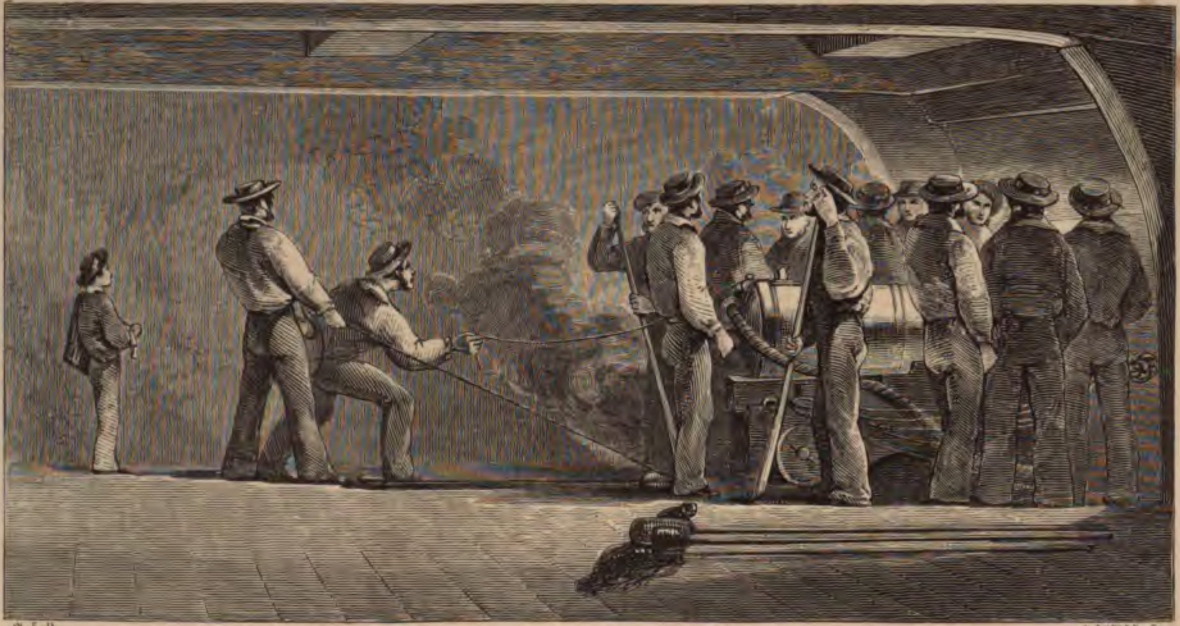

A GUN'S CREW OF H M. SHIP "EXCELLENT"

READY!

To face the Title.

E. C. V. Bla

DEDICATED BY SPECIAL PERMISSION

TO THE

LORDS COMMISSIONERS OF THE ADMIRALTY.

A TREATISE

ON

NAVAL GUNNERY

BY GENERAL SIR HOWARD DOUGLAS, BART.

G.C.B.; G.C.M.G.; D.C.L.; F.R.S.

FIFTH EDITION, REVISED.

WITH ILLUSTRATIONS.

LONDON:
JOHN MURRAY, ALBEMARLE STREET,
1860.

A GUN'S CREW OF H. M. SHIP "EXCELLENT"

READY!

To face the Title.

LONDON: PRINTED BY WILLIAM CLOWES AND SONS, STAMFORD STREET,
AND CHARING CROSS.

INTRODUCTION

TO THE FIRST EDITION.

London, 1819.

AWARE of the objections that may attach to the measure cultivating improvements in warlike practice through the m dium of the Press, I must explain the circumstances which ha led to the publication of this Work.

Having, during the war, made observations and form opinions respecting the state of Gunnery in the British Nav which led me to reflect studiously how this important bran of our martial system might be improved, I occupied myse for some time after the close of the war, in composing th Work; and in October, 1817, transmitted it to the Lor Commissioners of the Admiralty.

The long absence of the Senior professional Lord (the la Admiral Sir George Hope) from the Board, and the chang which took place upon the lamented death of that distinguish officer, occasioned some delay in taking my papers into co sideration; but I was soon afterwards honoured with "th thankful acknowledgment of the Naval Administration for th very able" (they were pleased to say) "and valuable comm nication I had made;" but no decision was then formed as the use that should be made of it.

In November, 1818, I was honoured with a further, and st more flattering, acknowledgment from the Admiralty, acco panied by a request, that I would permit a Copy of my Wo to be retained in the Admiralty Office, with a view to carry in effect the whole, or any part of my plans, hereafter, when tho considerations and financial circumstances, which at that ti

prevented their adoption, might admit. To this communi
I returned the following answer:—

SIR, Farnham, Nov. 29th,

I HAVE had the honour to receive your letter of th
instant, in which you acquaint me by Lord Melville's dirc
that his Lordship and the Board think very highly of the n
in which I have treated the important subject of Naval Gu
in the several MSS. which I have addressed to the Admi
their approbation of many of the suggestions contained in
papers—and their request to be permitted to retain a Copy
Work at the Admiralty, in order that they may be enabled t
into effect the whole or any part of my plans, in the e
changes in those circumstances and considerations which at
prevent the adoption of my suggestions.

