving the tunnel being below the estimate and the work being accomplished three weeks ahead of the stated contract date, which was September 1st, 1929. The contract included the designing of the tunnel and the lining, nothing but the alignment and gradient having been determined before the contract was let. The contractor was responsible during construction for alignment work and grades also.

Borings taken previous to construction of the tunnel were not located exactly on the line of the tunnel and the percentage of cores recovered was rather small. It was evident that the tunnel was diorite rock throughout most of its length but it was known that this rock had been badly shattered and decomposed so that it was a question as to how much of the tunnel would require lining. As the work developed, it proved that the quantity of soft and broken rock encountered was sufficient to greatly hamper the progress of the work, necessitating timbering in the soft rock and requiring a radical change in the driving programme each time that the material in the face changed from hard to soft. Approximately 45 per cent of the length of the tunnel had to be lined with masonry and a large part of this had to be supported temporarily with timber frames close up to the face of the tunnel pending the construction of masonry. Much of this timber was rotten by the time the masonry lining caught up to it, although it was difficult to drive nails into it during erection.

El Limon, the eastern portal of the tunnel, is at an elevation of 1,220 metres or 4,002 feet. Santiago, the western portal, is at elevation 1,259 metres or 4,129 feet. The distance between portals is 3,740 metres or 12,275.6 feet. To facilitate drainage during construction, the tunnel was run on a 0.25 per cent grade up from the Santiago portal for 1,626 metres and there was an upgrade of 2 per cent from the El Limon portal. (See Fig. 6.)

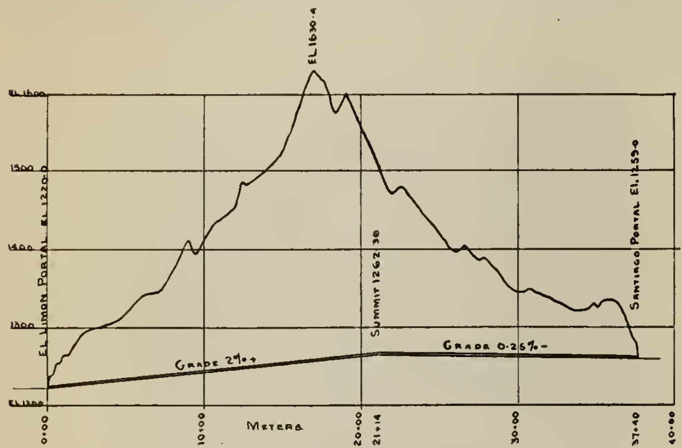

Fig. 6—Profile of Tunnel.

The dimensions of the tunnel correspond to the bridge clearance of the Ferrocarril de Antioquia. The distance from subgrade to spring line is 10 feet 6 inches and the radius of the arch 6 feet 6¾ inches, giving a 13-foot 1½-inch by 17-foot ¾-inch cross section. Where timbering and lining were necessary the width was increased by 5 feet 1 inch to allow for 3 inches of lagging and 10-inch by 10-inch postings and 18 inches of tunnel lining.

From sub-grade to spring line the lining was rubble masonry set in cement mortar, while the arch was of concrete. The reason for adopting this dual method was due to the inexpensive rubble masonry work done by the local masons, who place many spalls in the mortar and thus save cement. With cement costing 12 pesos per barrel this was important, also as the method required no forms the building up of the walls could be done without serious interference to the driving operations.

Conditions favoured starting the El Limon approach first and a start was made at this end on September 13th.

At Santiago, where work was started on November 10th, portal conditions were more complicated as it was necessary first to shift the location of a railway bridge which interfered with the disposal tracks from the tunnel, divert a small stream which cut across the mouth of the tunnel, take out a large side hill cut in front of the station to get in a disposal track and cut through the nose of a projecting hill to reach the dump.

The tunnel was driven 2,056 metres from El Limon, until the headings met on July 12th, 1929, having maintained an average speed of 14.96 metres per week.

The tunnel was driven from Santiago, a distance of 1,685 metres, making an average progress of 15.44 metres per week.

The best week's driving from El Limon was 35.4 metres, while the best month was 123½ metres; the best week's driving from Santiago was 32.4 metres and the best month was 102.4 metres.

The first equipment to be received was put to work at the El Limon portal and the work at that end was organized and running completely before the Santiago end was given serious attention.

At El Limon portal the rock appeared to be perfectly sound granite, but it was found that it could be dug out with pick and shovel for a short distance from the portal, then for some distance the top heading was driven by means of jack-hammer drills with gasoline-driven air compressors while the muck was removed in the small V dump cars running on the portable 24-inch gauge track. Progress was slow until the arrival of the large compressors and oil engines in the latter part of March 1927. The first two mucking machines arrived in April 1927 and one was put to work at the El Limon end toward the end of the month.

When the ground was hard enough to stand without timbering the organization of driving was pushed more vigorously. In December 1927 the change from one foreign miner in the heading to two foreign miners was made and three shifts of eight hours each instead of two shifts of ten hours each were organized. Driving progress improved during the continuance of hard ground; when the ground changed to soft there was always a loss of speed. The storage battery locomotives arrived and began work at El Limon in June 1927. The hydro-electric plant began operating in January 1928, and from then on there was sufficient power to run three compressors simultaneously at each end of the tunnel, also to operate the mucking machine in both headings simultaneously, and at any time during the twenty-four hours.

The ground first encountered at Santiago was hard, but the top heading and bench method was used for the first 410 metres. Soft ground was encountered about 600 metres from the portal and continued for about 600 metres. Thereafter two other short sections required timber.

The full face method adopted at El Limon and in the later part at Santiago in the hard ground, was to carry on the drilling from a horizontal bar jacked against the walls of the tunnel. The first position of the bar was above the springing line and from this position twenty-six holes were drilled including the cut holes which sloped downward. The second position of the bar was two or three feet above sub-grade and from this position about twenty holes were drilled including the cut holes sloping upward to intersect at the bottom of the cut holes drilled from the upper position. This method of drilling the bench or bottom of the tunnel with horizontal holes drilled from the tunnel bar is quite unusual. It was adopted at La Quiebra for several reasons— (*a*) The height of the tunnel, namely 17.06 feet, is greater then the width and for this reason a greater swing could be given to a vertical cut than would have been the case if the ordinary horizontal cut method had been used. (*b*) The use of the mucking machines removed the muck so quickly that there was ample time to set up the bar in the lower position and drill the last twenty holes of the round from that position after the removal of all the muck. The efficiency of this method is demonstrated by the fact that it was possible to drill, shoot and muck out two complete rounds pulling about from 7 to 9 feet each within a period of twenty-four hours. (*c*) The horizontal holes at the bottom of the tunnel broke the ground much more accurately to the correct line of sub-grade than was possible with vertical holes drilled from the top of the bench.

Four drills were used on the bar in each position but it was necessary to use an arm on the bar in the upper position in order to reach the top round of drill holes.

The success of the method was demonstrated by the small amount of trimming that had to be done after the tunnel was driven and it is considered that the method was also economical in the use of dynamite.

The sequence of tunnel operations in driving the full face was as follows:

After blasting, the ventilating fans were set to draw out the fumes through a 16-inch galvanized steel pipe; after about twenty minutes had elapsed the heading foreman and two men went to the heading to see that

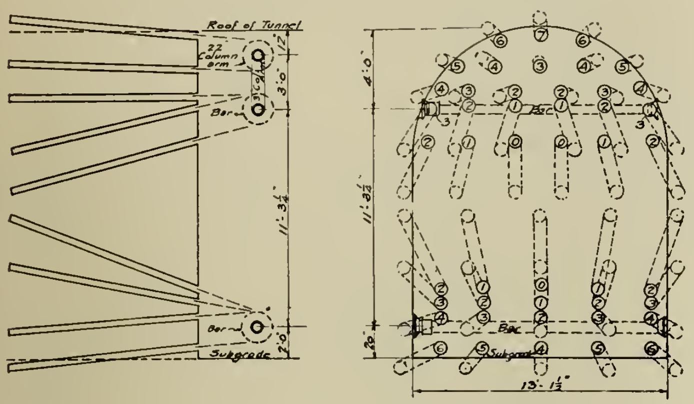

Fig. 7—Typical Full Face Round using Hammer Cut.

all shots had been exploded. If there had been any misfires or burnt holes these were loaded and fired. Meanwhile the blowers continued to draw out the foul air for another thirty minutes. After this the ventilating system was reversed and fresh air blown into the tunnel until conditions were safe for men to work — a gang of muckers then threw back all loose rock that might be piled up above the spring line, after which jack-hammer holes were drilled in the side walls 9 feet centre to centre at a little above the spring line to hold steel pins which supported a 3-inch plank staging. From this staging the barring down of all loose rock could be done and it also formed a platform on which the drillers could stand while drilling the upper twenty-six holes in the full face.

Thus while the muckers were operating on the subgrade level, drilling was being carried on in the upper portion of the tunnel heading. The drills used for this purpose were mounted on a 4½-inch bar or jack column 13 feet long, which was placed horizontally and jacked tight against the sides of the tunnel.

In a balanced round, it was found that the shovel would just about finish the mucking by the time the drillers finished the drilling of the upper holes. If it became unbalanced the drillers were usually ahead of the shovels. In the next move the drillers shifted the bar to the lower level and drilled the remaining twenty holes in the face.

Figure 7 shows the location and direction of holes, the position of the 4½-inch jack crossbars for supporting the drills, while the numbers indicate the sequence in which the holes were fired.

In hard ground the length of cut was from 7 to 10 feet. About 3.75 pounds of 60 per cent dynamite was used per cubic yard of tunnel excavation.

The pins in the side walls of the tunnel from which the platform was suspended were later used to support the blasting line on one side and the electric light and power line and ventilation pipe on the other.

In general the top heading and bench method was used wherever soft ground was encountered. In some cases, however, it was possible in moderately soft ground to continue the full face.

In soft ground the cut holes were shortened so that the violence of the blasting was reduced and it was found possible to excavate 15 or 20 feet of the full tunnel and then set up three or four sets of timber at one operation. This method was slower than progress accomplished in hard rock but it was much faster than the method which had to be adopted when the rock was so soft that timber had to be kept within a few feet of the face. In this latter case, the top heading only was carried forward and segmented timbers were set nesting on the wall plate at the springing line of the arch; then the bench was blasted out by means of short vertical holes and the wall plates were underpinned with the regular vertical posts placed one at a time as the removal of the bench permitted. This operation was, of course, very slow, but fortunately it was not required except for short sections.

Due to the shortage of equipment and power in the early months of the work, it was possible to drive only a top heading at the Santiago side in spite of the fact that the ground was hard enough to stand without timbering. In this case, the top heading was started on June 11th, 1927, and the bench was started on September 17th, 1927; but the mucking machine and electric locomotives were not available at this end until December 12th, 1927. The bench excavation went very fast after the installation of the mucking machine and overtook the heading at a distance of 454 metres from the portal on March 10th, 1928. From then on, although soft ground was encountered on April 21st, 1928, it was possible to carry the full face method most of the way to the junction of the two headings.

During the rapid excavation of the bench in overtaking the Santiago heading, the bench was drilled with horizontal lifting holes of great length, the drills in this way being able to break ground up to the full capacity of the mucking machines.

Where required, timbers were erected on 5-foot centres and the 3-inch lagging above the segments was wedged tightly against the roof. Close lagging was required in only a few places. In many cases the rock in the roof appeared quite firm for a few days after the shooting and the loosening of the roof was apparently due to some action of the atmosphere. There was no crushing of timbers or any evidence to indicate that heavy rock

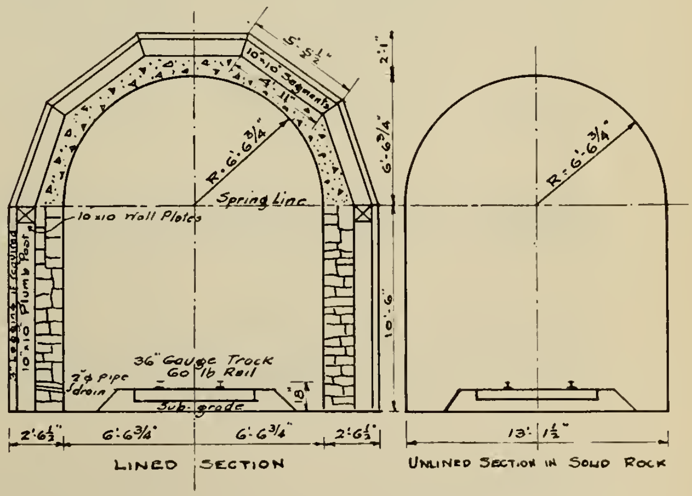

Fig. 8—Tunnel Sections without Line of Timber Sets used in Soft Ground for Concrete.

pressures were encountered or developed. A total of 3,550 linear feet of tunnel was lined with timber. No attempt was made to shut off the flow of water encountered in the tunnel driving — weep holes were provided in the masonry to permit its passage. The volume of water is not sufficient to give any trouble on the operation of the tunnel.

The storage battery locomotives in the tunnel handled five empty two-cubic-yard mine cars up a 2 per cent grade at eight miles or less per hour. Passing sidings were laid at convenient locations inside the tunnel at points where there was no lining.

Between portals there was a total of 144,566 cubic yards of rock excavation in the tunnel, of which 18,700 cubic yards was excess due to lining.

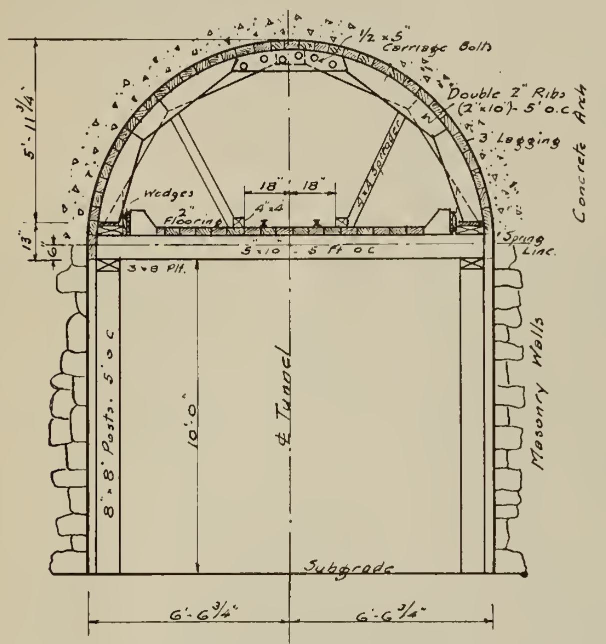

Fig. 9—Tunnel Form used in Pouring Concrete Arch.

The rock excavated from the tunnel was dumped over high banks close to the portals. Tunnel rock, of course, was used for rubble side walls and for the aggregate of the concrete roof. Both rubble and crushed stone were shipped out on the railway to many points and it is probable that all the spoil will be recovered and made use of in a few years.

Tunnel Lining

Where lining was necessary the masonry walls were carried up to the spring line as soon as the heading had progressed far enough ahead so as not to interfere, usually several hundred feet. The concrete arch was placed much later. Figure 9 shows the type of form adopted, which is of the usual wood construction. At El Limon the concrete was mixed outside the portal in a ½-yard mixer and dumped into a skip box placed on a flat car and pushed in by a locomotive. A hoist installed where the concreting was to be done lifted the skip through the platform onto a small flat car on the concrete form and pushed to where it was required. The concrete was then shovelled into the forms and thoroughly tamped.

The arch forms were made up in groups of 12 arch ribs enough for 55 linear feet of arch. The staging was erected in lengths of 150 feet. At Santiago the concrete was mixed on the floor level of the tunnel and was blown into the arch by a pneumatic machine made on the job.

5,619 linear feet of tunnel, or 45.8 per cent, was lined with masonry. Altogether there was placed 10,846 cubic yards of masonry in the walls and 6,304 cubic yards of concrete arch.

The job was officially turned over to the Ferrocarril de Antioquia on September 1st, 1929.

APPENDIX

Commercial Woods Found in the Nus Valley

Sample Number	Common Name	Specific Gravity	Affected by: Dry Rot	Affected by: Wet Rot	Affected by: Insects	REMARKS
0	Comino	.806	None	None	Very little	Very durable, plentiful, fine for furniture, inside and outside work. Excellent for every purpose of construction.
1	Comino	.652	None	None	Very little	Similar to No. 0 but lighter, with a curly grain.
2	Canelo	.670	None	Slowly	Very little	Durable. Excellent construction lumber, used for permanent roofing and inside work. Used in ties. Plentiful.
3	Guayacan Polvillo	1.162	None	None	None	Very durable, fairly plentiful, hardest quality tends to petrify under water. Too hard for use as furniture or inside work, but the best obtainable for timber and heavy construction.
4	Guayacan Colorado	1.200	None	None	None	Having all the qualities of Guayacan polvillo but a slightly less degree.
5	Alma megra	1.098	None	Slowly	None	Durable, good quality for interior and exterior, but resists the driving of nails, being cross-grained. Plentiful, used in ties.
6	Caimo blanco.	1.065	Some	Easily	Easily	Only fair quality even though hard and heavy. Takes a dry rot from exposure to the humid atmosphere of the rainy season.
7	Fresno	.547	Readily	Readily	Readily	Very plentiful; grows in very large trees. Use restricted to very temporary construction. Takes both dry and wet rot even if protected by paint.
8	Guayacan Jobo Cebollo	.755	None	None	None	Same qualities as No. 3 and No. 4 but to a still lesser degree. However is plentiful. Distinguished by its curly cross-grain. Difficult to drive nails and spikes into.
9	Sapan	1.045	None	A little	Some	Most common good durable timber obtainable. Excellent for heavy construction. Resists nails and spikes. Takes a fine polish. Very plentiful.
10	Maquimaqui	.910	None	A little	Some	Next to Sapan, having very similar qualities but not quite so durable. (If cut during wrong season, just after full moon, it will be affected by insects.) Fairly plentiful.
11	Carbonero	.668	A little	Yes	Readily	Used for interior work but subject to wet rot if used out doors. Affected by time of cutting, same as Maquimaqui. Plentiful. Should be painted as soon as possible.

Sample Number	Common Name	Specific Gravity	Affected by			REMARKS
			Dry Rot	Wet Rot	Insects	
12	Caimo rojo	1.118	Some	Yes	None	Fairly durable if care taken to protect against water. No good in ground as wet rot sets in. Fairly plentiful. Nailing difficult. Takes a fine polish.
13	Aceituno (Olive tree)	.702	Some	Some	None	Under favourable conditions is quite durable. Main use, furniture and inside work. However used also outside. Plentiful.
14	Yaya	.787	None	Yes	Some	Very durable while kept dry, used inside, but if subjected to successive wet and dry period takes dry rot and insects. Used extensively for tool handles.
15	Cedro baobo	.429	None	A little	A little	Very similar to the cedar of North America. Excellent furniture and interior wood. Fairly plentiful.
16	Cedro Munde	.650	None	A little	A little	Same as Cedro baobo with closer grain.
17	Guaymaro	1.029	Some	Yes	Some	If kept dry and protected will be quite durable, but otherwise takes a wet rot followed by insects. Fairly plentiful.
18	Cariano	.548	Some	Yes	Some	Useful only as an interior wood, affected greatly by humid atmosphere, taking a wet or dry rot.
19	Cauchillo	.720	Little	Some	Some	Similar in appearance to Comino. Good construction timber. Will take a very slow wet rot when used for tunnel timber. Fine interior wood. Must be treated if used in earth. Plentiful.
20	Charro	.635	Yes	Yes	Yes	Will last for a time inside if proper care taken to see that the surface is thoroughly painted. Plentiful.
21	Anime	1.048	Some	Some	Some	Fair quality, used for roofing but will take wet rot in earth. Only fairly plentiful.
22	Chingale		Yes	Yes	Yes	Poor quality.
23	Escubillo		Little	Some	Some	Good quality for interior work and temporary construction. On outside subject to insects and takes wet rot during rainy season. Quite plentiful.
24	Sange de Toro		Yes	Yes	Yes	Poor quality.
25	Orenillo		None	None	Slowly	Very durable, good quality construction timber. Slowly affected by insects. Good supply in Valley.
26	Guayabolion		Some	Yes	Some	Very similar in quality to No. 18, Cariano.
27	Aguacabillo		None	Some	Slowly	Slightly better than Cariano; fair outside wood, excellent for ordinary construction purposes. Not very plentiful.
28	Anon		Yes	Yes	Yes	Worthless.

The Detection of Internal Defects in Steel Rails

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Paper presented before the Moncton Branch of The Engineering Institute of Canada, January 24th, 1933.

SUMMARY.—The author refers to his experience in testing track for internal flaws in rails by the Sperry method. A short account of rail manufacture is given, the various types of rail failure are noted and the equipment and operation of the Sperry car are described.

The Sperry car and its operation in detecting internal flaws in rails is a subject with which the author has been in close contact for the past three seasons, having travelled over 3,200 miles on the car, and actually tested 1,770 miles of track in the Atlantic region of the Canadian National Railways.

In 1930, the car operated from Moncton to Riviere du Loup, testing 275 miles of track in sixteen working days of eight hours each, averaging 17 miles per day. In 1931, 550 miles of track were tested between Riviere du Loup, and Halifax, Truro and Sydney, and Moncton and Saint John, in thirty-two working days of eight hours each, averaging 17 miles per day. In 1932, 945 miles of track were tested between the same terminals, with the addition of the Cape Tormentine branch, in thirty-seven working days of eight hours each, averaging 25.5 miles per day. This increase in number of miles tested per day was due to an increase in testing speed of the car over previous years and to a small degree to the fact that fewer trains were in operation, thus causing less detention.

The weight of rail has increased in the last forty years from 56 pounds per yard to 100 pounds per yard and even 130 pounds per yard, in the high speed track of the Canadian National Railways. This increase in weight of rail has been due to the increased speed and weight of trains, and heavier axle loads. Not only has the weight per yard increased but the design of the section has changed within the past four years.

Before proceeding further, a brief description of the manufacture of steel rails and the defects found therein may prove helpful.

THE MANUFACTURE OF STEEL RAILS

On this continent rails are made from what is known as "basic open hearth steel," so called because made in a furnace lined with "basic" refractories which permit the use of slags high in lime content. Lime is in chemical parlance a "basic" material as distinct from an acid material, hence the name of the process.

Fig. 1—Sperry Detector Car, Single Unit.

An initial charge is made of limestone, pure iron ore, and steel scrap. These materials are heated to a fairly high temperature, until the scrap is almost at the melting point. At this point the main constituent of the charge is added, consisting of molten pig iron from the blast furnaces. Reactions immediately begin between the carbon, silicon, phosphorus and other impurities in the pig iron and the preheated ore and lime. The entire charge becomes molten and constitutes what is known as the bath. Ebullition of gas, resulting from the reaction between oxides and the carbon of the pig iron, keeps the bath in lively motion, which gradually subsides to a uniform well distributed gas liberation, giving the whole surface of the bath an appearance of a gentle boil or simmer. Samples are taken from the bath and analyzed for percentages of carbon, phosphorus and sulphur. If required, further additions of iron oxide and burnt lime may be added to bring the phosphorus and sulphur to a safe minimum and to adjust the carbon content. To aid in fluxing the lime additions, small amounts of fluor spar may be added. The bath at this time will contain only a small percentage of manganese, most of that element in the charge having entered the slag. The same is true of the silicon. Specifications for the finished steel definitely state what it shall contain in the way of percentages of carbon, phosphorus, sulphur, silicon and manganese. The Canadian National Railways specify for rails carbon 0.62 to 0.77 per cent, manganese 0.60 to 0.90 per cent, phosphorus not over 0.04 per cent, sulphur not over 0.055 per cent, silicon 0.10 to 0.20 per cent.

A few minutes before the molten steel is ready to be tapped from the furnace a suitable amount of ferro-manganese is added to the bath. This is an alloy containing about 80 per cent of manganese, and it serves to deoxidize and generally clean the molten steel and to bring the percentage of manganese fairly close to the desired figure. When the heat is ready to tap, the hole in the back of the furnace is opened up and the metal runs into a brick lined steel ladle carried on an overhead crane. While the molten steel is running from furnace to ladle additions are made of any further ferro-manganese required and also a proper amount of a 50 per cent silicon alloy known as ferro-silicon. From the ladle the steel is poured into cast iron ingot moulds. The nominal size of ingot mould in use at Sydney is 23½ inches by 26½ inches by 90 inches in height and the ingot usually weighs about 6 tons.

Each heat of steel made in the furnace is given a number so that the product made from that steel can be identified with the furnace in which the steel was made. A record is kept throughout the making of the heat of the amount of materials charged, type of materials charged, additions made to the bath during the refining, the way in which the steel is poured into the ingot and the analysis of the completed steel. As soon as the ingots have cooled down to approximately 1,700 degrees F., the moulds are stripped from the ingot by a mechanical stripper crane. The ingot is now too cool for rolling and must be heated. This is done by placing the ingot in a soaking pit, where it is slowly heated by producer gas for about three hours until a temperature of approximately 2,000-2,100 degrees F. is reached. The ingot is now ready for the blooming mill where the cross section is rolled down to a bloom about 8½ inches square by approximately 56 feet long. From this bloom it is expected to roll eight 39-foot 100-pound rails, but as it is too long to be put into the rail mill, it is cut up into lengths, each length sufficient to produce two rails.

As an ingot cools from liquid to solid state the bottom cools first, contracts and draws the metal from the upper portion, so that when finished, the top of the ingot is not sound or homogeneous. Naturally this top metal is not suitable to be rolled into products and sufficient metal must be cut off to ensure sound and homogeneous steel. Approximately 9 per cent is cut from the top end of the ingot and returned to the open hearth furnaces. After this has been discarded, four blooms, each of sufficient weight to give two rails, are cut off, leaving about 4 per cent of the original ingot which is scrapped. The blooms are kept in the order in which they are cut from the ingots so that the rails rolled therefrom can be marked and identified in relation to the part of the ingot from which they are rolled. This is done by a system of letters in which the top rail from ingot is called "A," the second "B," and so on.

Before being rolled into rails, the blooms are reheated by passing them through continuous coke-oven-gas fired furnaces. They are charged in at the back of the furnace and it takes about two hours to reach the front, where they are discharged at a temperature of approximately 2,000 degrees F. The blooms are now ready to be passed through the rolls of the rail mill.

The blooms are passed back and forth in the rolls about eleven times before the finished rail is formed. Great care must be taken so that the amount of reduction in size of section in each pass is such that no undue strain is put on the mill drive or the steel itself. Unless the consecutive passes are properly designed, it is absolutely impossible to obtain a finished rail within the tolerance of sizes allowed by specifications. The standard rail length today is 39 feet, but with each rail order, allowance is made for short lengths of 36, 33, 30 and 27 feet. When the rail leaves the final pass it is approximately 84 to 87 feet long, and is then cut into the standard lengths by high speed revolving saws. Allowance is made for shrinkage which varies according to the length of the rail and the temperature at which it leaves the final pass.

One of the rolls used in the last pass has cut into its surface what is known as the "brand" so that there appears on one side of the finished rail in raised letters the manufacturer's section number, the name of the manufacturer, the nominal weight per yard of rail, the letters indicating the rail section, the year and month of manufacture. The heat number, ingot number and rail letter are stamped on the opposite side of the web by a special stamping machine designed to facilitate changing number and letter stamps. The rails are conveyed at once to the hot bed for cooling.

Space will not allow dwelling longer on the remaining few processes through which the rail must pass before it is finally accepted by the inspection company as having conformed to the specifications as called for in the contract.

Types of Rail Failures

A rail is unfit for further service and is removed from the track on account of it being badly curve worn, ends battered, broken, damaged or defective. Defects which show up in a rail in service are classified under the following

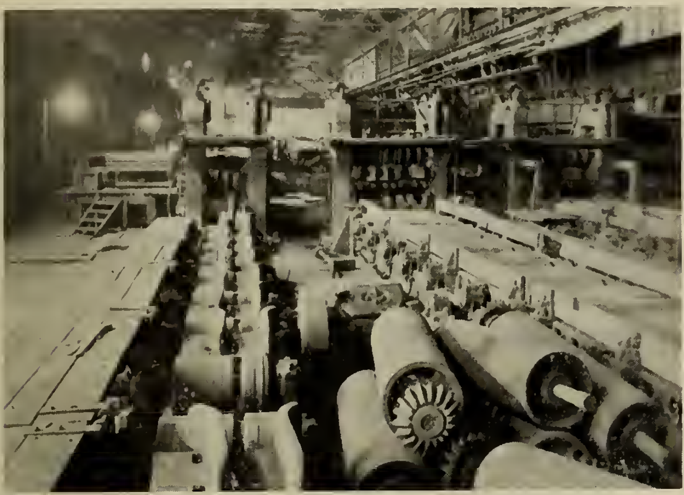

Fig. 2—Rail Mill, Sydney, N.S. Showing Driving Spindles and Three Stands of Rolls.

headings: transverse fissures, compound fissures, vertical split heads, horizontal split heads, crushed heads, battered ends, broken bolt holes, broken bases, pipes and cracked webs. Defects in rails can be divided into two classes, dangerous and non-dangerous. The dangerous defects can be classed as—

Internal — transverse and compound fissures, horizontal and vertical split heads and piped rails.

External — head and web separation, broken bases, cracked and split webs and breaks in bolt holes.

With the exception of the transverse fissure, all of the above defects give some warning before failure. The chances of detecting a transverse fissure before failure are almost negligible. The first notification of a transverse fissure is after it has worked out to the gauge side of the rail, when a very thin hair line crack appears, so fine that it is almost impossible for the human eye to detect. From a railway viewpoint, the transverse fissure is by far the most dangerous defect, and much time, money and research have been spent in order to prove just how, when and where the nucleus of the transverse fissure originates. Many causes of transverse fissures have been suggested, but it is generally agreed that the fissure starts from a point in the interior of the rail where the continuity of the structure has been broken, and keeps spreading from the break under repeated alternations of stress until failure.

Manufacturers have claimed that the primary break is caused either by overloading in service or by repeated alternating bending stresses produced by passing wheels.

The railways have argued that the primary break is caused by defective manufacturing processes.

Other theories advanced were: (*a*) fissures are caused by unequal cooling strains requiring subsequent excessive gagging to straighten the rail, especially near the ends; (*b*) fissures start from the breaking of an overstrained fibre, caused by a combination of internal strains due to cooling, and the strains produced by heavy wheel loads; (*c*) fissures are caused by finishing low carbon rails at too low a temperature; (*d*) fissures start from some internal defect such as slag inclusion or a segregation spot; (*e*) fissures start from minute cracks which do not weld up in the head during the cooling of the rails on the hot bed. These small cracks are called "shatter cracks," and it is the endeavour to manufacture steel which will be absolutely free from these cracks that has brought about the latest developments.

A process has recently been developed at Sydney by Mr. I. C. Mackie, chief metallurgist and test engineer for the Dominion Steel and Coal Company, by which it has been found possible to produce rails proved by laboratory tests to be free from shatter cracks. As only two orders of this quality of steel have been manufactured and as the length of service to date has been too short, it is yet too soon to make any definite statements as to whether the elimination of the shatter cracks will prevent subsequent fissure development in service.

It will be remembered that in the previous description of the manufacture of rails they were left on the hot bed to cool, and it is at this point that the Mackie process begins. The rails are left on the hot bed to cool until they have lost all visible red heat even in a dim light. They are then picked up by a magnet crane and lowered into corrugated sheet iron tanks, each tank large enough to hold about one hundred and forty rails, 39 feet long. As soon as a tank is full it is covered and a pyrometer is installed in one end of the tank at about the centre of the pile of rails. The reading half an hour after the tank has been filled must not be less than 600 degrees F. The rails are then left in this tank until cooled to a temperature of 90 degrees F. above atmospheric temperature. It takes from twenty-

Fig. 3—Transverse Fissure—Area of Fissure approximately 23 Per Cent of Rail head.

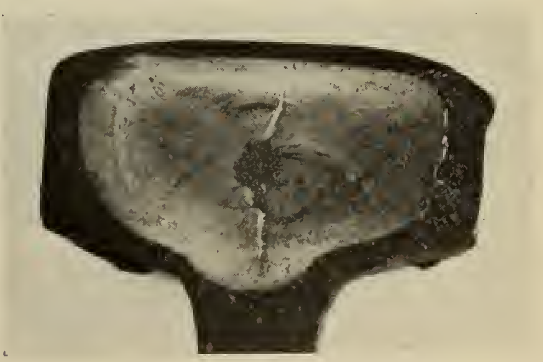

Fig. 4—Transverse Fissure—Area of Fissure approximately 80 Per Cent of Rail head.

four to twenty-eight hours for rails to reach this temperature and they must not be taken out until they have reached it. It is well known that when steel cools, it contracts, and because of the mass of metal in the head of the rail, it must cool more slowly than other parts of the rail, also that the outside metal in the head is always at a lower temperature than the metal at the centre of the head. This means that contraction of the metal takes place at an uneven rate and thus stresses are set up in the head of the rail which are possibly of sufficient magnitude to rupture the metal in the interior of the rail head. The Mackie process has proved that by retarding the cooling between the ranges mentioned the steel is free from rupture. The process has no effect on the hardness of the rail.

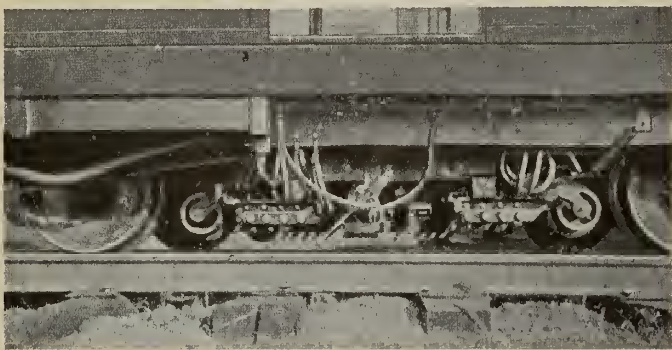

Fig. 5—Brush Carriage, Brushes and Pickup Unit,

Detection of Internal Flaws in Track Rails

The earliest known experimental work in detecting defects of internal origin in rail heads was carried out by the United States Bureau of Standards, commencing in 1915. The equipment was essentially a magnetizing solenoid surrounding the rail, search coils to detect flux leakage at irregularities in the material and a galvanometer in circuit as an indicator. The apparatus, while highly sensitive and accurate, produced results from which it was impossible to differentiate between the effect of slipping of driving wheels, gagging, accidental spike maul blows, etc., and transverse fissures.

Research in connection with this difficult problem was started in 1923 by Dr. E. A. Sperry, the inventor of such ingenious devices as the gyro compass and ship stabilizer. In his early attempts, he experimented with the magnetic principle but soon discarded it as impractical. Concentrated research during 1926 and 1927 resulted four years after his initial work in a method which in laboratory tests proved to be 100 per cent accurate. In practical track testing, further difficulties were encountered and again efforts were concentrated on laboratory and field work; in October 1928 the first detector car designed to find hidden fissures was considered satisfactory for commercial testing. The ingenious method finally perfected of passing a searching unit through the air just above the rail was the result of Dr. Sperry's research. It is now possible to find and remove from the track fissured rails before further growth of the hidden fissures can cause rail breakage. During the past four years many improvements have been made in the equipment, and from actual tests in the early part of 1932 the Sperry detector car was proved to be approximately 98 per cent efficient.

The principle of the detector car is based on the theory that a conductor carrying electricity is surrounded by a magnetic field the shape of which remains uniform as long as the cross section of the conductor remains uniform, but any change in the cross section of the conductor will produce a corresponding change in the field. (Fig. 6.)

The field about a good rail is uniform when the current is passed through it, but the field about a rail containing a transverse fissure is distorted at the location of the defect because the sectional area of the conductor is reduced by the gap between the surfaces of the fissure. The searching unit, which consists of four coils, two for the gauge side and two for the outside of the rail, is passed over the rail through the distorted field, generating an electromotive force. This impulse after being amplified many thousand times works a telegraph relay which operates the recording pen and painting equipment to mark the rail.

In 1928, the Sperry rail service started building a fleet of detector cars and at the present time is operating ten cars. These cars are classed under two headings, the double and single unit. The equipment in use is identical for both cars but as the single unit car is more modern in construction, this type only will be dealt with here.

The single unit type of detector car shown in Fig. 1 is a Brill model 55, gasoline driven, mounted on two four-wheel trucks 45 feet long, equipped with extra heavy frame and axles, and capable of a speed of 45 miles per hour when running to and from work. Just back of the driver's compartment are located the cook's galley and comfortable quarters for the crew. The crew consists of a chief operator, an assistant operator, a driver and a cook. Next to the living quarters is the compartment containing the power plant of the detector equipment. This consists of a specially designed double commutator, 3,000-ampere, 2-volt d.c. generator direct connected to a 50-h.p. four-cylinder gasoline engine. The exciting generator and air compressor are also driven by this engine. Current from the 2-volt generator is carried by heavy leads to the brush unit located on either side of the car and directly over each running rail. The brush unit assembly consists of two sets of eight solid phosphor-bronze brushes mounted about three feet apart and rigidly connected by a cast frame. These brushes are supplied with individual springs which ensure a pressure of 50 pounds per brush. Flanged wheels located at the end of the brush holder engage the rail when the brushes are down and due to their angular mounting cling to the gauge side regardless of varying track conditions. The brush units are applied to the rail

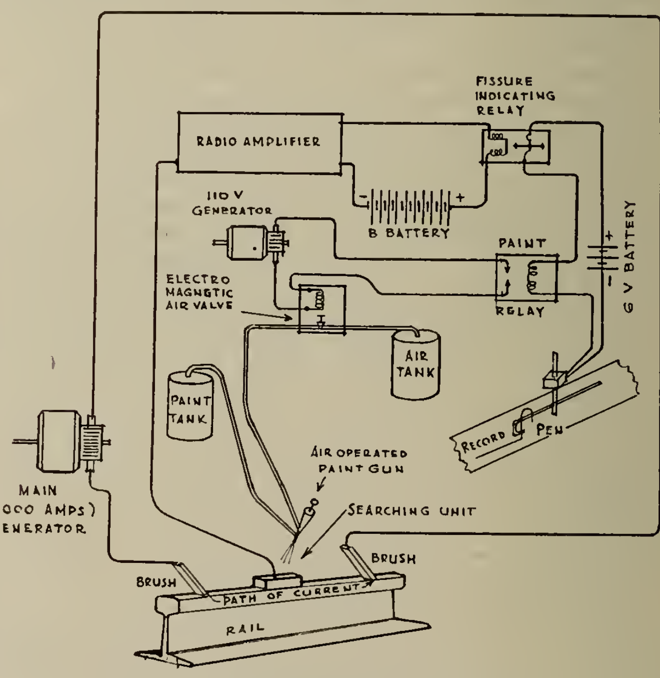

Fig. 6—Sperry Rail Detector from Searching Unit to Record and Painting of Rail.

by air operated pistons electrically controlled from the operator's switchboard. A safety switch is connected to the gear shift of the motor car drive so that the brushes will lift if the driver attempts to back up while they are on the rail. It has been found that the brush contact resistance is greatly reduced by the use of water on the rail. Provision is therefore made during summer testing to carry a sufficient supply of water for this purpose and the brush control switch applies the water to the rail automatically when the brushes are lowered. To insure good testing in winter, proper electrical contact with the rail is assured by non-freezing, non-corrosive liquid solution which is sprayed on the running surface of the rail instead of water. The cars are also equipped with sleet brushes to free the rail of ice and sleet. Mounted between the brushes is

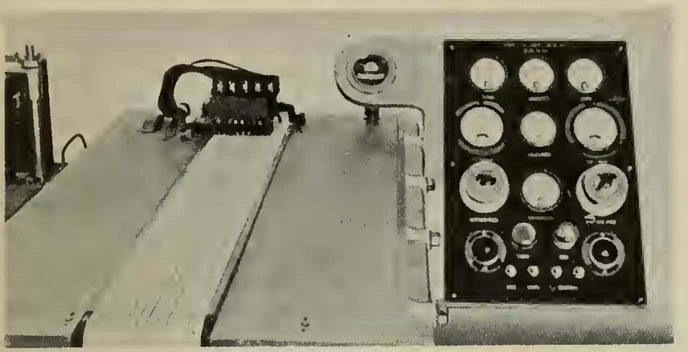

Fig. 7—Recording Table, Record Tape, Pen Units and Control Panel.

a separate carriage which supports the pick up unit. This carriage with its eight wheels and swivel mounting holds the pick up unit a fixed distance above the rail and rides over burns and flat spots without interruption to any large degree. Initially, burns and flat spots gave indications which tended to slow up testing, but the latest design of pick up unit or sled eliminates all indications due to flat spots and all but the largest burns.

The operating room is located at the rear of the car and contains the recording table and control board as well as amplifying equipment batteries, and calibrator. Before commencing work in the morning and at least once during the day, the sets are calibrated which insures efficient and accurate testing. The output from the pick up unit is brought up to a four-tube amplifier which is properly shielded and protected from shock. Three recorder pen relays are connected to the output of the amplifier and adjusted to respond to different values of plate current, thus giving an indication of the size of the defect detected. Other relays are provided to operate paint guns so that the fissure will be automatically marked by a paint spot. The latest record or tape is made up of seven lines, the two centre lines record the angle bars, while the two on either side record the relative size of the fissure. It is a continuous roll of thin paper (permitting blue prints) and is a complete diagram of all rails tested. The scale is $\frac{1}{16}$ inch per foot of track tested. (See Fig. 7.) Joint finger cut-outs mounted on the brush holders engage the angle bars and cut out the fissure pens and paint gun at the joint, at the same time operating the joint pens. The line to the extreme right is a land mark pen operated from the motor car driver's switchboard. He presses a button whenever a mile post, bridge, signal tower and other land mark is passed and the operator at the recording table stamps in the proper designation. An electric clock is also connected to this pen and every ten seconds is recorded, thus making it possible for testing speed of car to be checked. When the car is in operation it moves along the track at approximately six miles per hour with a minimum current of 2,000 amperes flowing through each rail. The operator seated at the recording table in the rear of the car has the record continually rolling before him and a clear view of tested track. When the car passes over a fissure an indication appears on the tape and the defect is automatically marked with a spot of paint. The operator notes the tape, sees the paint mark on the rail, and stopping the car backs it up to the paint mark for a hand test of the suspected spot.

In making a hand test the following procedure is observed:—First, the running surface of the rail head must be thoroughly cleaned of all rust and dirt by emery cloth and oil. Secondly, two air operated contacts are clamped on the rail head approximately three feet apart with the suspected spot midway and approximately 1,500 amperes introduced into the rail. Thirdly, beginning at a point on the head of the rail in the vicinity of either contact, a sliding set of contacts connected to a portable galvanometer are moved towards the suspected spot. When the current first passes through the galvanometer a constant reading is noted. This reading will increase as the contacts near the suspected fissure, reaching a maximum at the exact location. The difference between these two readings multiplied by 100 and divided by the maximum reading gives the per cent of fissure. It sometimes happens that a rail contains more than one fissure and as such is called a multi-fissure rail. The greatest number of fissures found in any one rail was nineteen, although not while operating on the Atlantic Region. These occurred in a rail with only eleven months' service, so it can be seen that age is not one of the deciding factors.

In work of this kind the Sperry car is leased to the railway under contract at a set rate per mile of track tested, with an additional hourly rate for any time the car is delayed for which the Sperry Company is not responsible, such as detention and train orders, etc. A testing day is considered to be not less than eight hours, and as an incentive to the railway to get the largest daily mileage possible, a minimum daily rate must be paid in all cases where the mileage rate and the hourly rate fails to equal the minimum rate. The railway supplies a conductor and pilot for safe operation of the car over the road and these men are responsible for train orders.

The railway representative remains with the car during the test on all divisions, designating track to be tested, arranging for train crews, keeping railroad records and instructing as to disposition of the defective rails.

THE
ENGINEERING JOURNAL
THE JOURNAL OF
THE ENGINEERING INSTITUTE
OF CANADA

VOLUME XVI DECEMBER 1933 No. 12

The Development of The Institute

After full discussion, the Council has decided to suggest a number of changes in the present by-laws, and its proposals will be placed on the agenda for discussion at the forthcoming Annual General Meeting. In due course they will be submitted for the approval of the membership by letter ballot.

These proposals have been embodied in a set of draft by-laws, which are printed elsewhere in this issue of The Journal, and are largely based on the original work of the Committee on Development, which presented its interim report in October 1932. The object of that committee was to prepare recommendations whose adoption would lead to the fullest possible development of the activities of The Institute. At an early stage of the work, however, it became evident that to attain this end, and build a suitable structure, some strengthening or even remodelling of the foundation would be necessary. The interim report, therefore, dealt with basic features of The Institute's constitution and management, which it was felt should be definitely determined before further progress could be made. That report was intended to call forth criticism and suggestions regarding these matters, on the part of individual members and branch executive committees, and it served its purpose well, since the Committee on Development soon found itself faced by a large number of communications from all parts of the Dominion. These expressions of opinion, with others received subsequently, have been considered by a committee appointed by Council for that purpose. The recommendations of that committee, prepared after close study of the various views expressed, formed the basis for the debates on the development of The Institute which have just taken place at the Sixth Plenary Meeting of Council, and which have resulted in the proposals now presented to the membership.

Summarizing the opinions received on the interim report of the Committee on Development, it may be noted that members were generally in agreement with the committee's proposal for a single class of corporate member. A considerable number expressed a desire for closer relationship with the Provincial Associations of Professional Engineers, but only a few considered that membership in The Institute should be restricted to members of those bodies.

Communications from branches also indicated that the proposal of one principal class of Member met the views of the majority. Comments on the subject of fees evidenced some opposition to any increase at this time.

Having considered all the opinions which have been expressed, the Committee of Council prepared its recommendations and presented them to the Plenary Meeting of Council. After full discussion, the Council reached the opinion that in addition to a limited number of Honorary Members, The Institute membership should be composed of three main classes, namely, Members, Juniors and Affiliates. The first named would constitute the corporate or voting membership of The Institute, and it was considered that admission to it should require (*a*) graduation from a school of engineering recognized by the Council, or (*b*) registration as a professional engineer in a provincial professional association whose requirements are considered satisfactory by the Council, or (*c*) the passing of an examination prescribed by the Council. In addition to one of these three qualifications the candidate for corporate membership should have at least four years of active practice. The two classes of non-voting members, styled Juniors and Affiliates, would have requirements for admission which will be found set forth in the draft by-laws printed elsewhere in this issue.

When the changes now proposed are adopted the corporate or voting membership of The Institute will consist solely of one class, the Members, who will be chosen (*a*) from engineering graduates having four years professional experience; (*b*) from members of such professional associations as in the opinion of Council enforce standards for admission equivalent to the above, or (*c*) from other persons who can establish to the satisfaction of Council that they have received equivalent theoretical training. In all cases four years of engineering practice will be required.

The new class of Junior is intended to provide an appropriate place in The Institute for younger men who have reached a certain educational standard (senior matriculation), and who are either undergraduates or recent graduates of engineering schools, or are engaged in the active practice of engineering.

There are many men engaged in engineering work who, although unable to qualify as Members or Juniors, possess engineering experience which enables them to make worth while contributions to the interchange of professional knowledge, possibly along some specialized line of work. Such men, although they may be holding engineering positions of minor importance, are frequently in a position to take an invaluable part in our professional meetings, both branch and Institute, and would also themselves derive considerable benefit from participation in The Institute's activities. It is possible that some in this category might be able later to qualify as Juniors or Members. In the case of others, circumstances may prevent this. The important class of Affiliate is intended to enable all these men to join us and find in The Institute a congenial means for mutual benefit. Such Affiliates of The Institute would be particularly welcome in the specialized sections which many of our branches have formed, and which it is hoped will now find opportunity for wider usefulness.

Among the other important changes recommended by the committee and now presented as proposals of Council may be mentioned a reduction in the present scale of

THE ANNUAL MEETING—MONTREAL

The Forty-Eighth Annual General and General Professional Meeting of The Institute will be held in Montreal

ON

Thursday and Friday, February 8th and 9th, 1934

HEADQUARTERS—THE WINDSOR HOTEL

OUTLINE OF PROGRAMME
(Subject to change)

Thursday, February 8th:
- *Morning*....Registration and Business Meeting.
- *Noon*.......Luncheon with Speaker.
- *Afternoon*...Business Meeting.
- *Evening*.....The Annual Dinner of The Institute—followed by a dance.

Friday, February 9th:
- *Morning*....Technical Sessions.
- *Noon*.......Buffet Lunch.
- *Afternoon*...Technical Sessions.
- *Evening*.....Smoker.

(Courtesy of The Montreal Star)
Lake St. Louis Bridge over the St. Lawrence River—November 1933

(Courtesy of Associated Screen News Ltd.)
The "Royal Scot" at Montreal

CHAIRMEN OF COMMITTEES

of Montreal Branch in Charge of Arrangements for Annual Meeting.

Chairman......E. A. Ryan, M.E.I.C.
Vice-Chairman..Dr. A. Frigon, M.E.I.C.
Papers.........F. V. Dowd, A.M.E.I.C.
Entertainment...F. S. B. Heward, A.M.E.I.C.
Publicity.......J. A. McCrory, M.E.I.C.
Registration.....H. W. Lea, Jr.E.I.C.
Hotel..........C. K. McLeod, A.M.E.I.C.
Ladies.........Mrs. E. A. Ryan.