I am gratified by this communication; and beg you to
to the Board my consent to their Lordships' retaining a
my Work; to which I request copies of all my Letters, in
this, may be attached, for the purpose of procuring referenc
should I be living, at the time *any* adoption of my plans
contemplated.

I had formed an intention of making a publication up
subject; but, considering this consent to the request w
Board has made as inconsistent with the measure of publi
willingly abandon that intention unless it should have the
tion of their Lordships.

I have the honour to be,
&c. &c.
(Signed) HOWARD DOUGL

To Vice-Admiral
Sir Graham Moore, K.C.B.,
&c. &c.

In answer to this letter I was soon afterwards acqua
Vice-Admiral Sir Graham Moore, that he had "comm
my letter of the 29th November to Lord Melville
Board, and was authorized to acquaint me that their L
did not see any objection to the publication of my
Naval Gunnery," which was accordingly soon afterw
turned to me, for this purpose, with the following let
the Secretary of the Admiralty:—

INTRODUCTION TO THE FIRST EDITION.

Sir, Admiralty Office, 25th Nov. 181

My Lords Commissioners of the Admiralty, having l under their consideration your Essay upon the Theory and Pract of Naval Gunnery, submitted to them in your letters of the 1 and 23rd October, 1817, command me to express to you th Lordships' thanks for the communication, and for the attent you have paid to this important subject; and in reference your intimation of causing it to be published, their Lordsh further command me to acquaint you, that they have no object to your doing so, if you should think proper; and with this vi I am directed to return to you herewith the original Manuscri and to add, that a Copy of it, together with your letters addres to the Members of the Board upon the subject, have been retai in this Office.

I am, Sir,
Your most obedient, humble Servant,
J. W. Croker.

Colonel Sir Howard Douglas.

Upon the receipt of this letter, I applied for and recei Lord Melville's permission to dedicate my Work, in print, to Lordship, as I had already done in MS., and I send it fo conscious of its defects, as well as of my inability to treat important subject in the way it merits.

PREFACE

TO THE FIFTH EDITION.

In issuing a new and revised edition of his work on "Naval Gunnery," in which considerable alterations and additions have been rendered necessary by the revolution that has taken place in the methods of attack and defence, both naval and military, owing to the rapid progress of modern scientific discovery and improvement, the author considers that he cannot better set forth the objects and views with which he has entered on his labours than by quoting the substance of his application to the Lords Commissioners of the Admiralty to secure for his new edition the high patronage that had been accorded to those preceding it.

"The fourth edition of the 'Naval Gunnery' being exhausted, and, in fact, out of print, and a new edition much asked for, I comply with the demand; and am engaged in the very laborious occupation, at my time of life, of preparing a fifth edition for publication; in the hope that the Lords Commissioners of the Admiralty will permit me to dedicate the work—as all the preceding editions from the commencement of my labours on this subject have been dedicated—to their Lordships; and that I may be permitted to announce, in the title-page, as heretofore, that the work is published with the consent and approbation of the Admiralty.

"Great changes have taken place in the condition and aspects of naval warfare since the publication of the fourth edition. I purpose in the forthcoming impression to apply myself, most especially, to give exact accounts of the Armstrong and the Whitworth guns, with observations on their comparative merits, value, and the uses to which they are best adapted; accompanied by references to well-established maxims and principles of the science of gunnery, by which only can the real-service merits and value of the Armstrong and Whitworth systems be correctly estimated, fairly judged, and efficiently applied. I propose likewise to examine the whole question of metallic defences, whether applied to floating or to land batteries.

"These new subjects, together with the great improvements now effected in the science, practice, and service of artillery, and the introduction of steam-propulsion to ships of war—of which I have ventured to treat in a special publication —form a new era, and will make a total revolution in all the operations of naval and military warfare. These points are, therefore, deserving of the most serious consideration; and I presume to apply myself to the subject accordingly, however incompetent in mental and scientific resources I may be at my time of life."

Having obtained permission of the Minister of War to have access to all reports of experiments made by his authority, for the purpose of giving a true statement of bare facts and results, without compromising any official personage on the one hand, or being compelled to trust to reports in public journals on the other,—which, however substantially true, can hardly be expected to be technically exact,—the author requested the sanction of the Lords Commissioners of the Admiralty to be given to the officer at the head of the Gunnery Establishment to supply him with such information as had been afforded by Captain Hewlett's predecessors in that responsible office, of the results of all experiments made under his direction, "subject to his judgment as to any matter that should not be noticed." But, so far from this reserve being necessary, in the author's opinion, he believes, as expressed in the conclusion of his application to the Lords Commissioners of the Admiralty, that, "on the contrary, all that we are now doing, to improve the efficiency of the services, not only adds to our national strength and security, but tends immensely to add to our moral strength, by deterring, and even defying aggression; and that the more formidable we make our preparations appear to be, by giving them publicity, and making the most of them on paper, as well as in fact, the less likely shall we be of being called upon to prove that force in reality."