The principal item at the business sessions will be the discussion of Council's proposals for the amendments of the By-laws, following the work of the Committee on Development.

Among the subjects on which professional papers will be presented may be mentioned two important bridges—the Broadway Bridge over the Saskatchewan River at Saskatoon and the Lake St. Louis Bridge over the St. Lawrence; the new Dunlap Memorial Observatory and telescope at Toronto; recent work on the utilization of magnesian rock in Canada for refractories and construction purposes; and the strength of stiffened circular tubes under external pressure.

entrance fees and annual fees; the requirement that application forms for admission shall be signed personally by a corporate member as proposer, and a change in the method of nominating and electing vice-presidents and councillors, intended to simplify the present procedure and avoid some of the difficulties which have occurred in its operation. It will be noted that Council also proposes to include in the by-laws a concise statement as to the spirit in which an engineer's professional work should be performed, deleting the present Code of Ethics with its ten clauses.

On studying the draft by-laws now presented, members will note the above changes and a number of others of lesser importance.

During the committee's work it was found that the major proposals would involve some change in many related sections of the by-laws. It therefore seemed advisable to suggest at the same time such other minor changes as would bring the whole set of by-laws into line with present conditions. It seems likely, however, that when the draft by-laws come up for discussion at the Annual General Meeting, the debate will centre largely around the question of classes of membership and the qualifications required for these, for it is really these matters which will decide the lines along which The Institute is to progress in future.

The Sixth Plenary Meeting of Council

The Sixth Plenary Meeting of the Council of The Institute was held at Headquarters on Monday, Tuesday and Wednesday, October 30th and 31st, and November 1st, 1933, the following members being present:

President O. O. Lefebvre, D.Sc., M.E.I.C., in the chair; Past-Presidents A. R. Decary, D.Sc., M.E.I.C., G. H. Duggan, LL.D., M.E.I.C., Julian C. Smith, LL.D., M.E.I.C., and H. H. Vaughan, M.E.I.C.; Vice-Presidents Ernest Brown, M.E.I.C. (Province of Quebec), A. H. Harkness, M.E.I.C. (Province of Ontario), A. B. Normandin, M.E.I.C. (Province of Quebec), and R. S. L. Wilson, M.E.I.C. (Western Provinces); Councillors G. H. Burbidge, M.E.I.C. (Lakehead), J. L. Busfield, M.E.I.C. (Montreal), C. V. Christie, M.E.I.C. (Montreal), H. Cimon, M.E.I.C. (Quebec), H. J. Crudge, A.M.E.I.C. (Moncton), J. B. deHart, M.E.I.C. (Lethbridge), G. J. Desbarats, C.M.G., M.E.I.C. (Ottawa), R. L. Dobbin, M.E.I.C. (Peterborough), A. F. Dyer, A.M.E.I.C. (Halifax), L. F. Goodwin, Ph.D., M.E.I.C. (Kingston), B. Grandmont, A.M.E.I.C. (St. Maurice Valley), F. C. Green, M.E.I.C. (Victoria), C. S. L. Hertzberg, M.E.I.C. (Toronto), W. J. Johnston, A.M.E.I.C. (Saint John), G. F. Layne, A.M.E.I.C. (Saguenay), D. A. R. McCannel, M.E.I.C. (Saskatchewan), H. J. MacLeod, Ph.D., M.E.I.C. (Edmonton), F. W. Paulin, M.E.I.C. (Hamilton), P. L. Pratley, M.E.I.C. (Montreal), O. Rolfson, A.M.E.I.C. (Border Cities), D. C. Tennant, M.E.I.C. (Montreal), J. J. Traill, M.E.I.C. (Toronto), J. A. Vance, A.M.E.I.C. (London), and A. S. Wootton, M.E.I.C. (Vancouver); Treasurer J. B. Challies, M.E.I.C., and, by special invitation, President-Elect F. P. Shearwood, M.E.I.C.

Expressions of regret at being unable to attend the meeting were received from Past-Presidents J. S. Dennis, C.M.G., M.E.I.C., J. M. R. Fairbairn, D.A.Sc., M.E.I.C., A. J. Grant, M.E.I.C., S. G. Porter, M.E.I.C., J. G. Sullivan,

Members of Council Attending Sixth Plenary Meeting.

M.E.I.C., and George A. Walkem, M.E.I.C.; Vice-President Sydney C. Mifflen, M.E.I.C. (Maritime Provinces); Councillors E. G. Cameron, A.M.E.I.C. (Niagara Peninsula), R. C. Harris, M.E.I.C. (Calgary), and J. W. Porter, M.E.I.C. (Winnipeg).

The President extended a cordial welcome to all out-of-town members, following which the minutes of the meeting held on October 6th, 1933, were taken as read and confirmed.

The Secretary reported that the American Society of Civil Engineers had decided to hold a summer convention in Vancouver, probably in June or July of 1934, and that having communicated with the Vancouver and Victoria branches it was suggested that a Western Professional Meeting of The Institute should be held in Vancouver at the same time, and that a cordial welcome and co-operation should be offered to the American Society of Civil Engineers. After discussion it was unanimously resolved that a Western Professional Meeting of The Institute be held in Vancouver under the auspices of the British Columbia Branches of The Institute and at the same time as the American Society of Civil Engineers convention in 1934.

It was decided that the Annual General and General Professional Meeting of The Institute should be held in Montreal on Thursday and Friday, February 8th and 9th, 1934, as suggested by the Montreal Branch Executive Committee.

It was unanimously resolved that The Institute should accept the invitation of the Royal Society of Canada to become one of the organizations affiliated with that Society.

Four Students were admitted, and one Life Membership was granted.

Council noted with appreciation that the American Concrete Institute would hold a meeting in Toronto on February 21st and 22nd, 1934, and it was decided that a welcome from the Council of The Institute should be sent to that body and that the Toronto Branch should be requested to co-operate with the American Concrete Institute.

Mr. Busfield, chairman of the Finance Committee, presented a financial statement containing, in concise form, detailed information regarding the revenue and expenditure of The Institute for the first nine months of 1933. He explained the various items and pointed out the difficulties which the Finance Committee had experienced during the past year on account of falling revenues. Discussion followed as to the financial situation of The Institute, during which the President pointed out that it would have been impossible to hold this Plenary Meeting of Council had the Branches not consented to contribute towards the expenses of the meeting.

A resolution of sympathy was passed with regard to the illness of Past-President A. J. Grant, M.E.I.C.

Discussion took place on the number of members now on the Suspended List, and it was decided that in future this should be known as the Non-Active List, and that every effort should be made to secure the Branches' co-operation in connection with members in arrears, members on the Non-Active List, and members resigning.

The principal business of the meeting was in connection with the report of the Committee on Development regarding which letters were submitted from the chairman of the Vancouver Branch, the Winnipeg Branch Executive Committee, from councillors, and from the Niagara Peninsula and Quebec branches.

The discussion which followed was based on the report of the Committee of Council which had been appointed to study the proposals of the Committee on Development and the various opinions and comments which those proposals brought out.

The afternoon of the first day, the whole of the second day, and the morning of the third day of the Plenary Meeting were devoted to this work. After considering the report of the Committee of Council it was decided to take up clause by clause a set of draft by-laws which had been prepared embodying the committee's proposals and the modifications agreed on during the first part of the discussion. This was done and as a result the draft by-laws underwent considerable modification before being approved as proposals of Council for submission to the Annual General Meeting and subsequent ballot by the membership.

On the afternoon of the third day reports were presented on unemployment and on membership, both giving rise to active discussion.

It was thought desirable to express and record the Council's desire to co-operate in every way possible with the provincial associations of professional engineers, and accordingly, on the motion of Mr. Wootton, seconded by Mr. McCannel, it was unanimously resolved that it is the opinion of this Plenary Meeting of Council that The Engineering Institute of Canada should take advantage of every possible opportunity to collaborate with the Provincial Associations of Professional Engineers in furthering the best interests of the engineering profession, and more particularly in endeavouring to secure a generally acceptable system of registration of engineers in all parts of the Dominion. The Secretary was directed to send a copy of this resolution to the Council of each Association of Professional Engineers.

The meeting terminated by a hearty vote of thanks on behalf of the visiting councillors to the President and Montreal members of Council for the hospitality extended.

Key to Photograph Appearing on Page 526

1. C. V. Christie, M.E.I.C.
2. R. J. Durley, M.E.I.C.
3. J. F. Plow, A.M.E.I.C.
4. W. J. Johnston, A.M.E.I.C.
5. D. C. Tennant, M.E.I.C.
6. F. C. Green, M.E.I.C.
7. H. H. Vaughan, M.E.I.C.
8. F. W. Paulin, M.E.I.C.
9. Dr. L. F. Goodwin, M.E.I.C.
10. J. B. DeHart, M.E.I.C.
11. A. S. Wootton, M.E.I.C.
12. D. A. R. McCannel, M.E.I.C.
13. B. Grandmont, A.M.E.I.C.
14. O. Rolfson, A.M.E.I.C.
15. J. J. Traill, M.E.I.C.
16. H. Cimon, M.E.I.C.
17. J. A. Vance, A.M.E.I.C.
18. H. J. Crudge, A.M.E.I.C.
19. H. J. MacLeod, M.E.I.C.
20. J. L. Busfield, M.E.I.C.
21. J. B. Challies, M.E.I.C.
22. G. F. Layne, A.M.E.I.C.
23. A. F. Dyer, A.M.E.I.C.
24. C. S. L. Hertzberg, M.E.I.C.
25. R. S. L. Wilson, M.E.I.C.
26. E. Brown, M.E.I.C.
27. G. J. Desbarats, M.E.I.C.
28. G. H. Burbidge, M.E.I.C.
29. A. B. Normandin, M.E.I.C.
30. A. H. Harkness, M.E.I.C.
31. O. O. Lefebvre, M.E.I.C.
32. A. R. Decary, M.E.I.C.
33. R. L. Dobbin, M.E.I.C.
34. P. L. Pratley, M.E.I.C.

Engineers Need Imagination

Engineers as a class are too conceited; they think they know a lot. They don't mix with enough different kinds of people. They lack imagination. They are not emotional enough. Few of them have a broad mental perspective. Too many of them are satisfied with things as they are. They are not dissatisfied enough. They are inclined to put formulae ahead of facts, and most of them lack the ability to transfer their thoughts in simple language to the general public.

—*C. F. Kettering in the S.A.E. Journal*

Report of the Committee on Unemployment

Presented at the Plenary Meeting of Council and now published by direction of Council.

The President and Council—

Your Unemployment Committee begs to report as follows regarding the continuation of its work to date.

It will be remembered that during 1932 a survey of the unemployment situation as affecting the members of The Institute was made by your committee, and local unemployment committees were established in twenty-one of the twenty-five branches of The Institute. These committees have been in operation since that time, and have continued keeping in touch with conditions in their branches.

The original survey was based upon a questionnaire sent out in September 1932 to all members asking each member to give certain information as to whether he was then employed, and, if so, whether he expected to become unemployed at a later date. This year the committee has made further inquiries, having sent out, on September 2nd, to the chairmen of the branch unemployment committees or to the secretaries of the branches where no branch unemployment committee exists, a request for information as to the number of members known to be unemployed, the number actually in need of relief, the number who have found employment recently, either temporary or permanent, the expenditure from branch funds for direct relief, if any, and certain other particulars. The information obtained in reply to this inquiry has been tabulated on page 529 and indicates little change in general conditions. Funds for direct relief of our members have been collected and disbursed in five localities only.

Project No.	Province	Military District or Headquarters	EIC & Ex Members: Engineers	EIC & Ex Members: Asst Engrs	EIC & Ex Members: Foremen	EIC & Ex Members: Sub Foremen & Gang Bosses	Professional Engrs: Engineers	Professional Engrs: Asst Engrs	Professional Engrs: Foremen	Professional Engrs: Sub Foremen & Gang Bosses	Duplication No. EIC or Ex EIC & PE	Information re Non Members & Non Prof Engrs Appointed by Branches
1	NS	6										
3	NB	7										
4	"	"										
5	Que	5										
6	"	"										
7	"	"										
8	Ont	North Bay			1				1		1	1 Sub F. Ottawa
9	"	"			1Ex	1Ex				1	1	
12	"	Nakina				1						
13	"	"										
14	"	"			1							
15	"	"										
16	"	Sioux Lookout			1							
17	"	Nakina			1				1		1	
18	"	"			1				1		1	
20	Man	10				1Ex						
22	B.C.	13										
23	"	"										
24	"	"										
25	"	11										
26	"	"										
27	Ont	NDHQ				1Ex 1				1		1 Sub F Ottawa
28	"	Toronto		1Ex								
29	NB	7										
30	Ont	Camp Borden			1							
33	"	"		1	1					1		1 Asst Engr & 1 Sub F-Toronto
34	B.C.	13										
35	Ont	Nakina		1								
37	"	RMC			1Ex	4						
39	Que	5	1	1	1	5						1 Sub F Quebec
40	Ont	Petawawa			1Ex 1	2Ex			1	1	1	1 Sub F Ottawa
42	"	3		1Ex		2Ex 3						1 Foreman & 4 Sub F-Kingston
43	Alta	13				3			1			
44	Sask	12		1	2	1Ex						
45	Ont	North Bay		1		1						1 Foreman & 1 Sub F Ottawa
46	"	"										1 Sub F Toronto
47	"	"	1	1Ex	1				1		1	
48	B.C.	11				2						
49	Alta	13										
50	Ont	Nakina										
51 (1-11)	"	Lac Seul		2Ex 1		1Ex 1		2	1	1	3	
52	Alta	13										
53	Que	4				2						
55	B.C.	Hope				1Ex 1				4	2	
56	"	Princeton										
57	"	[illegible]								1		
58	Alta	13										2 Sub F Calgary
59	Ont	NDHQ		1Ex 1								1 Asst. Engr & 1 Sub F Ottawa
60	B.C.	13			1Ex							
61	"	"							1			
62	"	"			1Ex				1		1	
63	BC	13							1			
64	"	"				-				1		
65	"	"			1Ex 1				2	1	2	
66	"	"							1			
67	"	"										
68	"	"			1	1				1	1	
69	"	"			1				1		1	
70	"	"	1Ex	1			1	1			2	
71	"	"	1	1			1	1			2	
73	"	11			1Ex					1		
74	"	"								1		
75	"	"										
76	"	"										
77	"	"					1	3				
78	"	"					1	1		1		
79	"	"		1				1			1	
80	"	13										
81	Ont	Nakina			1							
82	BC	11										
86	"	"					1	1		1		
87	"	"										
88	"	"										
89	"	"			1Ex							
90	Ont				1				1		1	
92	"	North Bay			1	2				1		1 Sub F Toronto
93		"										
94	"	"										
95	BC	11					1	1		1		
96		"										
97	"	"										
100	"	"										
101		"										
102	"	"										
103	"	"										
104	Man					1Ex						
105	BC											
106	Man											

Department of National Defence
Unemployment Relief Projects

Appointments of Engineers
to the Supervisory Staff

Summary

Members Engineering Institute	58
Ex " " "	26
Registered Professional Engineers	51
Non-Member Branch Appointments	20
	155
Duplication	22
Total Engineer Relief Appointments	133

October 27th 1933

The Engineering Institute of Canada
2050 Mansfield St Montreal, PQ

Employment Service at Headquarters

Unemployed members registered with our Employment Service Bureau total 376 as compared with 257 as at January 1st, 1933. Of the 376 upwards of 60 are to our knowledge temporarily employed.

Ninety-three advertisements for members are now being published in the Situations Wanted column of The Engineering Journal and the monthly bulletin of which 1,000 are issued each month, and these go to unemployed members and a selected list of employers.

During the last ten months the records of 170 members, as on file with our Employment Service Bureau, have been sent to prospective employers, and a further 89 members were notified of vacancies. Altogether during this period we were advised of some 71 vacancies, of which it was, however, only possible to fill 32. Unfortunately most of these positions called for men with some particular requirement, or turned out to be sales positions solely on a commission basis, which did not prove sufficiently attractive to be acceptable to those to whom they were offered.

Department of National Defence Relief Camps

During the spring and summer The Institute, through the branch unemployment committees and the Department of National Defence, has been instrumental in placing 133 engineers as supervisors in the various Unemployment Relief Camps through Canada, of the Department of National Defence. In addition to this number 30 were offered such employment and refused. Of those placed, 55 were members of The Institute, 22 ex-members of The Institute, and the remainder were members of the Professional Engineers, or engineers who were not known to be members of any society.

It is interesting to note that through the consideration of the Department of National Defence the openings filled by engineers amounted to just under 25 per cent of the total supervisory staff appointed.

During the past two months only a few of these appointments have been made, principally due it is understood to the inability of the Department of National Defence to obtain sufficient unemployed single men to start new camps. This lack of men is believed to be due to the recent harvest work in the west and to the indecision in the minds of the public as to municipal and provincial relief programmes.

This summer a representative of The Institute staff paid a visit to six of these camps, three at Petewawa, one at Trenton, and two at Kingston. Conditions there were found to be quite comparable to the usual construction camps, and the living and messing arrangements of the supervisory staffs were quite satisfactory.

There are no doubt unemployed members of whom we have not heard—their number is uncertain. In some cases members are unwilling to let us know of their situation, in others they have neglected registration with our Bureau, although invited to do so. Some unexpected information as to additional members who are unemployed comes in from time to time in response to the inquiries which are sent out to individual members regarding arrears of fees. Your committee feels, however, that every reasonable means of obtaining the desired information has been tried, and that the reports now received from the branches and the figures shown on the tabulated statement herewith, give as complete and reliable a picture of the situation as can be obtained.

Also attached is a chart showing the distribution of D.N.D. Relief Projects with the location and number of the engineers placed.

Your committee desires to express appreciation of the work of the branch unemployment committees and the secretaries of the professional associations and also the action of the Department of National Defence in consulting with The Institute when making appointments to the supervisory positions in their Relief Camp scheme. In this connection our thanks are particularly due to Major General A. G. L. McNaughton, M.E.I.C., and Group Captain E. W. Stedman, M.E.I.C. The personal assistance of Mr.

Information Received from the Branches Regarding Local Unemployment Conditions

October 24th, 1933

Branches	Number of members unemployed	Number in need of relief	Number receiving relief	Number who have found employment	On D.N.D. Unemploy. Relief Proj.	Expend. from Br. Funds	Relief Funds expended	Appeal, or further appeal be needed	Local prospects of employment for engineers Comments from Branches
Halifax	9 Corp. Mem. and no. Students	none	none	A number in temp. work	none	none	none	no	"Conditions somewhat better than a year ago. No engineering works of importance started."
Cape Breton	3	none	none		none	none	none	no	"Prospects for the winter look much better than was the case a year ago."
Saint John	14 mostly Students	none	none	6	none	none	none	no	"Does not look promising at present time."
Moncton	2 Corp. Mem. and no. Students	none	none	T-1	none	none	none	no	"The best we can hope for is that conditions become no worse."
Saguenay	1	none	none	none	none	none	none	no	"Prospects for new opportunities in this district are not good."
Quebec	6	none	none	1	1	none	none	no	"95% of the members of the Branch are employed."
St. Maurice V.	2	none	none	none	none	none	none	no	"Conditions do not show any signs of improvement for some time to come."
Montreal	108		11	T-16 P-6	10	none	$1,330.40	yes	"Believe the situation to be just as acute as at this time last year."
Ottawa	30	none			18	none	none	no	"Dom. Govt. still reducing staffs. No important work proposed for this section."
Peterborough	9	none	none	2 or 3	none	none	none	no	"No work for engineers but believe conditions generally are tending to improve."
Kingston	3	none	none	8	12	none	none	no	"Prospects for further employment are not good."
Toronto	57	20	7	T-24 P-9	10	$50	$600 on loan	no	"Not indicative of general situation in engineering." "Industrial positions seem to have improved over the past few months."
London	4	none		1	none	none	none	may be necessary	"The local prospect for work will be inadequate to keep all present local members employed."
Hamilton	very few	none		1	none	none	none	no	"There are comparatively few members unemployed."
Nia. Pen.	15	none	none	none	none	none	none		"Increase in number of unemployed due entirely to the layoff of engineers in a large organization."
Border Cities	7	2	none	none	none	none	$135	yes	"Situation not promising for employment of engrs. Expect that those employed will continue to be."
S. S. Marie	none	none	none		3	none	none	no	
Lakehead									
Winnipeg	40—E. I.C. and P.E.		3 or 4	T-2 or 3	5	none	Joint fund P.E.	likely	"No prospect of employment being obtained other than D.N.D. Unemployment Relief Projects."
Sask.	11	none	none	9	3	none	none	no	"No new developments. Prospects practically nil until Spring."
Lethbridge	none	none	none	none	none	none	none	no	"Unless conditions get worse, all Branch members will have fairly steady employment all Winter."
Edmonton	14	none	none	T-9 P-4	3	$20	none	yes	
Calgary	10	none	none	T-5	3	none	none	no	"Situation not very bright."
Vancouver					About 50		Joint fund P.E.		"If not for D.N.D. Camps conditions would have been as bad as in 1932."
Victoria	none	none	none	3	8	none	none	if necessary	"Slight improvement in B.C. in mining. Some prospect of construction improvement arising therefrom, next year."

G. J. Desbarats, M.E.I.C., has been invaluable in dealing with many questions which have arisen.

Respectfully submitted,

D. C. TENNANT, M.E.I.C.,
Chairman, Unemployment Committee.

Committee:

A. Duperron, M.E.I.C.
R. J. Durley, M.E.I.C.
D. C. Tennant, M.E.I.C., Chairman.

October 30th, 1933.

OBITUARIES

Arthur Edward Caddy, M.E.I.C.

We regret to announce the death at Peterborough, Ont., on October 25th, 1933, of Arthur Edward Caddy, M.E.I.C.

Mr. Caddy was born at Cobourg, Ont., on May 10th, 1866. He served a three-year apprenticeship in the engineering department of the Central Bridge and Engineering Company, Peterborough, Ont., and from 1882 to 1886 was chainman and transitman with E. C. Caddy on surveys in the Northwest Territories and Ontario. From 1889 to 1894 he was draughtsman with the Central Bridge and Engineering Co. Ltd., at Peterborough, and in 1894-1895 was transitman on the Trent canal at Kirkfield, Ont. In 1895 Mr. Caddy became draughtsman with the Massillon Bridge Company at Massillon, Ohio, and was afterwards chief draughtsman with the Brackett Bridge Company at Cincinnati, Ohio. In 1897 he went to Pittsburgh, Pa., with the Carnegie Steel Company Ltd., and from 1901 to 1904 was engineer with the American Bridge Company in the same city. Until 1908 Mr. Caddy was engineer with the Riverside Bridge Company at Wheeling, W.Va. In 1908 he was appointed chief engineer of the Dickson Bridge Works Company Ltd., at Campbellford, Ont., and in 1915 entered the service of the Department of Railways and Canals, as assistant engineer on the Trent Canal at Campbellford, where he remained until 1927 when he was transferred to Peterborough. At the time of his death, Mr. Caddy was assistant engineer of the Peterborough-Lakefield portion of the canal.

Mr. Caddy became an Associate Member of The Institute on June 10th, 1911, and on July 22nd, 1919, transferred to full Membership.

William Archibald Spence, A.M.E.I.C.

The death is reported on January 13th, 1933, of William Archibald Spence, A.M.E.I.C., of Oshawa, Ont.

Born at Glenarm, Ont., on November 11th, 1890, Mr. Spence graduated from Queen's University in 1917 with the degree of B.Sc.

From 1917 to 1919 he was a pilot in the Royal Air Force, and in 1919 became assistant on a survey of a portion of the interprovincial boundary between Manitoba and Saskatchewan for the Dominion government. In 1920 Mr. Spence was engaged on development work on mining properties in northern Manitoba, and during the years 1924-1925 was in charge of surveys on the investigation of the Bridge river power project, and the location of a transmission line for the British Columbia Electric Railway Company. In 1926 he was engineer on the construction of sidewalks, sewers, retaining walls, etc., for the municipality of South Vancouver, B.C., and in 1927 was engineer for the Thomsen and Clark Timber Company Ltd., in charge of logging, railway location and construction. In 1928 Mr. Spence was with Dominion Explorers Limited, at Fort Churchill, Man., and since 1930 has lived at Oshawa, Ont.

Mr. Spence joined The Institute as an Associate Member on May 18th, 1928.

PERSONALS

Julian C. Smith Elected President of Shawinigan

On November 15th, 1933, Julian C. Smith, LL.D., M.E.I.C., was elected president of the Shawinigan Water and Power Company. Mr. Smith has been vice-president and managing director of the company.

For over thirty years Mr. Smith, who was president of The Institute for the year 1928, has been identified with the development and transmission of hydro-electric power throughout Canada, and particularly in the province of Quebec.

Following graduation from Cornell University in 1900 with the degree of M.E., he began his business career as a draughtsman with Wallace C. Johnston, at Niagara Falls, N.Y., and in 1902 joined the organization of the Shawinigan Water and Power Company as assistant engineer of the company's plant at Shawinigan Falls, Que. In 1903 he was appointed superintendent of the plant, and gradually advanced to the position of general superintendent and chief engineer of the company. The next change was in 1913 when he became vice-president of the company, and this was followed by his appointment as vice-president and general manager in 1916. Besides the position which he holds with the Shawinigan Water and Power Company, Mr. Smith presides over the activities of its many subsidiary companies.

He has been the recipient of many honours, and in 1922 the degree of Doctor of Laws was conferred upon him by Queen's University in recognition of his high attainments.

R. G. Watson, A.M.E.I.C., formerly of Montreal, is now located in Toronto, where he has entered into partnership with Mr. D. C. Ferguson, and is specializing in plant design and improvements. Mr. Watson was at one time mechanical superintendent with the Nova Scotia Steel and Coal Company Ltd., at Wabana, Nfld., and in 1925 was chief engineer for the St. John Dry Dock and Shipbuilding Company, Saint John, N.B. In 1929 Mr. Watson was with the Beauharnois Power Company, and in 1930 with the Beauharnois Construction Company, at Beauharnois, Que.

J. P. M. Costigan, S.E.I.C., is now connected with T. Pringle and Son, Montreal. Mr. Costigan graduated from McGill University in 1926 with the degree of B.Sc. He was for a time assistant engineer with the Shawinigan Water and Power Company, and later was on the staff of the North Shore Power Company. In 1930 he returned to the Shawinigan Water and Power Company as assistant district engineer at Three Rivers.

Charles W. Crossland, S.E.I.C., who graduated from McGill University in 1931 with the degree of B.Sc., and later obtained the degree of M.Sc. from the Massachusetts Institute of Technology, is now located at Kingston-on-Thames, Surrey, England, where he is engaged in the stress department of Hawker Aircraft Limited.

D. G. MacKenzie, A.M.E.I.C., has been added to the board of directors and appointed vice-president and general manager of the Rogers-Majestic Corporation, Limited, Toronto. Following graduation from McGill University in 1921 with the degree of B.Sc., Mr. MacKenzie was engineer in charge of special road and bridge construction for the Roads Department of the Province of Quebec, and in 1926 was sales engineer in charge of engineering supplies department with the Drummond McCall Company, Montreal. Later in the same year he was secretary-treasurer and chief engineer for La Société Générale de Ponts et Chaussées, Limitée, Montreal. From 1926 to 1929 Mr. MacKenzie was consulting engineer with Johnson and Johnson, New Brunswick, N.Y., and from 1929 has been vice-president in charge of development with Don Mack Products Corporation, New York. He was also from 1930-1932 vice-president of Gilmour Brothers Limited, Montreal.

Proposed Amendments to By-laws

Following the work of the Committee on Development and later investigations by a Committee of Council, the recent Plenary Meeting of Council decided that it was desirable to propose a series of amendments to the present by-laws. These were intended to cover the many points which have received discussion and proved to be such as to require re-arrangement or change in much of the text of the existing by-laws. For the sake of clarity Council's proposals have, therefore, been embodied in a new set of by-laws, the adoption of which would involve the repeal of all existing by-laws.

These proposed new by-laws are printed below, and are now presented for the consideration of corporate members as provided by section 75 of the present by-laws, following which they will be submitted for discussion at the Annual General Meeting. In the pages which follow, the relation of the proposed by-laws to those now existing is indicated by brief notes in italics, and it may be added that the material of certain sections of the present by-laws is not contained in the new proposals. This applies to the existing sections 2, 24, 45, 58 to 63 inclusive, 65, 66, 74.

November 20th, 1933.

Objects

Section 1.—The objects of The Institute shall be (*a*) to facilitate the acquirement and the interchange of professional knowledge, (*b*) to collaborate with universities and other educational institutions for the advancement of engineering education, (*c*) to provide means whereby its members may be of service to the profession and to the community in general, (*d*) to co-operate with other technical societies or professional organizations for the advancement of mutual interests, (*e*) to enhance the usefulness of the profession to the public, (*f*) to encourage original research, (*g*) to promote the general welfare of its members and generally to maintain high ethical standards in the profession.

(*A rearrangement and modification of the present Section 1.*)

Code of Ethics

Section 2.—Every member shall at all times carry on his work in a manner becoming to a member of the engineering profession and in a spirit of fairness, fidelity and devotion to high ideals.

(*A new Section, replacing the former Code of Ethics.*)

Membership

Classes of members

Section 3.—The membership of The Institute shall consist of Honorary Members, Members, Juniors and Affiliates. Members only shall be styled corporate members; Honorary Members, Juniors and Affiliates shall be styled non-corporate members. A non-corporate member shall not be entitled to vote on Institute affairs, or to hold office as an officer of The Institute, or as chairman or vice-chairman of a branch, or to vote on branch affairs except as hereinafter provided.

(*A modification of the present Section 3.*)

Title

Section 4.—Any Honorary Member, Member, Junior, or Affiliate, having occasion to designate himself as belonging to The Institute, shall state the class to which he belongs, according to the following abbreviated forms: Honorary Members, Hon.M.E.I.C.; Members, M.E.I.C.; Juniors, Jr.E.I.C.; Affiliates, Affiliate E.I.C.

(*A modification of the present Section 4.*)

Resident and Non-Resident Members

Section 5.—Corporate and non-corporate members residing in Canada and not more than twenty-five miles from the headquarters of a branch or at such other distance as may be directed by the council shall be styled branch residents. All others resident in Canada shall be styled branch non-residents. Those residing outside of Canada shall be styled non-residents.

(*A modification of the present Section 5.*)

Honorary Members

Section 6.—Honorary Members shall be chosen from those who have become eminent in engineering or kindred sciences.

(*No change from the present Section 6.*)

Members

Section 7.—(*a*) A Member shall be at least twenty-seven years of age, and shall have an adequate knowledge of the theory of the science of engineering. In determining a candidate's eligibility under this clause, the following will be considered:—

(1) Graduation from a school of engineering recognized by the council will be sufficient proof of theoretical qualifications; (2) Registration as a professional engineer in any of the provincial associations in Canada or equivalent membership in other engineering bodies of a like nature, may, at the discretion of the council, be accepted as sufficient proof of theoretical qualifications; (3) If a candidate lacks the qualifications stated in either (1) or (2), the adequacy of his theoretical knowledge shall be judged by the applicant submitting to an examination which may be waived at the discretion of the council if evidence obtained from his references or from other competent sources is satisfactory. In any case it must be definitely established to the satisfaction of the council that the candidate possesses an adequate knowledge of the theory of the science of engineering.

(*b*) In addition to theoretical qualifications, he shall have been engaged successfully in the active practice of the profession of engineering for at least four years. An appointment as a professor, associate professor or assistant professor of engineering, at a school of engineering recognized by the council, will be considered as active practice of the profession of engineering.

(*Replaces the present Sections 7 and 8.*)

Juniors

Section 8.—(*a*) A Junior shall be at least seventeen years of age, and shall produce a certificate of having passed an examination equivalent to senior matriculation for a school of engineering recognized by the council.

(*b*) He shall either be pursuing a course of instruction in a school of engineering recognized by the council, or be receiving a practical training in the profession, or be engaged in the active practice of the profession of engineering, all under conditions satisfactory to the council.

(*c*) He shall not remain in this class for more than six years after graduation, nor after reaching the age of thirty-three years, unless in the opinion of the council special circumstances warrant the extension of these limits.

(*Replaces the present Sections 9 and 10.*)

Affiliates

Section 9.—(*a*) An Affiliate shall have as educational qualification a leaving certificate from a high school, or a satisfactory diploma from a technical school, or university matriculation, failing which the candidate shall produce evidence satisfactory to the council that he has reached a substantially equal degree of education and culture.

(*b*) He shall also produce evidence that his pursuits, scientific attainments or experience, qualify him to co-operate with engineers in the advancement of professional knowledge, or that he is employed on engineering work under the supervision of, and is responsible to, a corporate member of The Institute.

(*Replaces the present Section 11.*)

Admission and Transfer of Members

Honorary Members

Section 10.—(*a*) Honorary Members shall be elected by vote of the council. Nominations shall be made in writing by not less than five councillors and submitted at any regular meeting of the council. The nominations shall then be submitted to all councillors in the form of a letter ballot. Two or more negative votes shall be cause for rejection. At least thirty affirmative votes shall be required for an election.

(*b*) The number of Honorary Members shall not exceed twenty.

(*c*) The general secretary shall write to the Honorary Member advising him of his election, and shall request him to notify The Institute by letter of his acceptance within three months. Failing such acceptance his election shall be void.

(*A modification of the present Section 25.*)

Members, Juniors and Affiliates

Section 11.—(*a*) Applications for admission to The Institute or for transfer from one class to another, shall be on a form approved by the council, and shall contain a statement over the applicant's signature of his age, residence, the record of his engineering experience, and such other information as may be requested on the form. The applicant shall also undertake to conform to the regulations and by-laws of The Institute if elected or transferred.

(*b*) An applicant for admission or transfer to the class of Member shall give as references the names of at least four corporate members from whom the council shall obtain satisfactory evidence in writing that they know the applicant personally and that he is worthy of admission or transfer.

(*c*) An applicant for admission or transfer to the class of Junior shall give as reference the name of at least one corporate member from whom the council shall obtain satisfactory evidence in writing that he knows the applicant personally and that he is worthy of admission or transfer.

(*d*) An applicant for admission or transfer to the class of Affiliate shall give as references the names of at least three corporate members from whom the council shall obtain satisfactory evidence in writing that they know the applicant personally and that he is worthy of admission or transfer.

(*These subsections are a modification and rearrangement of the present Section 26.*)

(*e*) The application form must be signed in all cases by a corporate member as proposer, and forwarded by him to the general secretary. The proposer shall not be included as one of the applicant's references.

(*This is a new provision.*)

(*f*) Immediately on receipt of an application the general secretary shall forward a copy thereof to the secretary of the branch, if any, to which the applicant would belong. The executive committee of the branch shall thereupon make such enquiries concerning the applicant as it deems to be advisable, and shall recommend to the council the action that it considers should be taken with reference to the application.

(*g*) There shall be published in the Journal of The Institute or in such other way as the council may deem fit, a list of applicants for admission or transfer, containing a concise statement of the record of each applicant and the names of his proposer and references, with a request that members transmit to the council any information in their possession which may affect the eligibility or classification of the applicant.

(*h*) The general secretary shall also forward to each member of council a concise statement of the record of each applicant and the names of his proposer and references on a form to be approved by the council. The forms shall be mailed to councillors at least thirty days before the applications referred to are to be dealt with by the council. Each form must be signed by the councillor returning it, but it is not necessary that he should express a recommendation regarding all or any of the applicants.

(*i*) The procedure described above under subsections (*f*), (*g*) and (*h*) shall not be necessary in the case of applications for membership in the class of Junior received from persons enrolled at schools of engineering recognized by the council.

(*Subsections (f), (g), (h) and (i) are a modification of the present Section 27.*)

(*j*) The council shall consider all the information with reference to each application, making further enquiries 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 not less than twenty-five of the forms referred to in Section 11 (*h*) must have been returned to the general secretary and the recommendations contained in these forms must be placed before the council. If five or more members of council oppose the admission or transfer of the applicant he shall not be elected, otherwise a majority of three-quarters of those present at a council meeting shall determine the election and classification of the applicant under the provisions of Sections 7, 8 and 9.

(*No change from the present Section 28.*)

Notification of Election

Section 12.—(*a*) On the election of a candidate he shall be notified by the general secretary and shall be entitled to the privileges and incur the obligations of membership on payment of the annual fee, or one-half of the annual fee in case the notification is made subsequent to June 30th.

(*A modification of the present Section 29.*)

(*b*) A rejected candidate and his proposer 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.

(*A modification of the present Section 28.*)

Certificate

Section 13.—As soon as possible after the newly elected member has become entitled to the privileges of corporate membership a certificate shall be issued to him stating the date of his election.

(*A modification of the present Section 30.*)

Expulsion and Discipline

Section 14.—(*a*) The council shall have the right to expel from The Institute any corporate or non-corporate member who may be convicted by a competent tribunal of felony, embezzlement, larceny, misdemeanour, or other offence which in the opinion of the council renders him unfit to be a member. Such expulsion shall be effected by causing the name of such member to be erased from the register of members, and such member shall not be entitled to receive previous notice of such expulsion, but upon such expulsion shall be notified in writing by the general secretary to that effect.

(*b*) If, in the opinion of the council, any corporate or non-corporate member be guilty of a breach of the code of ethics adopted by The Institute, or have acted in a manner unbecoming to a member of The Institute or in a manner detrimental to the character, reputation or interests of The Institute, or adverse to the objects of The Institute, the council may discipline such offending member by:

1. Censuring such member in writing by letter addressed to him by the general secretary or by having such member appear in person before the council for the purpose of receiving such censure; or,
2. Suspending the membership of such member for such length of time as the council sees fit; or,
3. Causing the name of such member to be erased from the register and thereby expelling him from The Institute.

(*c*) Any enquiry or investigation with a view to disciplining a member as aforesaid, may be instituted by the council at any time by its own action, or upon the complaint in writing of any member or members, addressed to the general secretary, who shall submit the same for consideration to the council at its next meeting, and such enquiry and investigation shall be conducted in such manner and to such extent and at such time or times as the council may in its absolute discretion decide. No verbal or anonymous complaint against any corporate or non-corporate member shall be considered or acted upon by the council. If the council be of the opinion that any complaint is trivial and not of sufficient gravity or importance to justify an enquiry, the general secretary shall notify the complaining member to that effect, and the council shall not be obliged to take any further action in regard thereto and no further record shall appear in the minutes.

(*d*) No disciplinary action as aforesaid shall be taken by the council unless the same has been approved by the affirmative vote of at least three-fourths of the members of the council present at a meeting specially called for the purpose of considering the same, and at which at least twelve members of the council are present. Should the complaining member or offending member be a member of council, he shall not act as a member of council at any such enquiry or vote on any matter relating thereto.

(*e*) Any member, whose conduct or action is to be made the subject of enquiry with a view to disciplinary action as aforesaid, shall be entitled to be notified by the general secretary by registered letter addressed to his last known place of residence and specifying the nature of the charges against him, and before any such disciplinary action is taken by the council, such offending member shall be given a fair opportunity of being heard by the council, either by appearing in person before it, or, subject to the approval of the council, by submitting to the council a sworn statement in writing addressed to the general secretary.

(*f*) If the council, after holding an enquiry, decides to take disciplinary action, the same shall be duly recorded and the offending member notified thereof in writing by the general secretary.

(*No change from the present Section 31.*)

MANAGEMENT

Officers

Section 15.—The officers of The Institute shall be a president, five vice-presidents, one councillor from each branch having less than two hundred corporate members, two councillors from each branch having two hundred and less than four hundred corporate members, three councillors from each branch having four hundred corporate members, and an additional councillor from each branch for each two hundred corporate members over four hundred.

(*No change from the present Section 12.*)

Term of Office

Section 16.—(*a*) The term of office of the president shall be one year, of the vice-presidents two years, and of the councillors two years, except in the case of councillors representing branches entitled to three or more councillors, whose term of office shall be three years. At least one councillor shall be elected each year from each branch entitled to two or more councillors, and one councillor shall be elected each alternate year from each branch entitled to one councillor. The elections for branches entitled to one councillor shall be so held that as nearly as possible one half of such branches shall elect their councillors in any one year.

(*b*) The term of each officer shall begin at the close of the annual general meeting at which such officer is elected, and shall continue for the period above named or until a successor is duly elected or appointed by the council.

(*No change from the present Section 13.*)

Vacancies

Section 17.—(*a*) A vacancy in the office of president shall be filled by the senior vice-president, and in the office of vice-president by the senior councillor from the zone in which the vacancy occurs, and in the office of councillor by a nominee of the executive committee of the branch concerned.

(*b*) Seniority shall be determined by priority of election to the office in question regardless of continuity of holding the said office. Failing a decision by this means, priority of admission to corporate membership shall determine seniority. An officer filling a vacancy shall hold office for the unexpired portion of the term for which his predecessor was elected.

(*Modification of last portion of the present Section 13.*)

The Council

Section 18.—(*a*) The affairs of The Institute shall be managed by a council consisting of the officers and the three surviving past-presidents who have most recently held that office.

(*b*) The council shall direct the investment and care of the funds of The Institute, shall make appropriations for specific purposes, shall pass upon all applications for admission or for transfer, and in general shall direct the business of The Institute either itself or through its officials and committees, but it shall not incur any expenditure for extraordinary purposes unless previously authorized to do so at the annual general meeting or at a special general meeting called for that purpose.

(c) The council shall make a report at each annual general meeting, transmitting the reports of committees.

(d) The council shall appoint qualified auditors to audit the books and to certify the annual financial statement.

(*A modification of the present Section 14.*)

The President

Section 19.—The president shall have general supervision of the affairs of The Institute and shall be *ex-officio* a member of all committees. He shall preside at meetings of The Institute and of the council.

(*A modification of the present Section 15.*)

The Vice-Presidents

Section 20.—In the absence of the president, or if the president is unable to act, his place shall be taken by a vice-president. Each vice-president shall be the responsible officer of The Institute in his zone, shall take action on his own initiative in all matters of urgency, and shall advise and guide the branches in his zone. He shall not, however, make decisions regarding applications for admission or transfer nor in matters of general policy.

(*A new Section.*)

The Treasurer

Section 21.—(a) The treasurer shall be a corporate member of The Institute. He shall be appointed annually by the council and shall hold office subject to removal by the council.

(b) He shall attend meetings of council and shall sign all cheques, promissory notes, bills of exchange or other orders for the payment of money after he has satisfied himself that the expenditure and payment have been duly authorized. He shall also, with the general secretary, invest the funds of The Institute as may be ordered by the council, and he shall be an *ex-officio* member of the finance committee.

(*A modification of the present Section 17.*)

The General Secretary

Section 22.—The general secretary shall be a corporate member of The Institute. He shall be appointed by the council and shall hold office subject to removal by the council. He shall be the executive official of The Institute under the direction of the president and the council. He shall attend all meetings of The Institute and of the council; he shall present the business therefor and record the proceedings thereof.

He shall see that all moneys due to The Institute are carefully collected, and deposited with the funds of The Institute.

He shall personally certify the accuracy of all bills or vouchers on which money is to be paid and present them to the finance committee or its duly authorized representative for approval, and shall sign all cheques, promissory notes, and orders for the payment of money, as provided in Section 23.

He shall have charge of the books and accounts of The Institute.

He shall be responsible for editing the publications of The Institute.

He shall conduct the correspondence of The Institute and keep full records of the same.

He shall be in responsible charge, under the president and the council, of all the property of The Institute.

He shall, with the approval of the council, employ such help as may be necessary and shall be responsible for the work of all employees of The Institute.

He shall perform such other duties as may be assigned to him by the council.

His time shall be devoted solely to the affairs of The Institute.

He shall give a bond for the faithful performance of his duties, in a sum to be fixed by the council, at the expense of The Institute.

(*The present Section 16 with slight modification.*)

Payment of Accounts

Section 23.—The general secretary and the treasurer shall have authority on behalf of The Institute to draw, accept, sign, make and agree to pay all or any bills of exchange, promissory notes, cheques and orders for the payment of money. Two members of the finance committee may be authorized to act as substitutes for the general secretary and the treasurer for this purpose.

(*New Section, replacing part of the present Section 16.*)

Appointment of Treasurer and Committees

Section 24.—(a) The council shall meet within seven days after its election and shall then appoint the treasurer and from its members the chairmen of the following standing committees whose personnel may be appointed at its discretion by the council or by the chairman of the committee subject to the approval of the council.

A Finance Committee, of five members including the treasurer.

A Library and House Committee, of five members.

A Papers Committee, of such numbers and form as may be determined by the council.

A Publication Committee, of not less than five members representative of the principal branches of the profession.

A By-laws and Legislation Committee, of three members.

An Examinations Committee, of such number and form as may be decided by the council.

(b) The council may at any time appoint special committees for any purpose it deems fit.

(c) All committees appointed by the council shall report to the council and shall perform their duties under the supervision of the council until discharged by the council.

(*Modification of the present Section 18, with addition of an Examinations Committee.*)

Finance Committee

Section 25.—(a) Immediately after its appointment the finance committee shall prepare a budget for the following year's operations and shall submit the same to the council for approval.

(b) The finance committee shall have immediate supervision of the financial affairs of The Institute, and may authorize one of its members to certify all vouchers before payments are made.

(c) The finance committee may authorize two of its members to act as substitutes for the general secretary and treasurer for the purpose of signing cheques in the event of their absence.

(d) The finance committee shall make a monthly report to the council of its activities and shall also transmit to the council the auditors' report together with any explanatory remarks which may appear advisable.

(e) The finance committee shall make recommendations to the council regarding the investment of moneys and any matters directly affecting the revenues and expenditures of The Institute.

(*Modification of the present Section 19.*)

Library and House Committee

Section 26.—The library and house committee shall have general supervision of the library and house of The Institute and of the property therein.

(*Modification of the present Section 20.*)

Papers Committee

Section 27.—The papers committee shall advise and assist in obtaining papers for the meetings of The Institute or its branches, and shall carry out such functions in connection therewith as may be delegated to it by the council.

(*Modification of the present Section 21.*)

Publication Committee

Section 28.—The publication committee shall act in an advisory capacity to the editor of The Journal or other Institute publications and shall be responsible for the selection of papers and discussions to be published in the transactions.

(*Modification of the present Section 22.*)

By-laws and Legislation Committee

Section 29.—(a) All proposals to amend by-laws shall be submitted by the general secretary to the by-laws and legislation committee who shall report to the council regarding the propriety thereof. In the case of proposals emanating from the council the committee shall only be required to report on questions of consistency, conflict and wording.

(b) The committee shall consider all suggestions and reports regarding legislation emanating from branches or individuals and shall report thereon to the council, and it shall also keep itself advised of any legislation, actual or proposed, which is likely to affect the interests of The Institute or of its members and shall report to the council thereon.

(*Amplification of the present Section 23.*)

Examinations Committee

Section 30.—The examinations committee shall arrange for the setting and marking of examination papers, and/or for the holding of oral examinations for admission to membership or for transfer. The committee shall arrange for the holding of examinations at suitable places and shall report to the council through the general secretary whether in their opinion the candidate fulfils the educational requirements of the class to which he seeks admission. The chairman of the examinations committee shall keep the council informed of the activities of the committee.

(*A new Section.*)

FEES

Entrance Fees

Section 31.—The entrance fees payable at the time of application for admission to The Institute shall be as follows:

Members	$10.00
Juniors who are not enrolled at schools of engineering recognized by the council	5.00
Affiliates	5.00

(*A modification of the present Section 32.*)

Transfer Fees

Section 32.—(*a*) A member when transferred from any one class to any other shall pay the difference between the entrance fees of the two classes.

(*b*) Entrance or transfer fees shall be refunded to unsuccessful applicants within thirty days of their notification.

(*A modification of the present Section 38.*)

Annual Fees

Section 33.—(*a*) The annual fees shall be due and payable on the first of January for the calendar year then commencing, at which time a bill shall be mailed to each member in accordance with the following schedule of fees:

	Montreal Branch Residents	Branch Residents	Non-Residents
Members	$11.00	$9.00	$7.00
Juniors who are enrolled at schools of engineering recognized by the council	2.00	2.00	2.00
Juniors—all others	7.00	5.00	4.00
Affiliates	7.00	5.00	4.00

(*b*) A deduction of $1.00 will be made in the cases of all Members, Juniors and Affiliates who pay their fees prior to March 31st, which may be taken to include all payments mailed up to midnight of that date.

(*A modification of the present Sections 33 and 34.*)

Journal Subscription

Section 34.—In addition to the annual fee provided in Section 33, every Member, Junior and Affiliate shall subscribe two dollars per annum for The Journal of The Institute, except those Juniors who are enrolled at engineering schools recognized by the council, in whose case the subscription shall be optional. Honorary Members and Life Members shall receive The Journal gratis. Branch Affiliates may receive The Journal upon paying a subscription of two dollars per annum. The annual subscription to The Journal for non-members shall be three dollars.

(*Modification of the present Sections 73 and 74.*)

Compounding of Fees

Section 35.—At the time of his election a corporate member may compound all future annual fees by a single payment of two hundred and fifty dollars. A corporate member in good standing after ten years of corporate membership may compound all future annual fees by a single payment of one hundred and fifty dollars, and after fifteen years of corporate membership by a single payment of one hundred dollars. The money thus received shall be invested and only the income thereof used for the current expenses of The Institute.

(*No change from the present Section 39.*)

Liability of Members

Section 36.—(*a*) Any member elected after the thirtieth day of June shall be liable for only one-half of the annual fees for that year, with a deduction of fifty cents if paid within one month of notification of admission.

(*b*) Any person once admitted to The Institute shall belong thereto, and be liable for the payment of all fees until he shall have resigned, have been expelled or have been relieved from payment by the council.

(*No change from the present Sections 35 and 36.*)

Arrears—Exemptions

Section 37.—(*a*) The general secretary shall notify any member whose fees become in arrears. No member shall be considered in arrears for any year until after the thirtieth day of June of that year. A member who is in arrears shall not have the right to vote, he shall not receive the publications of The Institute, nor shall he be eligible for office in The Institute or any of its branches.

(*b*) Should his fees still be in arrears on the first day of October, he shall again be notified in form prescribed by the council and if still in arrears on the first day of January of the year following, he shall forfeit his connection with The Institute and shall be so notified by the general secretary.

(*c*) The council, however, may for cause deemed by it sufficient, extend the time for payment and for the application of these penalties. Further, the council may for sufficient cause temporarily excuse from payment of annual fees any member who from ill health, advanced age or other good reason assigned, is unable to pay such fees, and the council may remit the whole or part of fees in arrears.

(*Same wording as in the present Section 37.*)

Life Membership

Section 38.—The council, at its discretion, may as a privilege exempt from further payment of annual fees any corporate member who has reached the age of sixty-five, or who has been a corporate member for thirty years, or who has rendered signal service to The Institute. The names of such members shall be placed on a life membership list.

(*Same wording as in the present Section 37.*)

Re-Admission

Section 39.—The council at its discretion, may re-admit, with or without the payment of a second entrance fee, any person who has resigned or who has ceased to be a member for non-payment of fees.

(*Same wording as in the present Section 40.*)

NOMINATION AND ELECTION OF OFFICERS

President

Section 40.—The three surviving past-presidents who have most recently held that office shall nominate one corporate member for the office of president.

(*A new Section.*)

Vice-Presidents

Section 41.—(*a*) The membership of The Institute shall be divided into five vice-presidential zones as follows: Zone A—the provinces of Manitoba, Saskatchewan, Alberta and British Columbia; Zone B—the province of Ontario; Zone C—the Montreal Branch territory; Zone D—the province of Quebec exclusive of Zone C; Zone E—the Maritime Provinces.

(*b*) The chairmen of the branches within each zone shall form the nominating committee for vice-president for that zone, with the exception of Zone C for which the Montreal Branch executive committee shall act as a nominating committee.

(*c*) The branch chairman within each zone who has seniority by virtue of priority of admission to corporate membership in The Institute shall act as chairman and organizer of the nominating committee for vice-president within his zone.

(*d*) Each alternate year the nominating committee for vice-president for each zone shall nominate for the office of vice-president one or more corporate members resident within that zone.

(*A rearrangement of the present Section 64 and part of Section 67.*)

Councillors

Section 42.—Branch executive committees shall nominate councillors for their respective territories from the corporate members resident therein.

(*A new Section.*)

Number of Nominations and Acceptance

Section 43.—One or more nominations may be submitted for each vacancy, except that of president, and each nomination must be accompanied by a letter of acceptance from the nominee.

(*Rearrangement of part of the present Section 67.*)

Nominating Dates

Section 44.—(*a*) The nomination for the office of president shall be submitted to the council not later than at the first meeting of the council in the month of September, following which the chairmen of the nominating committees for vice-presidents shall be notified of the nomination.

(*b*) Nominations for vice-presidents and councillors shall be submitted to the council not later than the fifteenth day of October.

(*c*) If nominations are not made as provided in Sections 40, 41, 42, 43 and 44 (*a*) and 44 (*b*), council shall make the necessary nominations.

(*d*) If any nominee be found ineligible through non-payment of fees, through non-acceptance of nomination, or other cause, the council shall nominate a substitute.

(*Rearrangement of parts of the present Sections 67 and 68.*)

Publication of Nominations

Section 45.—The list of nominees for officers shall be published in the November issue of The Journal of The Institute or in such other manner prior to November fifteenth as may be directed by the council.

(*Covers part of the present Section 68.*)

Additional Nominations

Section 46.—Additional nominations for the list of nominees for officers, signed by ten or more corporate members and accompanied by written acceptances from those nominated, if received by the general secretary within thirty days of the publication of nominations as required under Section 44, shall be accepted by the council and shall be placed on the officers' ballot. The words "Special Nomination" shall be printed conspicuously near such names and the names of the members making such nominations shall be printed on some part of the officers' ballot.

(*No change from wording of second paragraph of the present Section 68.*)

Officers' Ballot

Section 47.—(*a*) A ballot form prepared in accordance with the nominations shall be mailed to each corporate member at least thirty days before the annual general meeting.

(*b*) The ballot form shall state the names in alphabetical order and the residences of the nominees. Each voter shall only vote for a vice-president for his own zone, and/or for councillors to be elected from his own branch territory. Suitable directions shall be printed on each ballot form.

(c) All letter ballots to be valid shall be enclosed in two envelopes, the inner of which shall have no identifying mark, and the outer, addressed to the general secretary, shall be identified by the signature of the voter. They must be delivered to the general secretary not later than twelve noon of the day of the annual general meeting, when the polls shall be closed, and the ballot shall be canvassed by scrutineers appointed by the annual general meeting.

(*Rearrangement of the present Sections 70, 71 and part of 69.*)

Elections

Section 48.—The nominee receiving the highest number of votes for any office shall be declared elected to that office. In the event of a tie between two or more nominees for the same office, election shall be determined by the priority of admission to corporate membership. If a tie still exists, the presiding officer at the annual general meeting shall cast a deciding vote.

(*A modification of the present Section 73.*)

MEETINGS

Annual General Meeting

Section 49.—(*a*) The annual general meeting of The Institute shall begin on the fourth Thursday in January, or on such other day as the council may direct, at the headquarters of The Institute, and notice thereof shall be published in The Journal of The Institute, or notice may be given in such other manner as the council may direct, provided always that at least eighteen days are allowed to elapse between mailing the notice and the date of the meeting.

(*b*) The council shall present its report, signed by the president and general secretary, of the proceedings of The Institute for the preceding calendar year. The financial statement prepared by the auditors, reports of standing committees, of branches and such other reports as the council may determine, shall be presented. The address of the retiring president shall be delivered. The vote for the election of officers shall be announced. Any other business pertinent to the affairs of The Institute may be transacted at this meeting.

(*c*) Thirty corporate members shall constitute a quorum.

(*A modification of the present Section 41.*)

Special General Meetings

Section 50.—Special general meetings of The Institute may be called by the council, and shall be so called on receipt of written requests from thirty corporate members or from a majority of the branches. The notice for such a meeting shall state the specific object thereof and shall be mailed at least thirty days before the date of the meeting. No other business shall be taken up. Thirty corporate members shall constitute a quorum.

(*No change from the present Section 42.*)

General Professional Meetings

Section 51.—General professional meetings of The Institute may be held once a year in each province subject to the approval of the council and also at such places and times as the council may direct, for the presentation of papers and the discussion thereof, visiting engineering works of interest, and generally for professional intercourse.

(*No change from first paragraph of the present Section 43.*)

Meetings of Council

Section 52.—The council shall meet at least once each month, from the beginning of October to the end of April and at such other times as may be deemed necessary. Five members shall constitute a quorum.

(*No change from the present Section 64.*)

Standing Committees

Section 53.—Standing committees shall meet with sufficient frequency to transact properly the business before them. One-half of the membership of the committee shall constitute a quorum.

(*A modification of the present Section 46.*)

Presiding Officer

Section 54.—In the event of the absence of the president, one of the vice-presidents, and in the absence of the vice-presidents, a member of the council, shall preside at all meetings of The Institute and of the council. In the absence of the officers above mentioned, the meeting shall select a member to act as chairman.

(*No change from the present Section 47.*)

BRANCHES

Formation and Title

Section 55.—(*a*) A branch of The Institute may be established under the authority of the council at the request of ten or more corporate members who are desirous of forming themselves into such a branch.

(*b*) Branches shall be distinguished by the name of their locality, as for example, "The Montreal Branch of The Engineering Institute of Canada."

(*No change from the present Section 48.*)

Branch Membership

Section 56.—(*a*) The membership of a branch shall consist of the members of The Institute of all classes residing within an area known as the branch territory and so allocated that such members are members of the branch most convenient geographically, branch territories to be so apportioned that all members of all classes resident within the Dominion shall be members of a branch. The boundaries of the branch territories shall be determined by the council.

(*This subsection is a modification of the first paragraph of the present Section 49.*)

(*b*) A non-resident member shall have the right to designate himself a member of any branch he may choose, failing which designation he shall be attached, for Institute voting purposes only, to the Montreal branch.

(*c*) Branches may at their option admit persons not members of The Institute who shall be styled Branch Affiliates. The qualifications, fees and privileges of branch affiliates shall be such as may be specified by branch by-laws.

(*Subsections (b) and (c) are the last two paragraphs of the present Section 49, unchanged.*)

Financial Responsibility

Section 57.—The establishment of a branch shall not release members from any of their obligations to The Institute, nor shall The Institute be liable for any expense incurred by a branch.

(*No change from the present Section 50.*)

Management

Section 58.—(*a*) Each branch shall be managed by an executive committee which shall include:—A chairman, secretary and treasurer, and not less than three other members, all to be known as elected members and to be balloted for by all members of the branch entitled by branch by-laws to vote at branch elections.

The secretary and treasurer may, as an alternative, be appointed by the executive committee, instead of being elected by the members of the branch.

(*b*) Those members of the council resident within the branch territory, the immediate past-chairman, and the immediate past-secretary, shall all be known as *ex-officio* members, the two latter only for the year immediately following their term of office.

(*A modification of the present Section 51.*)

Sections of Branches

Section 59.—(*a*) At the request of ten corporate members of a branch made in writing to the secretary of the branch, and approved by the executive committee, sections of the branch may be established, corresponding to any of the generally recognized divisions of the engineering profession, such as chemical, civil, electrical, mechanical, mining, etc.

(*b*) Student or Junior sections may likewise be established at the request of ten members of a branch, made in writing to the secretary of the branch, and approved by the executive committee.

(*c*) The rules for such sections shall be submitted to council for approval.

(*Same provisions as in the present Section 52.*)

By-laws

Section 60.—Branches shall adopt by-laws governing the election of officers, the holding of meetings, and other matters of local jurisdiction. As far as possible, there shall be uniformity in the by-laws of all branches of The Institute. The draft of the by-laws and of amendments or additions thereto, shall be submitted to the council for approval, and shall then be submitted by letter ballot to the vote of the corporate members of the branch for final adoption.

(*No change from the present Section 53.*)

Functions

Section 61.—The branches shall promote the objects and interests of The Institute, and shall encourage the preparation of papers and addresses on engineering subjects or on subjects of scientific or engineering interest, both for presentation at meetings of the branch and of The Institute.

(*No change from the present Section 54.*)

Annual Report

Section 62.—Each branch shall submit an annual report of its proceedings and of its finances to the general secretary, who shall present it to the annual general meeting of The Institute.

(*No change from the present Section 55*)

Revenue

Section 63.—(*a*) The general secretary shall each year remit to each branch a rebate of the annual fees, current or arrears, received from the members of that branch during that year, payments being made quarterly as follows: Thirty per cent to all branches having a corporate membership of less than one hundred, twenty-five per cent to all branches having a corporate membership of one hundred and less than two hundred, and twenty per cent to all branches having a corporate membership of two hundred or more.

(*b*) For the purpose of this by-law, the branch membership list shall be revised on the first day of January and the first day of July in each year but the change shall not be retroactive except in the case of new admissions to The Institute.

(*No change from the present Section 56.*)

General

Section 64.—Where not otherwise provided for, the branches shall conform in rules of order and general procedure to the methods and rules adopted by The Institute.

(*No change from the present Section 57.*)

Amendments

Section 65.—(*a*) Proposals to introduce new by-laws or to amend or repeal existing by-laws shall be signed by at least twenty corporate members, and shall reach the general secretary not later than the first day of October. Such proposals shall forthwith be submitted to the by-laws and legislation committee who shall report thereon to the council as provided in Section 28 (*a*). 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 fifteenth 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 general secretary in time for the December meeting of the council, the date of which shall be announced to the proposers. The proposals, as accepted by the proposers, shall be published in the January issue of The Journal of The Institute or communicated to all corporate members of The Institute in such other manner as the council may direct, provided always that at least eighteen days are allowed to elapse between mailing the proposals and the date of the meeting.

(*b*) Proposals to introduce new by-laws or to amend or repeal existing by-laws, may also be made by the council and shall be communicated to all corporate members in the manner provided in sub-section (*a*).

(*c*) All proposals shall be submitted for discussion at the annual general meeting; the members there present may propose an amendment or amendments thereto, and all proposals together with such amendment or amendments as are accepted by the annual general meeting for that purpose, shall be printed in a letter ballot to be submitted to the corporate membership of The Institute. The general 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 general 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.

(*d*) 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.

(*e*) 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.

(*A modification of the present Section 75.*)

BOOK REVIEW

Modern Materials Handling

By Simeon J. Koshkin, John Wiley and Sons Inc., New York, N.Y., 1932, Cloth, 6 by 9 inches, 488 pp., photos., figs., tables, $6.00.

The preface of this book states that it is an outgrowth of a lecture course given by the author during the past six years at Cornell University, and as such provides a good introduction to the subject for the use of students. Beyond this, however, the book has very little value except for those desiring an elementary knowledge of material handling equipment. A great deal of the subject matter is taken from catalogues issued by the various manufacturers from time to time, and dealing as it does with such a wide range of machinery, does not go into detail fully enough to be of much use to those interested in the design, detail and functioning of such equipment.

It is also noted that there is no reference to equipment used for handling coal and ore in large quantities, such as unloading towers, coal and ore bridges, and box car unloaders; also unloaders for grain are not mentioned—all of which types of equipment are very important in Canada and deserve consideration in a book of this scope.

RECENT ADDITIONS TO THE LIBRARY

Proceedings, Transactions, etc.

American Society of Civil Engineers: Transactions 1933.

Reports, etc.

Toronto Harbour Commissioners:
Facts Concerning Toronto Harbour, 1933.

Canada, Department of Marine, Hydrographic Service:
Tide Tables for the Pacific Coast of Canada, 1934.
Tide Tables for The Atlantic Coast of Canada, 1934.

Canada, Department of Trade and Commerce, Bureau of Statistics:
Transportation and Public Utilities Branch: The Highway and Motor Vehicle in Canada, 1932.

The Smithsonian Institute:
Annual Report of the Board of Regents, 1932.

Canada, Department of the Interior:
Publications of the Dominion Observatory, Ottawa; Bibliography of Seismology No. 18.

University of London:
Calendar 1933-1934.

The Financial Post:
Survey of Mines, Canada and Newfoundland 1933-1934.

Quebec Streams Commission:
Twenty-first Report 1933.

Hydro-Electric Power Commission of Ontario:
Twenty-fifth Annual Report, 1932.

Sewerage and Water Board of New Orleans:
Sixty-sixth Semi-Annual Report, December 31st, 1932.

Dominion Bureau of Statistics:
The Canada Year Book 1933.

Air Ministry, Aeronautical Research Committee, Great Britain:
Reports and Memoranda:
No. 1544—Interference of a Wind Tunnel on a Symmetrical Body.
No. 1549—Fuel Volatility and Carburetter Freezing.
No. 1543—Wind Tunnel Tests on Aerofoils R.A.F. 38 and 48.
No. 1555—Effect of Ailerons on Spinning of Bristol Fighter.
No. 1548—Influence of Wing Elasticity upon Longitudinal Stability.

Technical Books, etc., Received

Electrical Engineering Practice, by Meares and Neale. (*Chapman and Hall, London.*)

BULLETINS

Conveyors—A 4-page bulletin No. CHC-750, has been received from Canadian Hoists and Conveyors Limited, Montreal, containing a description of a new design of conveying belt and idlers which they have just introduced. This employs a flat belt with rubber curbs vulcanized at the edges, made in varying widths from 12 to 48 inches, with capacities up to 800 pounds an hour.

Paint—A 4-page folder has been received from the Electrical Painting Equipment Company, Inc., New York, containing particulars regarding a new airless painting machine which is a self contained electrical unit, easily held in the hand. The use of this machine is said to reduce greatly maintenance and industrial costs through its rapid application of paint and enamels.

Cranes—A 2-page folder received from the Cleveland Tractor Company, Cleveland, Ohio, gives specifications of their commercial utility crane, to be used for material handling, and for regular winch operations. Mounted on a tractor unit, its lifting capacity is from 2,800 pounds at 3 feet to 1,000 pounds at 12 feet.

Electric Motors—The Louis Allis Company, Milwaukee, Wis., have issued a 24-page booklet, containing features of motor development and application, and data on the care and application of motors.

Steam Turbines—Catalogue No. 38-B, containing 16 pages, has been received from Babcock-Wilcox and Goldie-McCulloch Ltd., Galt, Ont. This contains particulars regarding various types of turbines manufactured by the company, together with illustrations and drawings, and giving a list of the information required when asking for quotations.

Concrete—A folder received from the Portland Cement Association, Chicago, contains specifications and pertinent information for making, placing, curing and the protection of concrete in winter.

Compressors—Four pamphlets have been received from the Worthington Pump and Machinery Corporation as follows:

8-page pamphlet giving particulars regarding their single horizontal, single stage steam and motor driven compressors.

6-page pamphlet, with information regarding vertical duplex type compressors for refrigeration use.

8-page pamphlet describing the company's portable, vertical triplex, 3-cylinder compressor with 360 cubic feet displacement.

8-page pamphlet describing the company's portable compressor with 310 cubic feet displacement.

Blowers—A 4-page folder received gives particulars of heavy duty blowers in activated sewage disposal plants manufactured by Roots-Connersville-Wilbraham, Connersville, Indiana. These are of the rotary positive type.

Meters—A 4-page folder published by the National Meter Company of Canada, Ltd., Toronto, describes the advantages of using the oscillating piston meter equipped with meter duplicator in handling petroleum products, and the use on gasoline and fuel pipe lines, unloading racks and tank wagons.

Concrete surfacers—A 28-page bulletin received from the Concrete Surfacing Machinery Company, Cincinnati, Ohio, gives details of concrete and highway surfacers and finishers, their attachments and accessories, together with dimensions of the different models and price lists.

Dumpy Levels—An 8-page pamphlet received gives particulars in connection with the latest type of precise tilting dumpy level manufactured by C. L. Berger and Sons Inc., Boston, Mass.

BRANCH NEWS

Calgary Branch

J. Dow, M.E.I.C., Secretary-Treasurer.
H. W. Tooker, A.M.E.I.C., Branch News Editor.

Television

Television was the subject of an address delivered by Mr. A. M. Mitchell, comptroller of the Alberta Government Telephones, to over one hundred and thirty members and friends of the Calgary Branch on the evening of October 12th, 1933.

By the use of lantern slides the speaker took his audience through the various processes of changing a light ray into electric energy, transferable through wires or the ether to another machine which converted the energy back into a light ray visible to the eye. The whole process consists of turning an actual vision into an optical illusion presented in turn instantaneously to the receiving auditor.

Mr. Mitchell gave a résumé of the early developments and experiments in television, which, quite contrary to what might be anticipated, requires only modest equipment. The speaker went on to say that while there are several systems of television in the experimental stages, he would confine his remarks to the developments made by the Bell Telephone Company of New York, and explained many delicate points involved in transmission and reception performed in their laboratories. The principle of the mechanism of the transmitting station consists of a photoelectric cell used as a "light microphone," one in which the degree of current passing through will be varied in accordance with the intensity of the light striking it. These photoelectric cells become active only when exposed to light, and generate a current so small that it must be measured in millionths of an ampere. Therefore the degree of this current is regulated in exact proportion to the intensity of the light striking the cell. The next problem is to convert these picture impulses into light waves of varying intensity. Consequently the Neon gas lamp was found to answer the purpose admirably. When the gas "Neon" is enclosed in a glass container and subjected to an electrical current of sufficient intensity, the gas will glow, giving forth a pinkish light. This is a little objectionable, but so far no white Neon gas has been discovered. The degree of brilliancy will depend entirely upon the amount of current passing through the lamp.

The Neon lamp has no filament, as its illumination is caused entirely by the use of gas atoms, consequently it may be turned on and off as many as one hundred thousand times a second and still go from total darkness to full brilliancy.

To see an object poised before a "light microphone" three photoelectric cells are used in order to increase the sensitiveness and the scope of the transmitter. Directly to the rear of the photoelectric cells there is what is known as a scanning disc, and back of the scanning disc there is arranged a powerful source of light. This disc is very necessary to control the light source, otherwise the beam of light centred on an object would produce a jumble of impressions on the photoelectric cell. The object must be scanned, that is, it must be explored in a progressive fashion with light, so that a fine but powerful beam will start at the top of the object and sweep across it, first at one level then at a slightly lower level and so on until the object has been illuminated. The scanning disc performs this function, through the agency of holes spirally arranged.

The minute currents of fleeting impressions generated in the photoelectric cells are subjected to powerful vacuum tube amplifiers and connected to one transmitter. The second radio transmitter, working on a different wave length, is used to send out what is known as the synchronizing signal; this keeps the transmitting and receiving apparatus operating at harmonious speed. The third transmitter is used to carry the sound of the performer.

The television receiver is attracted by these picture impulses which are presented in such a fashion as to cause the picture illusion. Due to the synchronizing wave the scanning disc keeps perfect step with the disc at the receiver, i.e., No. 1 hole at the transmitter will be in corresponding position with No. 1 hole at the receiving end, picked up on a standard radio tuner, amplified and carried to the Neon lamp, which is connected to the receiver. In front of the scanning disc is arranged a small aperture usually about 2 inches by 2½ inches through which the observer sees the object at the distant end.

Following the appreciation of the audience for a most interesting and instructive lecture, a hearty vote of thanks was given the speaker.

The meeting adjourned at 10 o'clock p.m.

Hamilton Branch

Alex. Love, A.M.E.I.C., Secretary-Treasurer.
V. S. Thompson, A.M.E.I.C., Branch News Editor.

A very successful combined meeting of the Hamilton Branch E.I.C. and Babcock-Wilcox and Goldie-McCulloch Engineering Society was held in Galt on Tuesday, October 10th, 1933.

The gathering of fifty was addressed by Professor E. A. Allcut, M.E.I.C., of Toronto University, who chose as his subject "Some Aspects of Scientific Management."

Some Aspects of Scientific Management

Professor Allcut opened his address with a definition of the word "management" —"the science or art of reaching a given end with the utmost economy of means." In this connection, wise leadership is more essential to successful operation than extensive organization or perfect equipment. Responsibility for the execution of work must be accompanied by authority to control and direct the means for doing the work. This unfortunately is not always the case. The modern phase of mass production is the logical sequence of the industrial revolution. This has led to a lessening demand for the skill of the craftsman and a greater demand for the semi-skilled operative, a transfer of ownership from sole proprietor to the large company, and lately the aggregation of similar industries. A secondary result has been the removal of personal contact between employer and employee, an important matter in labour disputes.

The mechanization of industry, for which of course engineers are responsible, is, however, here to stay, but it is still inaccurate to assume that most things are made by mass production methods, or even that there has been a sudden increase of such methods in the last ten years.

Generally speaking, there is more unemployment in less mechanized industries. For example, in Great Britain more men were employed in the highly mechanized motor industry during 1932-33 than in 1928, but fewer in the shipbuilding trade over the same period.

The advantages of mass production are:—

1. Expansion of employment in the industry (including raw materials and power).
2. Expansion of employment in distributing trades.
3. Expansion of employment in other industries due to increased spending power.

The restriction of production is fundamentally unsound.

In equipping a plant the points to be considered are:—

1. First cost, i.e. price and installation.
2. Cost to own, which includes interests, depreciation, taxes and insurance.
3. Operation cost, i.e. power, labour, maintenance and rent.

Proper balance of these items will give the best service to customers, best wages to the workers and the greatest advantage to the community as a whole.

There is a definite need of a replacement fund and a depreciation and obsolescence policy which must be governed not merely by physical decrepitude but also by economic necessity and earning power.

One authority has estimated that if plants would buy today such new equipment as would pay for itself in one year, the entire machine tool industry would be back to normal.

In the present stage of world industrialization no nation can afford to considerably reduce working hours unless by international agreement. Previous efforts along this line have not survived the competition of hard times, as witness the Washington Convention of 1919. National spending power is not enhanced by increasing the number of men on full wages unless those wages are earned in the production of more goods.

Increase of wages with no increase in the total volume of trade is merely a transfer of spending power from one section to another. On the other hand, wage cuts lead to lower prices and decreased spending power.

All men will respond to fair treatment. As a rule, wages vary from 27 per cent to 50 per cent of total costs.

Bonus systems lead to disputes unless operation time and basic rate are very carefully studied.

Strikes should always be settled by arbitration as soon as possible, as loss to both sides is inevitable.

The best brains in modern industry are engaged in production, but distribution should be planned with the same care and skill as production. That such is not the case is apparent when it is known that an automobile selling for $600, is made for $100 to $120.

Professor Allcut remarked that the right cure for unemployment is to set people to make the things they lack rather than to employ them upon public works which do not increase present wealth and upon the cost of which interest must be paid.

In closing, it was stated that the objective of scientific management is the elimination of waste, both in labour and material. Like all other systems, however, it is no more perfect than the men who apply it. If, therefore, it is so handled as to be merely a cunningly devised speeding system for the purpose of exploiting labour, its end will be both speedy and certain.

Mr. Crawford of the Babcock Wilcox-Goldie McCulloch Engineering Society occupied the chair at the outset. Mr. Goldie extended a welcome to the visitors from Hamilton. T. S. Glover, A.M.E.I.C., chairman of the Papers Committee, Hamilton Branch, E.I.C., then took the chair and introduced the speaker. Following the address, Mr. Spotton, of the Babcock-Wilcox and Goldie-McCulloch Engineering Society, proposed a vote of thanks to the speaker.

London Branch

W. R. Smith, A.M.E.I.C., Secretary-Treasurer.
Jno. R. Rostron, A.M.E.I.C., Branch News Editor.

The first monthly meeting of the season was held in the Board of Education board room on October 18th, 1933, V. A. McKillop, A.M.E.I.C., Branch chairman, presiding.

The Manufacture of Portland Cement and Its Uses

The speaker was J. M. Breen, A.M.E.I.C., sales engineer of the Canada Cement Company, and his subject "The Manufacture of Portland Cement and Its Uses." The lecture was illustrated by lantern views of the various units at the Port Colborne plant of the company and a description of these views was given by Mr. L. M. McDonald, superintendent of the Port Colborne plant.

Mr. Breen opened by saying that cement had a thousand uses and the aim of the manufacturer is to make his product as good and uniform as possible. The speaker referred briefly to the history of cement and stated that a crude cementing material was used in the building of the Pyramids of Egypt.

In the present day manufacture of Portland cement, the essential elements in cement are lime, silica and alumina. Roughly the lime provides the strength in the cement; silica, alumina and iron determine the setting qualities. There are two distinct processes of manufacture, dry and wet, in the latter the materials are mixed with water to form a slurry which is pumped into the kiln. This method is the most modern and was the one discussed.

At Port Colborne there is an overburden of 6 feet of clay on the limestone. Both of these are excavated and conveyed to the plant. The clay is dumped directly into the wash mill and water added to 55-60 per cent by volume.

The limestone is put through a crusher which reduced it to 6-inch size then a second crusher reduces the size to ¾-inch and under. The next process is the grinding or Unidan mill in which the mixture of stone and clay is ground sufficiently to permit of 92 per cent passing through a 200-mesh sieve. The feed of stone is constant and changes in the lime content are controlled by the addition or removal of clay. From the mill the slurry passes to the correction tanks. The contents of these vary in the percentage of lime which the chemist by means of tests can determine. By mixing the contents of two or more tanks he can get the percentage desired. From the correction tanks the slurry flows by gravity to the mixing tank, where by paddles and compressed air it is kept constantly in agitation. The slurry then passes to a storage basin with a capacity of 12,000 barrels, where it is also kept constantly agitated. From the basin the slurry is pumped to the kiln feeder the speed of which is synchronized with the speed of the kiln. The kiln at Port Colborne is known as the "water glass" type and is the largest revolving unit on this continent.

The kiln consists of a huge metal cylinder (lined with 9-inch high alumina firebrick) 412 feet long and approximately 11 feet in diameter with a slope of ½-inch to the foot. It requires 650 pounds of raw material to produce 350 pounds of cement. Slack coal, dried and pulverized, is the fuel used at Port Colborne. The coal is blown by air into the kiln and ignited, giving a temperature from 2,500 degrees to to 2,700 degrees F. Eighteen per cent of the air required for combustion is blown in and the remainder drawn in by the draught fans. The product of the kiln called "clinker" is discharged into ten coolers 5 feet in diameter and 20 feet long which reduces the temperature of the clinker from 1,200 degrees F. to 250 degrees F. Four per cent of gypsum is added to the clinker before grinding to retard the too rapid setting of the cement. The gypsum and clinker then pass through grinding mills until 90 per cent will pass a 200-mesh sieve and this constitutes the finished product called Portland cement.

After describing the method of storage and bagging (87½ pounds to a bag), the speaker proceeded to give a series of rules for making good concrete, viz.:

1. Clean, well-graded aggregate.
2. Relatively rich mixture.
3. Minimum amount of mixing water, avoid segregation.
4. Thorough mixing, one minute, preferably one and one-half minutes, in a batch mixer.
5. Place concrete in 6-inch layers and rod it to prevent voids or pockets.
6. Cure concrete by keeping it warm and damp for seven days.

Water-Cement Ratio law—Provided sound clean aggregates are used the strength of the concrete is governed solely by the net quantity of mixing water per sack of cement.

When it is desired to expedite the setting of cement concrete the admixture of calcium chloride may be adopted with advantage. A 2 per cent by weight of weight of cement solution was recommended and this was accomplished by mixing 100 pounds of calcium chloride in 25 imperial gallons of warm water and using 2 quarts to every sack of cement.

Following this a movie was given showing the laying of concrete roadways in Quebec province and featuring the employment of up-to-date machinery.

Charts were shown giving costs and quantities per mile and it was noted the cost per mile of pavements have been reduced from $36,000 in 1923 to $17,000 in 1932. In the discussion which followed, W. M. Veitch, A.M.E.I.C., city engineer of London, in moving a vote of thanks to Mr. Breen and Mr. McDonald, asked for information as to the storage of cement, limit of age before using, effect of atmospheric temperature, etc., and also in the case of ready mixed concrete on a long haul whether over-mixing was liable to deteriorate the mixture.

Mr. Breen in reply stated that the mixture was cooled ready for use and if it was kept in a dry atmosphere little deterioration took place. He had known cement stored over the winter that had not lost more than 5 per cent of its efficiency. So long as the cement was not lumpy it could be considered fit to use. As to over-mixing on a long haul, this would not harm the concrete if well spudded when placed. The mixer should not run too fast. As a rule the mixer was started five minutes before the destination. The initial set occurred in one and a half hours and the final set in ten hours.

W. R. Smith, A.M.E.I.C., seconded the vote of thanks.

About thirty members and guests were present, and after the meeting sandwiches and coffee provided by the Executive were much enjoyed.

Moncton Branch

V. C. Blackett, A.M.E.I.C., Secretary-Treasurer.

In honour of his visit to Moncton on October 27th, 1933, Dr. O. O. Lefebvre, M.E.I.C., President of The Engineering Institute of Canada, was entertained by the Branch at a shore dinner held at Bayview restaurant, Cocagne, N.B. Dr. Lefebvre motored to Moncton from Sackville with the Branch chairman, Professor H. W. McKiel, M.E.I.C., after he had addressed the engineering students at Mount Allison University at a luncheon gathering there at noon.

Members of the Branch with their guest left the city by motor at 5.30 and upon arrival at Cocagne enjoyed a sumptuous repast, consisting of oysters, lobsters, etc. During the evening a quartette composed of Messrs. E. A. Cummings, T. H. Dickson, A.M.E.I.C., G. E. Smith, A.M.E.I.C., and James Pullar, A.M.E.I.C., rendered several selections which were enthusiastically applauded.

Professor McKiel announced to the gathering that a member of the Branch executive, H. B. Titus, A.M.E.I.C., was celebrating his birthday anniversary which according to his own reckoning had just reached his majority. He congratulated Mr. Titus on the event and pointed out that one of such comparative youth could look forward to a long and useful life ahead. A birthday cake adorned with 21 lighted candles was then placed in front of Mr. Titus who made a fitting reply in response to the felicitations extended.

Dr. Lefebvre on being introduced by the chairman expressed his deep appreciation of the honour conferred upon him when he had been elected president of such an important organization, only five per cent of which was French speaking. He spoke at length on matters of interest to the engineering profession, referring particularly to the relations between The Institute and the Provincial Engineering Associations. He expressed the hope and belief that in the course of time all would form one Dominion-wide body.

Following Dr. Lefebvre's address, F. O. Condon, M.E.I.C., past Vice-President of The Institute, and G. C. Torrens, A.M.E.I.C., President of the New Brunswick Association of Engineers, spoke briefly.

Psychological Tests as Used in Industries

Psychological tests as used in industries was the subject of an interesting address delivered before the Branch on November 16th, 1933, by Professor C. A. Krug, M.A, of Mount Allison University, Sackville. Professor H. W. McKiel, M.E.I.C., chairman of the Branch, presided. The meeting was open to the public.

For perhaps thousand of years, stated Professor Krug, psychology had been considered merely as a theoretical or speculative study and it was only within recent years that it had been put to practical use. Modern psychology may be defined as the scientific measurement of human behaviour.

The work of the consulting psychologist in general covers efficiency programmes, personnel adjustment in industry and vocational guidance. Standard tests have been devised which indicate the intellectual possibilities with which a person is born. Other tests show fitness for various vocations. Special methods are employed to determine the probable reaction of an individual when faced with an emergency, a knowledge of which has proved of great value to transportation companies.

More and more large industrial concerns are seeking the advice of the psychologist in dealing with their employees. As an example of the benefits derived, Professor Krug cited the case of an American corporation whose weekly labour turn-over was 10 per cent, a situation promptly remedied when scientific methods were introduced in selecting employees. Another instance coming under his own observation was that of a Canadian firm. The sales efficiency of a certain department, suddenly and without apparent reason fell below 50 per cent. On investigation it was discovered that a new employee was undermining the morale of the whole department. The misfit was removed and in two weeks the department was back to normal. Referring to psychological tests on students the speaker said there was considerable difficulty in deciding whether or not a young man could become a successful engineer. The medical student was not so hard to deal with, and easiest of all was passing judgment on a candidate for the ministry.

A discussion followed the address, and a vote of thanks was tendered Professor Krug on motion of C. S. G. Rogers, A.M.E.I.C., seconded by T. H. Dickson, A.M.E.I.C.

Montreal Branch

REPORT OF UNEMPLOYMENT COMMITTEE, MONTREAL BRANCH
Submitted on behalf of the Committee by
C. K. McLeod, A.M.E.I.C., Secretary-Treasurer.

Realizing the seriousness of the unemployment situation amongst engineers, and in accordance with a suggestion of The Institute Unemployment Committee, the Executive Committee of the Montreal Branch appointed an Unemployment Committee in the Fall of 1932. This Committee consisted of Dr. O. O. Lefebvre, M.E.I.C., J. A. McCrory, M.E.I.C., E. A. Ryan, M.E.I.C., and C. K. McLeod, A.M.E.I.C.

A survey of the unemployment situation was made, which showed that approximately 14 per cent of the Montreal Branch were either out of employment or only temporarily employed. It was realized that the Branch could not undertake to assist all of those out of employment, and the committee recommended that assistance be given only to those who were in dire need.

It was realized that the investigation of cases where assistance was asked for would require handling by an experienced organization. Therefore, through Mr. Holliday, the assistance of the Registration Bureau for Office Workers was asked. They kindly consented to investigate any case sent to them, render assistance where necessary and the Branch had only to reimburse them for the actual disbursements made.

In December last a request for subscriptions was sent out to the membership, and the response, while not up to what was requested, has been sufficient to handle the situation up to the present. The financial statement of the fund is as follows:

Subscriptions	$1,351.15	
Bank interest	13.65	$1,364.80
Cost of printing and mailing	27.72	
Financial assistance	1,381.15	1,408.87
Deficit		$44.07

While only those members who were in absolute necessity were assisted, it is noted that the funds have been completely exhausted. The Executive Committee has further studied the situation, and it is felt that any improvement in general business conditions will not materially affect the employment situation amongst engineers throughout this winter. The Committee therefore has felt it essential to call for additional funds, and it is sincerely hoped that the membership will respond at least as generously as they did last year.

Niagara Peninsula Branch

P. A. Dewey, A.M.E.I.C., Secretary-Treasurer.
C. G. Moon, A.M.E.I.C., Branch News Editor.

About twenty-eight members of the Branch motored to Hamilton on the afternoon of November 7th, 1933, to join in a welcome to President Lefebvre.

Visits were made to the filtration plant, the Dominion Foundries and Steel, and Porritt's and Spencer textile mills.

Dinner was held at the Wentworth Arms with E. P. Muntz, M.E.I.C., in the chair, and short addresses were made by A. B. Crealock, A.M.E.I.C., chairman of the Toronto Branch, W. R. Manock, A.M.E.I.C., chairman of the Niagara Peninsula Branch, and O. O. Lefebvre, M.E.I.C., President of The Institute.

The meeting then adjourned to McMaster University where W. G. Milne, A.M.E.I.C., presented some of his moving pictures showing the eclipse of the sun in 1932.

President Lefebvre then discussed various questions relating to The Institute, showing how expenditures had been curtailed to the very minimum and giving a résumé of the business transacted at the recent Plenary Council Meeting in Montreal.

Refreshments were then served and the Niagara Peninsula Branch members left for the drive home feeling that they had enjoyed a very excellent trip and impressed with the fact that the Hamilton Branch had quite lived up to their well-earned reputation for hospitality and efficiency in organization.

Ottawa Branch

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

FUEL RESEARCH

"Fuel Research an Aid to the Solution of Canada's Fuel Problems" was the address given at the noon luncheon on October 19th at the Chateau Laurier by B. F. Haanel, M.E.I.C., chief engineer, Division of Fuels and Fuel Testing, of the Department of Mines.

Group-Captain E. W. Stedman, M.E.I.C., chairman of the local Branch, presided, and in addition head table guests included: F. J. Gaxiola; Dr. H. M. Tory; Dr. Charles Camsell, M.E.I.C.; Dr. G. S. Whitby; Dr. W. H. Collins; Dr. B. R. Mackay; L. L. Bolton, M.E.I.C.; A. F. MacAllum, M.E.I.C.; W. H. Munro, M.E.I.C.; A. L. Entwistle; W. S. Lawson, M.E.I.C.; R. E. Gilmore, M.E.I.C.; G. A. Browne, A.M.E.I.C.; John McLeish, M.E.I.C., and F. C. C. Lynch, A.M.E.I.C.

Mr. Haanel traced the history of fuel research from the time when the fuel value of coal was first discovered down to the present day. He stated that many substances indispensable to our civilization have been derived from coal, including cokes, oils, dye-stuffs, drugs, etc. Concurrent, however, with the research upon coals, has been the discovery and use of other sources of energy, such as crude oils and water powers, which has somewhat complicated problems relating to the use of coal. However, in spite of this, coal is still our principal source of heat energy, the world consumption advancing from a few million tons per year in 1800 to almost a thousand million tons today.

Canada is fortunate in having one of the largest coal reserves in the world, embracing some 17 per cent of the total estimated world supply. This includes all varieties, ranging from anthracite to peat. The geographical location, however, is rather unfortunate, in that these large resources occur at the extreme eastern and western parts of the country, leaving a highly industrialized area in the centre devoid of other than low grade fuel deposits, such as peat and lignites.

The necessity for developing higher temperatures as power apparatus has been improved, has brought out inherent defects in coal that were never before thought of, and one line of research, accordingly, has been the investigation of various types of coals from various localities under different conditions to be imposed upon them. All coals cannot be used in the raw state. Some must be treated before they are suitable for use, for instance, at high temperatures. Up to the present there has not been a uniform system for the classification of coals which would be suitable to ourselves and to other countries with which we deal in connection with imports and exports. At the present time there is being worked out on this continent by fuel technologists in the United States and Canada, such a classification which, it is hoped, will prove acceptable and be put into general use.

Fuel research was undertaken by the principal coal producing countries a little over thirty years ago. In Canada such research was undertaken twenty-six years ago when the Fuel Research Laboratories were organized as a permanent part of the Department of Mines. These laboratories deal with both economic and technical problems and are concerned with the chemical and physical properties, alteration by heat and other treatment, beneficiation by washing, etc., of Canadian coals. Research, by the way, is not confined to coal alone, but also to their by-products.

In conclusion, the speaker remarked that it would appear to him that the desire to use as much of Canada's natural resources as possible is becoming strongly fixed in the minds of large users of coal, and he looks forward to the time when this objective will be brought nearer and render this country independent of foreign fuel resources.

Peterborough Branch

H. R. Sills, Jr. E.I.C., Secretary.
W. T. Fanjoy, Jr.E.I.C., Branch News Editor.

DIESEL ENGINES

"The people of Ontario don't know what power costs are. We are extremely fortunate in our hydro-electric utility. If we had to pay the charges that prevail in Great Britain and many parts of the United States we'd have three kinds of fits."

This incidental commentary on power costs was a parenthesis in the address on Diesel engines, delievered by Lieut.-Colonel E. J. Schmidlin, M.E.I.C., of the Royal Military College, Kingston, at the meeting of the Peterborough Branch, held on November 9th, 1933.

His subject included the principles of the Diesel internal combustion engine, its development and refinements, its economy of operation, and its extensive commercial use. It differs essentially from the gasoline engine in its method of firing the combustible mixture in its cylinder. The gasoline engine employs spark plugs, and the Diesel effects corresponding ignition by compression. Air is drawn into the chamber on the first downward stroke and then on the upstroke is compressed in the ratio of 12 or 15 to one. This compression causes heat, and when the confined air becomes "red hot" the fuel is injected and exploded by the intense heat.

Another material difference necessitated by the method of ignition lies in the time with relation to the stroke at which the fuel is introduced and also the method of introduction. In the gasoline engine, air and "gas" are mixed in the carburetor and are drawn into the combustion chamber during the suction stroke and the mixture is then compressed by the compression stroke and exploded by an electric spark. The Diesel on the other hand has its fuel forced into the compression chamber by mechanical means at or near the time when the charge of air is compressed to its maximum and on meeting this heated air it burns and drives the piston during the power stroke.

The efficiency of an internal combustion engine depends directly on its compression ratio, and the compression ratio of the ordinary engine cannot be increased much beyond about 6½ to 1 otherwise "pre-ignition" will occur. For this reason, the speaker declared the gasoline engine could never be made more efficient than at present.

With the Diesel, however, the compression ratio could theoretically be increased to 100 to 1, but for mechanical reasons is limited to 12 or 15 to 1. The increased efficiency of the Diesel is therefore very apparent.

One of the smaller types of Diesels will deliver one horse power at a cost of half a pound of fuel oil an hour. The medium size engine would increase this cost to one horse power at 4 pounds of fuel, and in the very large size the cost is around .375 pounds of oil per h.p.h.

The first Diesel ran at 125 r.p.m., but in recent years high speeds have been attained up to 2,500 and 3,000 r.p.m. While the speed has been increased in the proportion of 25 to 1, the unit weight has been reduced in the proportion of 50 to 1. Only ten years ago 300 r.p.m. was considered high speed.

Diesel engines non-stop operations exceed 4,000 hours, and the longest continuous performance was 10,000 hours.

The first Diesel built in the United States was put to work in 1897 and is still running, and the first installation on a large scale in oceanic vessels was eight years ago on the Pacific Ocean. This has run more than one million miles without on involuntary stop, and has operated at within 5 per cent of its rated efficiency. The expanding use of the Diesel engine in the large passenger ships was one of its greatest advancements during recent years. Other uses mentioned included motor trucks and busses, Diesel electric railway cars and trains such as those developed by the Reading and New York Central Railway Companies, butter and cheese factories removed from cheap electric power sources, and also for community power requirements.

Quebec Branch

Jules Joyal, A.M.E.I.C., Secrétaire-Trésorier.

La Section de Québec de l'Institut des Ingénieurs du Canada eut son premier déjeuner de la saison 1933-34 au Château Frontenac le 13 octobre dernier.

A cette occasion les membres de la section québecoise avaient le très grand plaisir d'avoir comme invité d'honneur, le Dr. O. O. Lefebvre, M.E.I.C., Président de l'Institut.

Le président de la Section, Monsieur Hector Cimon, M.E.I.C., se fit l'interprète de ses confrères pour exprimer à Monsieur Lefebvre le plaisir que nous causait sa visite et l'invita à nous adresser la parole.

Monsieur Lefebvre a d'abord remercié ses confrères de Québec de l'accueil sympathique et chaleureux qu'ils lui faisaient et les félicita de l'oeuvre accomplie par leur groupement puis en vint à faire certaines remarques sur les affaires de l'Institut.

Le Président fit part à l'assistance que le Conseil de l'Institut entend boucler son budget sans recourir à une souscription spéciale de ses membres et que devant les diminutions des recettes l'Institut se verra dans l'obligation de supprimer certains services; l'annuaire et les "Transactions" entre autres pourraient être retranchées sans que les membres souffrent outre-mesure de leur disparition.

Monsieur Lefebvre a aussi signalé que les Corporations d'Ingénieurs Professionnels sont des créations de l'Institut destinées à prendre en mains le contrôle légal de la profession; il a expliqué que ces associations ne viennent pas en concurrence avec l'Institut et il a invité tous les ingénieurs à leur accorder un appui égal.

Le Président a ensuite exprimé le voeu que tous les ingénieurs canadiens se groupent en une fédération nationale modelée sur l'association des architectes; il a conclu ses remarques en pressant les membres de l'Institut d'étudier bien soigneusement et consciencieusement le rapport qui sera présenté à l'assemblée plénière du conseil afin de se former une opinion raisonnée sur l'opportunité de la réforme que l'on projette de faire subir à l'Institut.

En terminant le Président a attiré l'attention de ses confrères sur la situation pénible faite aux jeunes sortant de nos Universités canadiennes avec le brevet d'ingénieur; plusieurs d'entre eux se voient forcés d'aller grossir les rangs des chomeurs et Monsieur Lefebvre a pressé les ingénieurs plus fortunés de s'intéresser à eux, de ne pas leur ménager les encouragements et de faire l'impossible pour leur assurer une situation viable.

Le Dr. Lefebvre fut remercié par le Dr. A. R. Decary, M.E.I.C., président de la Corporation des Ingénieurs Professionnels de Québec, qui l'a assuré que l'organization qu'il préside entend maintenir les rapports les plus cordiaux avec l'Institut.

A la table d'honneur, en outre de MM. Lefebvre et Cimon, l'on remarquait MM. A. R. Décary, S. F. Rutherford, A.M.E.I.C., A. Amos, T. C. Denis, A. B. Normandin, M.E.I.C., A. O. Dufresne, R. B. McDunnough, A.M.E.I.C., et I. E. Vallée, A.M.E.I.C.

Assistance totale 41.

St. Maurice Valley Branch

J. A. Hamel, A.M.E.I.C., Secretary-Treasurer.

On November 4th, 1933, the first dinner meeting of the St. Maurice Valley Branch was held at Chateau De Blois, Trois-Rivières. The Branch had the honour of listening to an address by Dr. O. Lefebvre, M.E.I.C., President of The Institute. Dr. Lefebvre spoke upon "Engineering Institute Affairs."

In his address, Dr. Lefebvre outlined the history of The Institute in general, and particularly in connection with its relations with the various Provincial Associations of Engineers. He reminded the members that the control of engineering practice cannot be exercised under Dominion charter, by the fact that under the British North American Act the control of the practice of the engineering profession being a matter of education, is one of the prerogatives of provincial legislation and is regulated by provincial laws.

The President also said a few words about the work of the Committee on Development which has, as its principal function, the revising of the by-laws of The Institute.

Bruno Grandmont, A.M.E.I.C., chairman of the Branch, presided over the meeting and the head table guests included Dr. A. R. Décary, M.E.I.C., Past-President of The Institute and President of the Corporation of Professional Engineers of the Province of Quebec; A. B. Normandin, M.E.I.C., Vice-President of The Institute; E. B. Wardle, M.E.I.C., vice-chairman of the Branch.

The meeting was well attended, over forty members being present.

Toronto Branch

W. S. Wilson, A.M.E.I.C., Secretary-Treasurer.
R. E. Smythe, A.M.E.I.C., Branch News Editor.

The first regular monthly meeting of the Toronto Branch for the season 1933-34 was held on October 19th, 1933, at the Royal York hotel and presided over by Archie B. Crealock, A.M.E.I.C., chairman of the Branch. It took the form of a luncheon meeting and was addressed by the Hon. Leopold Macauley, K.C., Minister of Highways, Province of Ontario.

The Financing of Our Highways System

The subject of the address was "The Financing of our Highways System." Mr. Macauley at the outset of his address dealt with the function of roadways and highways in general. Each country had to develop its highway system according to its needs and the financing ability of its people. He cited a case he had met with in England where, notwithstanding that the location was on an old Roman roadway with its consolidated roadbed, the local authorities spent $500,000 per mile in rebuilding. Needless to say, the requirements of Ontario, even in its most densely populated areas, do not warrant such an expenditure.

The roadway system in Ontario is made up as follows:

	Miles
King's highways	2,999
County roads	7,955
Township roads	41,299
Northern Ontario roads	14,291
	66,544

Of this 5,620 miles are paved and 42,400 miles are graded and gravelled, leaving only 18,520 miles without surfacing.

The Ontario government has expended $235,420,086 of provincial funds on these roadways in the past thirty-two years. Added to this, the municipalities have raised and expended $166,485,358 on rural roads, making a gross expenditure of $401,905,444 in this period.

The basis of equitable highway finance is that the cost of construction and maintenance of roads shall be allocated in direct proportion to the benefits derived therefrom. It is indeed a difficult matter to equitably apportion the cost of highways between the local property owners, the active users and the general public. In fact, there is no doubt that every inhabitant of the country benefits from improved roads.

In England, following recent investigations, the conclusion seems to have been reached that motorists should bear approximately two-thirds of the cost, the other one-third being borne by the country as a whole. To date the motorists of Ontario have not been called upon to bear even this share.

To the end of 1932 the net expenditure of the Ontario government on highways amounted to over $235,000,000. During this period only $129,000,000 was collected in taxes from motor vehicle owners, leaving $106,000,000 to be borne by the general public. The expenditure of this government on highways in southern Ontario has been drastically reduced during the past few years, dropping on King's highways from $12,500,000 in 1931 to $7,750,000 in 1932. The subsidies towards county and township roads have also dropped during the same period, $6,700,000 being paid in 1931 as compared with $5,500,000 in 1932. To offset the drop in southern Ontario, however, expenditures have been increased materially in northern Ontario, including construction of the trans-Canada highway. This, of course, was chiefly owing to unemployment, the work in northern Ontario being undertaken largely as a relief measure. During these two years expenditure jumped from nearly $9,000,000 in 1931 to over $15,000,000 in 1932.

Mr. Macauley concluded his remarks by stating his belief that transportation is in a state of adjustment. Increasing numbers of the public and quantities of freight are making use of the public highways for transportation purposes, leaving the heavy and slow moving freight to the railroads. In the same manner, fast moving passenger traffic is taking to the air for rapid transportation. For this reason, judgment must be exercised in proceeding with further great extensions in our highway system.

Ontario has supplied itself with an excellent system of roadways at reasonable cost on which construction in the near future will be principally confined to maintenance.

Victoria Branch

I. C. Barltrop, A.M.E.I.C., Secretary-Treasurer.
Kenneth Reid, Jr.E.I.C., Branch News Editor.

On October 27th, 1933, the Victoria Branch of The Engineering Institute of Canada opened its fall and winter programme with an address by Mr. J. D. Galloway, Provincial Mineralogist, and President of the Association of Professional Engineers of B.C., on the subject "Gold Mining in British Columbia and Relative Engineering Features." The address, which was attended by thirty-three members and friends of the Branch, was preceded by a dinner at the Dominion hotel. H. L. Swan, M.E.I.C., chairman of the Branch, presided.

Gold Mining in British Columbia

Mr. Galloway opened his remarks by saying that to many, gold mining in B.C. meant certain chalk marks and figures on the boards in brokers' offices, but that there was something much more real and important than that.

The history of gold mining in B.C. goes back to 1851, when Indians reported lode-gold in the Queen Charlotte Islands. The pioneering and settlement of B.C. was brought about by the rush to the placer gold fields of the Cariboo in the sixties. In the first ten years over $30,000,000 of golden wealth was turned out.

Old reports do not mention lode-gold mining until 1860, when quartz claims were located at the head of Kitimat Arm. It was not, however, until 1875 that much search was made for lode-gold. This was in the Cariboo district where placer miners commenced searching for the "motherlode" of the rich alluvial deposits.

The building of the Canadian Pacific Railway caused much interest in prospecting and lode-gold discoveries were reported from many districts. The year 1889 was one of importance, for the Nelson area was being settled with miners who were attracted by the silver-lead prospects around Kootenay lake. The district which later became Trail Creek with the city of Rossland, was prospected this year and the first claims were staked.

Rossland, although sometimes considered as a copper camp, has actually been the most important gold-producing section of the province. The official records show that Rossland camp to date has produced $59,000,000 in gold values and only $17,645,000 in copper.

From then on gold discoveries were made in many areas with spectacular operations such as Premier and Pioneer. The total gold production to the end of 1932 was approximately $227,000,000, $80,000,000 of which was placer gold and over $147,000,000 lode-gold.

As placer mining has since taken second place to lode-gold the speaker confined most of his remarks to the latter field.

In 1932 and 1933 nearly 400,000 ounces were mined. It is estimated that reserves are better today than in 1931, say perhaps $40,000,000 in known ore bodies and probable extensions.

The widest distribution of gold, however, is in the quartz-vein type and veins are numerous in British Columbia where no productive mines have been developed. This is particularly true of the central belt of British Columbia containing the Columbia and interior systems of mountain ranges and plateaus. This great belt has no lode-gold production from quartz veins of importance as yet, but it is the belt that has produced the bulk of the 79 millions of placer gold that the province has yielded. Furthermore, geologic evidence clearly shows that the bonanza placers of this area were mainly formed from the erosion and concentration in the streams of gold from quartz veins.

The idea drawn from this is that much more intensive investigation of quartz veins is justified; a more or less casual inspection of random sampling is not sufficient. Under the system in British Columbia the Geological Survey does the areal geology, while the Provincial Bureau of Mines issues much information regarding actual mineral occurrences and prospects. The work of intensive economic geologic investigation of small areas, is, however, also required.

Gold production in the province for 1931, the low point in the present cycle, was $3,018,894; 1932, $3,753,261; and 1933 (estimated), $4,250,000. These figures are based on the standard mint price of $20.67 per ounce. With the addition of the premium returns for the first half of this year averaged $25 per ounce, with a probable return of $27.50 for the full year. In Canadian funds the total production for the year 1933 should be about $6,250,000, probably exceeding the record year of 1913 with $6,137,000.

The present interest in gold mining is shown by the new companies in the provincial field. For the nine months ending September 30th, 1933, there were sixty-eight private and sixty-six public new gold companies in British Columbia, together with ten others totalling one hundred and forty-four new gold companies.

Perhaps one of the greatest benefits of this renewed interest is the resultant increased employment, there being probably one thousand more men employed in gold mining than a year ago.

There have been many new discoveries reported this year in various parts of the province but time will tell how important these are. Prospecting is very active, there having been over 18,000 free miners' certificates issued to date under the new government plan including provisional certificates.

Statistics of the Association of Professional Engineers show that 95 per cent of all registered mining engineers are employed, while for civil engineers only 60 per cent, and electrical and structural engineers only 40 per cent to 50 per cent. Many engineers other than miners have obtained work in the mines, and such professions as surveyors, assayers, etc., have benefited. Mining embraces a variety of engineering branches and provides employment for civil, mechanical, electrical, and other engineers.

Mr. Galloway concluded his address with the showing of fine slides depicting many of the well known mines and methods of gold mining in the province.

The meeting was concluded with a very hearty vote of thanks being tendered the speaker for his enlightening address.

Winnipeg Branch

E. W. M. James, A.M.E.I.C., Secretary-Treasurer.
E. V. Caton, M.E.I.C., Branch News Editor.

A regular meeting of the Winnipeg Branch, Engineering Institute of Canada, was held in Theatre "A," University of Manitoba, Broadway, on Thursday, October 19th, 1933, at 8.15 p.m., with Professor G. H. Herriot, M.E.I.C., in the chair.

There were forty-two members and visitors present.

The speaker of the evening was Major H. G. L. Strange, of the Research Department, Searle Grain Company, who gave a most interesting talk on the subject; "The Course of the Depression and Recovery — Some Facts — Some Fallacies."

The Course of the Depression and Recovery

"Booms and depressions are merely substitute terms for fluctuations in prices" said the speaker who, by means of the first of four charts, showed that the price of wheat for the last 500 years has followed wholesale prices closely. A curve, representing wholesale prices during the last 2600 years, had high peaks at the time of "The Thirty Years' War," "Napoleonic Wars" and "World War." A superimposed curve for the price of wheat since 1700 showed very similar peaks. The curious thing in all three cases was that the price of wheat went to three times the pre-war price. Such fluctuations in prices always harm somebody.

As for the present depression there are two main schools of thought. The first claims that complete recovery from the "World War" was achieved by 1922. From 1923 to 1929 the Western world enjoyed the luxury which it deserved. After 1929 someone, or some group, did something wrong which wrecked the world, and if such a party, or group, could be found and just what they did to wreck the world determined, everything would be all right once more and prices would return to the 1926 level.

The second school of thought attribute the cause of the depression to the rapid rise of prices after the war. It was with this school with which the speaker agreed.

Major Strange then went on to describe the economic effect of "The Thirty Years' War," "Napoleonic Wars" and "World War." He explained that the march of economic events after the "Napoleonic Wars" and "World War" were closely related. There was an exact similarity in the circumstances.

Farmers represent 50 per cent of the buyers in the world, said the speaker, and when prices return to the 1914 level the farmers' wheat will sell on a par with commodities and good times will have returned.

With the aid of another chart Major Strange showed how, based on 1914 levels, prices were away out of line. Since 1914 prices have become all splayed out, up until June 1932 when a marked change, with a tendency to return to the 1914 datum, was noted.

There was ample gold in the world. There was never a time in the history of the world when there was so much money. The trouble was the non-confidence of holders, in lending, due to prospects of little or no return.

The claim that there was over-production of world wheat was untrue; the production of wheat in the world this year would be less than in 1925.

Among those taking part in the discussion were the chairman, T. C. Main, A.M.E.I.C., Mr. Schumacher, T. L. Woodhall, S.E.I.C., and several visitors.

Mr. H. M. White moved a hearty vote of thanks to the speaker, and the meeting adjourned at 11.30 p.m.

The Fusenko Power Plant, Korea

The Fusenko power plant, situated on the Fusenko river in Korea, is the largest hydro-electric installation in the Far East. The upper reaches of the Fusenko river flow through the Kantairi valley, where it is dammed to form a reservoir. This reservoir extends over an area of 9.3 square miles and has a storage capacity of approximately 25,000 million cubic feet.

A pressure tunnel of horse-shoe section, having a height of 13 feet 4 inches, a width of 12 feet 4 inches and a length of 17 miles, conducts the water to the surge chamber on the other side of the mountain range, which rises from 4,920 feet to 5,900 feet.

The power station occupies a floor-space of 2,550 square yards and contains four single-wheel double-nozzle Pelton turbines, supplied by Messrs. J. M. Voith of Heidenheim, Germany. These are designed to work under an effective head of 2,180 feet and to develop each 50,000 h.p., with a flow of 1,280 gallons of water per second, the speed being 360 r.p.m. The rotors of these turbines are of cast steel and fitted with thirteen double buckets, the external diameter being 11 feet 4½ inches. The total weight of a rotor is about 11.5 tons. The maximum diameter of the turbine shaft is 21.6 inches.—*Engineering.*

Preliminary Notice

of Applications for Admission and for Transfer

November 24th, 1933

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, 1934.

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

BRIDGE—JOHN FRANKLIN, of Walkerville, Ont., Born at Kincardine, Ont., Dec. 31st, 1900; Educ., B.A.Sc., Univ. of Toronto, 1925; 1925-26, General Electric test course; 1926-30, with the Detroit Edison Co., six months meter installns. of all types, three and a half years in the gen. test divn. of the operating dept., work included considerable research in the equipment field, inspn. of constrn. and mtce. work, and acceptance tests of mfrs. equipment supplied; 1930 to date, electr'l. engr., Canadian Industries Limited, Sandwich, Ont.

References: C. F. Davison, T. H. Jenkins, I. R. Tait, W. J. Campbell, R. C. Leslie.

GOODWIN—EDWARD ARTHUR, of Montreal, Que., Born at St. Helens, Lancashire, England, June 13th, 1890; Educ., 1905-11 (Nights) St. Helens Technical School; Board of Education and City and Guilds Certs. in applied mechanics, machine design and drawing; 1905-07, ap'tice, Robinson Cook & Co., St. Helens, chem. engrs. and pump makers (turning and fitting shops); 1907-11, premium ap'tice, Robt. Daglish & Co., St. Helens, steam engines and boiler makers (full training and drawing office); 1911-14, asst. dftsman. (design of hoisting mchy. (steam) pumping engines and boilers), with same company; 1915-19, technical officer in charge of aeronautical constrn. (Major commanding an Aeroplane Repair Park); 1919-21, asst. engr., Sutton Heath and Lea Green Collieries Ltd., St. Helens; 1921-24, designing engr. and erection supervisor, Stewart & Lloyds Ltd., Birmingham, design and erection of high and low press steam pipes, boiler plant layout; 1924-26, chief engr., Dye and Chemical Co. of Canada Ltd., Kingston, Ont.; 1927-28 designer, J. M. Robertson, M.E.I.C., Montreal; 1928-29, designer, H. S. Taylor, M.E.I.C., Montreal; 1929-30, designing engr., Dominion Engineering Works, Montreal; 1930-31, designer to United Engineers and Constructors Ltd. (Canada), Montreal; 1931 to date, chief engr., Silent Glow Oil Burner Corporation Ltd. (Canada), Montreal, Que.

References: F. S. B. Heward, R. M. Henderson, K. G. Cameron, G. S. Davis, G. R. Pratt, L. H. Birkett, J. M. Robertson.

HARKNETT—STEWART GEORGE, of Gainsborough Apts., Winnipeg, Man., Born at Chelmsford, Essex, England, March 22nd, 1905; Educ., 1922-26, Science and Art School, Chelmsford, and pupil ap'tice at the electr'l. engrg. works of Messrs. Crompton & Co., England; 1926-33, with Crompton Parkinson Ltd. (formerly Crompton & Co.), 1926-29, estimating for all kinds and sizes of electr'l. plant including complete power factor correction and similar schemes; 1929-30, advising customers and drawing up specifications, preparing complete schemes for layout of new factories, small power stns., etc., and supervising erection, installn., cabling, testing and mtce. of above; 1930-33, advising as to advantages or otherwise of various designs of electr'l. equipment; at present, manager, electr'l. dept., Mumford Medland, Winnipeg, Man., with practically same duties as outlined above. (Assoc. Member Inst. E.E.).

References: E. V. Caton, L. M. Hovey, T. C. Main, F. A. Becker, R. H. Andrews.

MAILHIOT—ADHEMAR, of Montreal, Que., Born at Ste Julienne, Que., March 11th, 1884; Educ., Civil, Mining and Chem. Engr., Ecole Polytechnique, Montreal, 1910. One year post graduate studies at Ecole Supérieure des Mines, Paris, France; 1910-18, asst. professor of geology and mining, and from 1918 to date, professor of mining, geology and metallurgy, Ecole Polytechnique, Montreal.

References: A. Frigon, O. O. Lefebvre, A. R. Decary, T. J. Lafreniere, A. B. Normandin, H. Massue, A. Duperron, H. Cimon.

FOR TRANSFER FROM THE CLASS OF JUNIOR

WIGHTMAN—JOHN, of Amos, Que., Born at Digby, N.S., Feb. 1st, 1900; Educ., B.Sc. (Mining), McGill Univ., 1922; 1922-23, surface surveying (railway and concentrator constrn., foundations, steel, etc.), Cons. Mining and Smelting Co. of Canada, Ltd., Kimberley, B.C.; 1923-24, underground surveying, Sullivan Mine; 1924-25, mine surveyor, at Upper Mine, Kimberley, B.C.; 1925-26, surveying and standardizing maps at the Coast Copper Co. mine, Vancouver Island; 1926 to date, with the Cons. Mining and Smelting Co. of Canada—1926-32, in charge of mine examination work and exploration in Nova Scotia, New Brunswick, Newfoundland and Labrador. At present, field engr., examining mining properties, and in charge of preliminary development in Quebec gold district, Rouyn to Senneterre. (*St. 1920, Jr. 1928.*)

References: J. R. Morrison, A. P. Theuerkauf, R. R. Moffatt, K. H. Marsh, S. C. Mifflen, W. S. Wilson.

FOR TRANSFER FROM THE CLASS OF STUDENT

BLACK—FRANK LESLIE, of Sackville, N.B., Born at Moncton, N.B., Sept. 14th, 1909; Educ., B.Sc. (E.E.), N.S. Tech. Coll., 1931; 1929 (summer), recorder and dftsman on geol. survey party; 1930 (summer), electrn's helper for Shawinigan Engrg. Co.; 1930-31 (winter), electrn. for Nova Scotia Technical College; 1931-32 (winter), radio serviceman for Maritime Accessories Ltd., Halifax; 1932 to date, asst. professor in engrg. dept., Mount Allison University, Sackville, N.B. (*St. 1930.*)

References: F. L. West, H. W. McKiel, G. L. Dickson, F. R. Faulkner, G. H. Burchill.

WILFORD—JOHN RICHARD, of Lindsay, Ont., Born at Iroquois, Ont., Nov. 29th, 1898; Educ., 1919-22, Faculty of Applied Science, Univ. of Toronto. Did not graduate. Left in 1922 on account of illness. Training in aerodynamics with R.N. A.S., 1916-18; 1919-21 (summers), timekeeping, etc., on constrn. jobs, with F. R. Wilford & Co. Ltd., engrs. and gen. contractors; 1922-24, confined to Sanatoria; 1924 to date, with F. R. Wilford & Co. Ltd., 1924-26 as office manager and later as supervisor on constrn. jobs, and at present, secretary, estimator and supt. Work included the following: 1926, supervising constrn. of factory, Beal Leather Co., Lindsay; 1927, supervising constrn., laundry bldg., Lindsay Hospital—renovation of store for Loblaw Groceterias, Lindsay; 1928, suptg., warehouse, McColl Frontenac Co., Lindsay; 1928, supervising, grading job, Dept. Highways; 1929, in charge constrn. of warehouse, Shell Co. of Canada, Lindsay; 1929, in charge constrn., 3½ miles grading and macadam highways, Dept. of Highways, Collingwood; 1930, completion of above and additional work in stone crushing, Collingwood; 1931, addition to Lindsay Hospital, in charge of additions to two schools, Belleville; 1931-32, stone crushing, Dunsford, Ont.; 1933, no work on hand. (*St. 1920.*)

References: F. R. Wilford, C. H. Mitchell, A. L. Killaly, E. L. Miles, A. A. Smith.

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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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MECHANICAL ENGINEER, Canadian, with technical training and executive experience in both Canadian and American industries, particularly plant layout, equipment, planning and production control methods, is open for employment with company desirous of improving manufacturing methods, lowering costs and preparing for business expansion. Apply to Box No. 35-W.

MECHANICAL ENGINEER, A.M.E.I.C. Married. Experience in machine shops, erection and maintenance of industrial plant mechanical and structural design. Reads German, French, Dutch and Spanish. Seeks any suitable position. Apply to Box No. 84-W.

YOUNG ENGINEER, B.A., B.SC., A.M.E.I.C., R.P.E., Ont. Competent draughtsman and surveyor. Eight years experience including design, superintendence and layout of pulp and paper mills, hydro-electric projects and general construction. Limited experience in mechanical design and industrial plant maintenance. Apply to Box No. 150-W.

PURCHASING ENGINEER, graduate mechanical engineer, Canadian, married, 34 years of age, with 13 years' experience in the industrial field, including design, construction and operation, 8 years of which had to do with the development of specifications and ordering of equipment and materials for plant extensions and maintenance; one year engaged on sale of surplus construction equipment. Full details upon request. Apply to Box No. 161-W.

CIVIL ENGINEER, age 44, open for employment anywhere, experience covers about 20 years' active work, including 7 years on municipal engineering, 2 years as Town Manager, 3 years on railway construction, 3 years on the staff of a provincial highway department, 2 years as contractor's superintendent on pavement construction. Apply to Box No. 216-W.

REINFORCED CONCRETE ENGINEER, B.SC., P.E.Q., eight years experience in construction design of industrial buildings, office buildings, apartment houses, etc. Age 30. Married. Apply to Box No. 257-W.

MECHANICAL ENGINEER, B.Sc., McGill '19, A.M.E.I.C. Married. Twelve years experience including oil refinery power plant, structural and reinforced concrete design, factory maintenance, steam generation and distribution problems, heating and ventilating. Available at once. Location immaterial. Apply to Box No. 265-W.

ELECTRICAL ENGINEER, B.SC., '28, Canadian. Age 25. Experience includes two summers with power company; thirteen months test course with C.G.E. Co.; telephone engineering, and the past thirty months with a large power company in operation and maintenance engineering. Location immaterial and available immediately. Apply to Box No. 266-W.

PLANE-TABLE TOPOGRAPHER, B.SC., in C.E. Thoroughly experienced in modern field mapping methods including ground control for aerial surveys. Fast and efficient in surveys for construction, hydro-electric and geological investigations. Apply to Box No. 431-W.

ELECTRICAL ENGINEER, B.SC., A.M.E.I.C., AM.A.I.E.E., age 30, single. Eight years experience H.E. and steam power plants, substations, etc., shop layouts, steel and concrete design. Location immaterial. Available immediately. Apply to Box No. 435-W.

CIVIL ENGINEER, B.A.SC., and C.E., A.M.E.I.C., age 30, married. Experience over the last ten years covers construction on hydro-electric and railway work as instrumentman and resident engineer. Also office work on teaching and design, investigations and hydraulic works, reinforced concrete, bridge foundations and caissons. Location immaterial. Available at once. Apply to Box No. 447-W.

CIVIL ENGINEER, B.SC., A.M.E.I.C., with six years experience in paper mill and hydro-electric work, desires position in western Canada. Capable of handling reinforced concrete and steel design, paper mill equipment and piping layout, estimates, field surveys, or acting as resident engineer on construction. Now on west coast and available at once. Apply to Box No. 482-W.

Situations Wanted

MECHANICAL ENGINEER, B.SC. Age 28, married. Four and a half years on industrial plant maintenance and construction, including shop production work and pulp and paper mill control. Also two and a half years on structural steel and reinforced concrete design. Available at once. Apply to Box No. 521-W.

CIVIL ENGINEER, Canadian, married, twenty-five years' technical and executive experience, specialized knowledge of industrial housing problems and the administration of industrial towns, also town planning and municipal engineering, desires new connection. Available on reasonable notice. Personal interview sought. Apply to Box No. 544-W.

ELECTRICAL AND MECHANICAL ENGINEER, B.SC., A.M.E.I.C. Experience includes C.G.E. Students Test Course and six years in engrg. dept. of same company on design of electrical equipment. Four summers as instrumentman on surveying and highway construction. Recently completed course in mechanical engineering. Available at once. Location preferred Ontario, Quebec, or Maritimes. Apply to Box No. 564-W.

CIVIL ENGINEER, age 25, single, graduate. Creditable record on responsible hydro and railroad work in both Eastern and Western Canada. Apply to Box No. 567-W.

MECHANICAL ENGINEER, A.M.E.I.C., with twenty years experience on mechanical and structural design, desires connection. Available at once. Apply to Box No. 571-W.

Report of the Committee on Unemployment

You are requested to note particularly the Report of the Committee on Unemployment presented at the recently held Sixth Plenary Meeting of Council, and published by direction of Council. This appears on pages 528-530 of this number of The Journal.

Employment Service Bureau

This bureau is maintained by The Engineering Institute of Canada for the benefit of members and organizations employing technically trained men.

An enquiry addressed to 2050 Mansfield Street, Montreal, will bring full information concerning the services offered. Details can also be obtained from Branch secretaries who are located in the larger centres throughout Canada.

MECHANICAL ENGINEER, B.A.SC., '30, desires position to gain experience, and which offers opportunity for advancement. Experience in pulp and paper mill and one year in mechanical department of large electrical company. Location immaterial. Available immediately Apply to Box No. 577-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.

MECHANICAL ENGINEER, Canadian, technically trained; eighteen years experience as foreman, superintendent and engineer in manufacturing, repair work of all kinds, maintenance and special machinery building. Location immaterial. Available at once. Apply to Box No. 601-W.

CHEMICAL ENGINEER, S.E.I.C., B.SC., University of Alberta, '30. Age 31. Single. Six seasons' practical laboratory experience, three as chief chemist and three as assistant chemist in cement plant; one year's p.g. work in physical chemistry; three years' experience teaching. Desires position in any industry with chemical control. Available immediately. Apply to Box No. 609-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.

Situations Wanted

CIVIL ENGINEER, A.M.E.I.C., R.P.E., Ontario; three years construction engineer on industrial plants; fourteen years in charge of construction of hydraulic power developments, tower lines, sub-stations, etc.; four years as executive in charge of construction and development of harbours, including railways, docks, warehouses, hydraulic dredging, land reclamation, etc. Apply to Box No. 647-W.

MECHANICAL ENGINEER, A.M.E.I.C., Canadian, technically trained; six years drawing office. Office experience, including general design and plant layout. Also two years general shop work, including machine, pattern and foundry experience, desires position with industrial firm in capacity of production engineer or estimator. Available on short notice. Apply to Box No. 676-W.

ELECTRICAL AND CIVIL ENGINEER, B.SC., Elec., '29, B.SC., Civil '33. Age 27. JR.E.I.C. Undergraduate experience in surveying and concrete foundations; also four months with Canadian General Electric Co. Thirty-three months in engineering office of a large electrical manufacturing company since graduation. Good experience in layouts, switching diagrams, specifications and pricing. Best of references. Available immediately. Apply to Box No. 693-W.

MECHANICAL ENGINEER, B.SC., '27, JR.E.I.C. Four years maintenance of high speed Diesel engines units, 200 to 1,300 h.p. Also maintenance of D.C. and A.C. electrical systems and machinery. Draughting experience. Westinghouse apprenticeship course. Practical mechanical and electrical engineer with a special study of high speed Diesel engine design, application and operation. Location in western or eastern Canada immaterial. Apply to Box No. 703-W.

COMBUSTION ENGINEER, R.P.E., Manitoba, A.M.E.I.C. Wide experience with all classes of fuels. Expert designer and draughtsman on modern steam power plants. Experienced in publicity work. Well known throughout the west. Location, Winnipeg or the west. Available at once. Apply to Box No. 713-W.

YOUNG ENGINEER, B.A.SC., (Univ. Toronto '27), JR.E.I.C. Four years practical experience, buildings, bridges, roadways, as inspector and instrumentman. Available at once. Present location, Montreal. Apply to Box No. 714-W.

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

MECHANICAL ENGINEER, age 41, married. Eleven years designing experience with project of outstanding magnitude. Machinery layouts, checking, estimating and inspecting. Twelve years previous engineering, including draughting, machine shop and two years chemical laboratory. Highest references. Apply to Box No. 723-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.

DESIGNING ENGINEER, M.SC. (McGill Univ.), D.L.S., A.M.E.I.C., P.E.Q. Experience in design and construction of water power plants, transmission lines, field investigations of storage, hydraulic calculations and reports. Also paper mill construction, railways, highways, and in design and construction of bridges and buildings. Available at once. Apply to Box No. 729-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.

CIVIL ENGINEER, M.SC., 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.

ELECTRICAL AND RADIO ENGINEER, B.SC. '31, S.E.I.C. Age 25. Nine months experience on installation of power and lighting equipment. Eight months on extensive survey layouts. Two summers installing telephone equipment. Specialized in radio servicing and merchandising. Available at once. Location immaterial. Apply to Box No. 740-W.

CIVIL ENGINEER, graduate '29. Married One year building construction, one year hydro-electric construction in South America, fourteen months resident engineer on road construction. Working knowledge of Spanish. Apply to Box No. 744-W.

SALES ENGINEER, B.SC., McGill, 1923, A.M.E.I.C. Age 33 Married. Extensive experience in building construction. Thoroughly familiar with steel building products; last five years in charge of structural and reinforcing steel sales for company in New York state. Available at once. Located in Canada. Apply to Box No. 749-W

DESIGNING ENGINEER, graduate Univ. Toronto '26. Thoroughly experienced in the design of a broad range of structures, desires responsible position. Apply to Box No. 761-W

Situations Wanted

ELECTRICAL ENGINEER, B.Sc. (McGill Univ. '29). S.E.I.C. Married. Experience in pulp and paper mill mechanical maintenance, estimates and costs and machine shop practice. Desires position with industrial or manufacturing concern. Location immaterial. Available on short notice. References. Apply to Box No. 770-W.

CIVIL ENGINEER, S.E.I.C., B.Sc. Queen's Univ '29. Age 25. Married. Three years experience as construction supt. and estimator for contracting firm. Experience includes general building, bridges, sewer work, concrete, boiler settings, sand blasting of bridges and spray painting. Available at once. Apply to Box No 776-W.

CIVIL ENGINEER, B.Sc., '25, JR.E.I.C., P.E.Q., married. Desires position, preferably with construction firm. Experience includes railway, monument and mill building construction. Available immediately. Apply to Box No. 780-W

DRAUGHTSMAN, experience in civil engineering, forestry engineering, land surveying and house construction. Good references. Apply to Box No. 781-W.

ELECTRICAL AND SALES ENGINEER, S.E.I.C., grad. '28. Experience includes one year test course, one year switchboard design and two years switchboard and switching equipment sales with large electrical manufacturing company. Three summers Pilot Officer with R.C.A.F. Available at once. Apply to Box No. 788-W.

ELECTRICAL ENGINEER. Specializing in power and illumination reports, estimates, appraisals, contracts and rates, plans and specifications for buildings. Available on interesting terms. Apply to Box No. 795-W.

CIVIL ENGINEER, S.E.I.C., graduate '30, age 23. single. Experience includes mining surveys, assistant on highway location and construction, and assistant on large construction work. Steel and concrete layout and design Apply to Box No. 809-W.

CIVIL ENGINEER, college graduate, age 27, single. Experience includes surveying, draughting concrete construction and design, street paving both asphalt and concrete. Available at once; will consider anything and go anywhere. Apply to Box No. 816-W.

CIVIL ENGINEER, B.E. (Sask. Univ. '32), S.E.I.C. Single. Experience in city street improvements; sewer and water extensions. Good draughtsman. References. Available at once. Location immaterial. Apply to Box No. 818-W.

CIVIL ENGINEER, E.E.I.C., B.Sc. (Queen's '32), age 21. Three summers surveying in northern Quebec. Interested in hydraulics and reinforced concrete. Available at once. Location immaterial. Apply to Box No. 822-W.

CIVIL ENGINEER, B.Sc., A.M.E.I.C., with fifteen years experience mostly in pulp and paper mill work, reinforced concrete and structural steel design, field surveys, layout of mechanical equipment, piping. Available at once. Apply to Box No. 825-W.

ELECTRICAL ENGINEER. E.E.I.C., grad. '29, age 24, married; experience includes one year Students Test Course, sixteen months in distribution transformer design and eight months as assistant foreman in charge of industrial control and switchgear tests. Location immaterial. Available at once. Apply to Box No. 828-W.

CIVIL ENGINEER, B.A.Sc., D.L.S., O.L.S., A.M.E.I.C., age 46, married. Twelve years experience in charge of legal field surveys. Owns own surveying equipment. Eight years on technical, administrative, and editorial office work. Experienced in writing. Desires position on survey work, assisting in or in charge of preparation of house organ, on staff of technical or semi-technical magazine, or on publicity, editorial or administrative office work. Available at once. Will consider any salary, and any location. Apply to Box No. 831-W.

CIVIL ENGINEER. M.Sc., R.P.E. (Sask.). Age 27. Experience in location and drainage surveys, highways and paving, bridge design and construction city and municipal developments, power and telephone construction work. Available on short notice. Apply to Box No. 839-W.

CIVIL ENGINEER, E.E.I.C., B.Sc. '32 (Univ. of N.B.). Age 25, married. Two years experience in power line construction and maintenance; one year of highway construction; one summer surveying for power plant site, location and spur railway line construction. Available at once. Location immaterial. Apply to Box No 840-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.

CIVIL ENGINEER, B.Sc. (Alta. '31), S.E.I.C., age 24. Experience, three summers on railroad maintenance, and seven months on highway location as instrumentman. Willing to do anything, anywhere, but would prefer connection with designing or construction firm on structural works. Available immediately. Apply to Box No. 846-W.

MECHANICAL ENGINEER, graduate, '23, A.M.E.I.C., P.E.Q., age 32, married. (English and French.) Two years shop, foundry and draughting experience; one year mechanical supt. on construction; six years designing draughtsman in consulting engineers' offices (mechanica)equipment of buildings, heating, sanitation, ventilation, power plant equipment, etc.). Present location Montreal. Available immediately. Montreal or Toronto preferred. Apply to Box No. 766-W.

Situations Wanted

MECHANICAL ENGINEER, JR.E.I.C., technical graduate, bilingual, age 30. Two years as designing heating draughtsman with one of the largest firms of its kind on this continent handling heating materials; three years designing draughtsman in consulting engineers' office, mechanical equipment of buildings, heating, ventilation, sanitation, power plant equipment, writing of specifications, etc. Present location Montreal. Available at once. Apply to Box No. 850-W.

BRIDGE AND STRUCTURAL ENGINEER, A.M.E.I.C., McGill. · Twenty-five years' experience on bridge and structural staffs. Until recently employed. Familiar with all late designs, construction, and practices in all Canadian fabricating plants. Desirous of employment in any responsible position, sales, fabrication or construction. Apply to Box No. 851-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

MECHANICAL ENGINEER, B.Sc. '32, S.E.I.C. Good draughtsman. Undergraduate experience:—One year moulding shop practice; two years pipe fitting and sheet metal work; one year draughting and tracing on paper mill layout; six months machine shop practice; and eight months fuel investigation and power heating plant testing. Desires position offering experience in steam power plants or heating and ventilating design. Will go anywhere. Apply to Box No. 858-W

MECHANICAL ENGINEER, age 31, graduate Sheffield (England) 1921; apprenticeship with firm manufacturing steam turbine generators and auxiliaries and subsequent experience in design, erection, operation and inspection of same. Marine experience B.O.T. certificate thoroughly conversant with Canadian plants and equipment. Available on short notice. Any location. Box No. 860-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.

CONSTRUCTION ENGINEER (Toronto Univ. of '07). Experience includes hydro-electric, municipal and railroad work. Available immediately. Location immaterial. Apply to Box No. 886-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.Sc., Montreal 1930, age 26, single, French and English, desires position technical or non-technical in engineering, industrial or commercial fields, sales or promotion work. Experience includes three years in municipal engineering on paving, sewage, waterworks, filter plant equipment, layout of buildings, etc. Available immediately. Apply to Box No. 891-W.

ELECTRICAL ENGINEER, grad. Univ. of N.B. '31. Experienced in surveying and draughting, requires position. Available at once Will go anywhere. Apply to Box No. 893-W.

CIVIL ENGINEER, B.A.Sc., JR.E.I.C., age 29. single. Experience includes two years in pulp mill as draughtsman and designer on additions, maintenance and plant layout. Three and a half years in the Toronto Buildings Department checking steel, reinforced concrete, and architectural plans. Available at once. Location immaterial. At present in Toronto. Apply to Box No. 899-W.

ENGINEER, JR.E.I.C., specializing in reconnaissance and preliminary surveys in connection with hydro-electric and storage projects Expert on location and construction of transmission lines, railways and highways. Capable of taking charge. Location immaterial. Apply to Box No. 901-W.

MECHANICAL ENGINEER, Canadian, age 25, B.Sc. (Queen's '32). Since graduation on supervision of large building construction. Undergraduate experience in electrical, plumbing and heating, and locomotive trades. Available at once. Apply to Box No. 903-W.

DESIGNING ENGINEER, A.M.E.I.C. Permanent and executive position preferred but not essential. Fifteen years experience in designing power plants, engine and fan rooms, kitchens and laundries. Thoroughly familiar with plumbing and ventilating work, pneumatic tubes, and refrigeration, also heating, electrical work, and specifications. Apply to Box No. 913-W.

YOUNG CIVIL ENGINEER, JR.E.I.C. Six years as instrumentman on subway work. Two years as timekeeper cost clerk on building construction. Four years as job engineer on buildings, tunnels, dams, power houses. Location immaterial. Available at once. Apply to Box No. 916-W.

INDUSTRIAL ENGINEER, B.Sc. in M.E., age 25, married, is open for a position of a permanent nature with an industrial concern. Experience includes three years in various divisions of a paper mill and two years in an electrical company. Apply to Box No. 917-W.

ENGINEER, B.Sc., A.M.E.I.C., R.P.E. (N.B.), age 35, married. Seven years' mining experience as sampler, assayer, surveyor, field work, and foreman in charge of underground development; two years as assistant engineer on highway construction and maintenance. Available on short notice. Apply to Box No. 932-W.

Situations Wanted

CIVIL ENGINEER, B.Sc., '25, McGill Univ., JR.E.I.C., P.E.Q, age 32, married. Experience as rodman and instrumentman on track maintenance. Seven and one-half years with Canadian paper company, as assistant office engineer handling all classes of engineering problems in connection with woods operations, i.e., road buildings, piers, booms, timber bridges, depots, dams, etc. Apply to Box No. 933-W.

ELECTRICAL ENGINEER, Dipl. of Eng., B.Sc. (Dalhousie Univ.), S.B. and S.M. in E.E. (Mass. Inst. of Tech.), Canadian. Married. Seven and a half years' experience in design, construction and operation of hydro, steam and industrial plants. For past sixteen months field office electrical engineer on 510,000 h.p. hydro-electric project. Available at once. Apply to Box No. 936-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.

ELECTRICAL ENGINEER, twenty years experience, desires position, either temporary or permanent. Experienced in design, construction, and operation of power and industrial plants, and supt. of construction. Apply to Box No. 974-W.

INDUSTRIAL ENGINEER, B.Sc., in C.E. (McGill Univ. '30), graduate student in industrial engineering '33 session, age 27, single, available for a position of temporary or permanent nature with industrial concern. Has theoretical knowledge of latest methods of market analysis, production control, management and cost accounting. Also experience in the design and construction of industrial buildings. Location immaterial. Apply to Box No. 981-W.

CIVIL ENGINEER, B Sc. (Univ. of Sask. '33), S.E.I.C., age 28, single. Experience in testing hydro-electric equipment, draughting, surveying, city street, improvements, technical photography. Available at once. Location immaterial. Apply to Box No. 986-W.

ELECTRICAL ENGINEER, B.A.Sc., '27, JR.E.I.C., A.A.I.E.E. Married. Age 31. One and a half years G. E. Test Course, Schenectady; four and a half years motor and generator design including induction motors, D.C. and A.C. motors and generators. Willing to do anything, design or sales preferred. Available at once. Present location Toronto. Apply to Box No. 993-W

MECHANICAL ENGINEER, E.E.I.C., B.Sc., Queen's University '33. Age 24, desires position on power plant and power distribution problems, factory maintenance, heating and ventilation or refrigeration design. Willing to work for living expenses in order to gain experience. Apply to Box No. 999-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

CIVIL ENGINEER, B.Sc. (Queen's 14), A.M.E.I.C., Dominion Land Surveyor, 5 months' special course at the University of London, England, in municipal hygiene and reinforced concrete construction. Experience covers legal and topographic surveys, plane tabling and stadia surveying, railway and highway construction, drainage and excavation work. Available at once. Apply Box No. 1035-W.

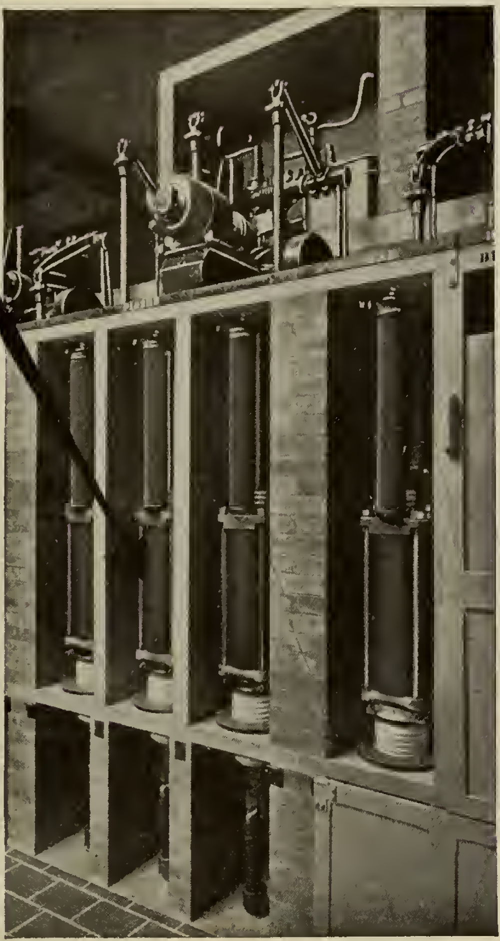
ELECTRICAL ENGINEER AND GEOPHYSICIST. Age 36. Married. Seven years experience in geophysical exploration using seismic, magnetic and electrical methods. Two years experience with the Western Electric Company of Chicago, working on equipment and magnetic materials research. Experienced in radio and telephone work, also specializing in precise electrical measurements, resistance determinations, ground potentials and similar problems of ground current distribution. Apply to Box No. 1063-W.

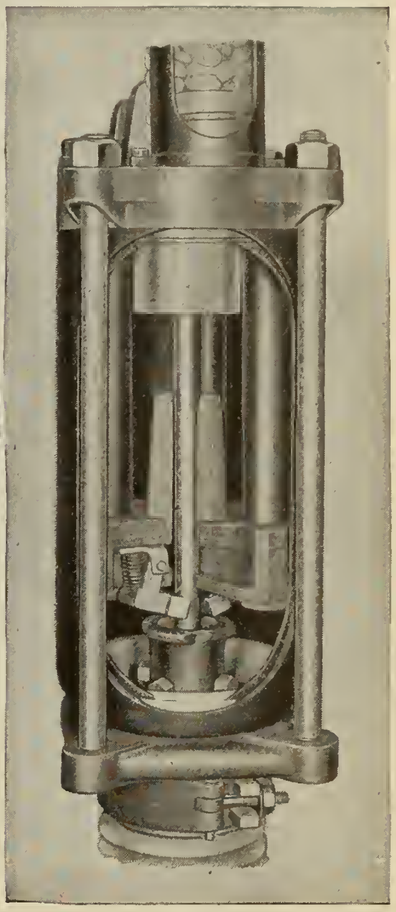
ELECTRICAL ENGINEER, B.A.Sc. Univ. Toronto '28. Experience includes Can. Gen. Elec. Co. Test Course. Also more than two years in the engineering dept. of the same company. Available on short notice. Preferred location central or eastern Canada. Apply to Box No. 1075-W

ELECTRICAL ENGINEER, B.Sc. Married. Eight years electrical experience, including operation, maintenance and construction work, electrical design work on large power development, mechanical ability, experienced photographer, employed in electrical capacity at present. Available on reasonable notice. Apply to Box No. 1076-W.

GRADUATE IN MECHANICAL ENGINEERING, 1927, desires opportunity in Diesel engine field, preferably in design and development work. Skilled draughtsman and clever in design. Familiar with basic theories of the Diesel engine and in touch with recent developments and applications. Anxious to obtain a foothold with up-to-date company. No objection to shopwork or other duties as a start but would prefer shopwork and assembly if possible. Apply to Box No. 1081-W.

INDUSTRIAL ENGINEER, B.A.Sc. in Chem. Eng. (Tor. '31), E.B. in Indust. Eng. (Mass. Inst. of Tech. '32), S.E.I.C. Age 25 years. Northern Electric Training Course. Construction and sales experience. Rockefeller Research Associate at McGill University in industrial engineering for past year and to date. Desire work in production or financial departments of a manufacturing plant. Apply to Box No. 1098-W.





Purchasers' Classified Directory

A Selected List of Equipment, Apparatus and Supplies

For Alphabetical List of Advertisers see page 18.

A

Acids:
Canadian Industries Limited.

Aerial Survey:
Canadian Airways Ltd.

Ammeters and Voltmeters:
Bepco Canada Ltd.
Crompton Parkinson (Canada) Ltd.

Angles, Steel:
Bethlehem Steel Export Corp.

Ash Handling Equipment:
Babcock-Wilcox & Goldie McCulloch Ltd.
Combustion Engineering Corp. Ltd.
E. Long Ltd.

B

Ball Mills:
Dominion Engineering Works Limited.

Balls, Steel and Bronze:
Can. S.K.F. Co. Ltd.

Barking Drums:
Canadian Ingersoll-Rand Company, Limited.

Bars, Steel and Iron:
Bethlehem Steel Export Corp.

Bearings, Ball and Roller:
Can. S.K.F. Co. Ltd.

Billets, Blooms, Slabs:
Bethlehem Steel Export Corp.

Bins:
Canada Cement Co. Ltd.

Blasting Materials:
Canadian Industries Limited.

Blowers, Centrifugal:
Can. Ingersoll-Rand Co. Ltd.

Blue Print Machinery:
Montreal Blue Print Co.

Boilers:
Babcock-Wilcox & Goldie-McCulloch Ltd.
Canadian Vickers Ltd.
Combustion Engineering Corp. Ltd.
Foster Wheeler Limited.
E. Leonard & Sons Ltd.
Vulcan Iron Wks. Ltd.

Boilers, Electric:
Can. General Electric Co. Ltd.
Dominion Engineering Works Limited.
Northern Electric Co. Ltd.

Boilers, Portable:
E. Leonard & Sons Ltd.

Boxes, Cable Junction:
Northern Electric Co. Ltd.

Braces, Cross Arm, Steel, Plain or Galvanized:
Northern Electric Co. Ltd.

Brackets, Ball Bearing:
Can. S.K.F. Co. Ltd.

Brakes, Air:
Can. General Elec. Co. Ltd.

Brakes, Magnetic Clutch:
Northern Electric Co. Ltd.

Bridge-Meggers:
Northern Electric Co. Ltd.

Bridges:
Canada Cement Co. Ltd.
Dominion Bridge Co. Ltd.

Bucket Elevators:
Jeffrey Mfg. Co. Ltd.
Plessisville Foundry.

Buildings, Steel:
Dominion Bridge Co. Ltd.

C

Cables, Copper and Galvanized:
Northern Electric Co. Ltd.

Cables, Electric, Bare and Insulated:
Can. Westinghouse Co. Ltd.
Can. General Electric Co. Ltd.
Northern Electric Co. Ltd.

Caissons, Barges:
Dominion Bridge Co. Ltd.

Cameras:
Associated Screen News Ltd.

Capacitors:
Bepco Canada Ltd.
Can. Westinghouse Co. Ltd.
Lancashire Dynamo & Crypto Co. of Can. Ltd.

Cars, Dump:
E. Long Ltd.

Castings, Brass:
The Superheater Co. Ltd.

Castings, Iron:
Babcock-Wilcox & Goldie-McCulloch Ltd.
Canadian Vickers Ltd.
Dominion Engineering Works.
E. Leonard & Sons Ltd.
E. Long Ltd.
The Superheater Co. Ltd.
Vulcan Iron Wks. Ltd.

Castings, Steel:
Vulcan Iron Wks. Ltd.

Catenary Materials:
Can. Ohio Brass Co. Ltd.

Cement Manufacturers:
Canada Cement Co. Ltd.

Chains, Silent and Roller:
The Hamilton Gear & Machine Co. Ltd.
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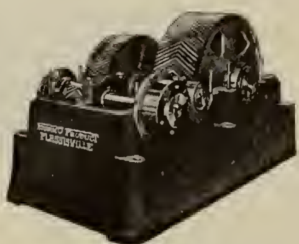

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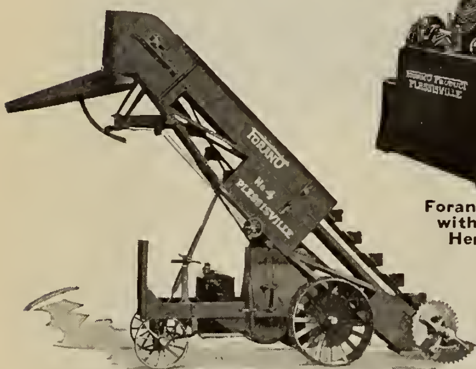

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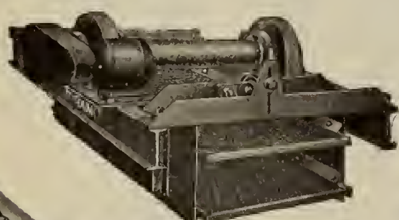

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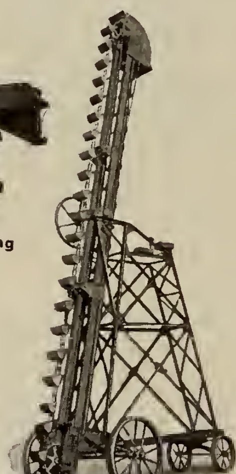

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