The following reply from the Lords Commissioners of the Admiralty, according the permission requested by the author, was received in answer to his application, the substance of which is embodied in the foregoing preface.

Admiralty, March 13, 1860.

Sir,—Having laid before my Lords Commissioners of the Admiralty your letter of the 12th inst., requesting permission to dedicate to their Lordships a fifth edition of your book on 'Naval Gunnery,' and that the officer at the head of the Gunnery Establishment may be authorized to supply you with such information as may be necessary for your Publication; I am commanded to acquaint you that my Lords will have great pleasure in accepting the dedication of your book, and have instructed Captain Hewlett, of H.M.S. "Excellent" to afford you all such information as can with propriety be communicated to you.

I am, Sir,
Your most obedient Servant,

W. G. ROMAINE.

General Sir Howard Douglas, Bart., G.C.B.,
&c. &c.

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NAVAL GUNNERY.

PART I.

ON THE ORGANIZATION AND TRAINING OF NAVAL GUNNERS.

1. Soon after the termination of the wars arising from the French Revolution (of 1793), the author published the first edition of his work on Naval Gunnery, with the view of drawing public attention to a subject which he considered of vital importance to the interests of the country. This he was induced to do in consequence of the very unsatisfactory state of practical gunnery at that time, to which he attributed some of the disastrous results which ensued. To the remarks which he was then led to offer he would still solicit attention, not for the purpose of conveying censure, which is far indeed from being his intention, but simply to show in bolder relief the improvements which have since been made, and to hold out encouragement to the exertion of every effort for maintaining and increasing the advantages already gained. The author here takes leave to state, that he has had the most gratifying assurances from officers of every rank, and of the most distinguished character, that the present improved condition of our officers and seamen, with respect to this essential branch of the naval profession, is mainly, if not wholly, to be attributed to the means adopted, conformably to his suggestions, for its cultivation theoretically and practically; and he hopes he shall be able to show, in the present work, the necessity we are under of extending our *Gunnery Establishment*, both as the best means of keeping up and advancing our attainments in the objects of instruction there, and of placing the country in a

state of security in the event of the occurrence of any sudden emergency.

2. When the fleets of Europe, opposed to us in the late war, had been swept from the face of the ocean by the gallant achievements of the British marine, a period of triumphant, undisputed dominion ensued, during which our seamen were not, in general, sufficiently practised in the exercise of those weapons by which that dominion had been gained; but, in the pride of conquest, were suffered, in many instances, to lose much of that proficiency in warlike practice which had been acquired in a long series of arduous service.

3. Reviewing carefully our naval actions with European enemies during the whole of the war from 1793 to 1815, and comparing them with the battles which were fought in that which immediately preceded, there appears abundant proof that the navies of Europe had, in the later epoch, very much deteriorated in the practice of gunnery. In the later years of Napoleon's reign, though considerable improvements had then been effected in the marine of France, the state of practical gunnery among French seamen was so bad, that we have seen ships, strongly manned, playing batteries of twenty or thirty heavy guns against our vessels, without more effect than might easily have been produced by one or two well-directed pieces; and we have seen some cases in which heavy frigates have us
powerful batteries against our vessels for a considerable ti
without producing any effect at all.

4. The danger of resting satisfied with superiority ove
system so defective as that of our former opponents, has
made sufficiently evident. We became too confident by
feebly opposed; then slack in warlike exercise, by not
opposed at all; and lastly, in many cases, inexpert fo
even of drill practice; and herein consisted the great
vantage under which, without suspecting it, we entered, i
with too great confidence, into a war with a marine muc
expert than that of any of our European enemies.

5. Other considerations besides comparative views
force, and warlike skill, are necessary to a correct
naval actions. If a vessel meet an enemy of eve
superior force, it is due to the honour of her flag

effect of a few rounds; but, unless in this gallant attempt she leave marks of her skill upon the larger body, whilst she, the smaller, is hit at every discharge, she does but salute her enemy's triumph and discredit her own gunnery.[a] It is not disgraceful that a vessel should be compelled to yield to another of superior force; but it is so, that the enemy should not be made to smart for his conquest: yet the defenders of the devoted vessel could not in justice be blamed, so long as naval gunnery was not a matter of professional cultivation and absolute obligation.[b] We do well to augment our naval strength by the construction of large and small ships, and by attention to all the details of personal and material; but it is even more important to make it an object of timely consideration how our ships are to be provided, at the beginning of a war, with an adequate proportion of officers, gunners, and seamen trained to warlike practice.

6. The material of our navy is in the finest possible condition. Our ships are greatly improved in every feature of strength and quality, and our ordnance is the best in the world. We possess excellent seamen, trained by the operations of our commercial navy. Our officers, many of them educated at the public expense, are good navigators, excellent astronomers, and are full of energy, activity, and courage; but all these qualifications do not satisfy the requirements of a good *ship of war:* to them should be added a competent knowledge of the science and practice of gunnery.

7. Till lately this important element was almost wholly wanting. After years of war had afforded us ample opportunities of practice, and yielded us many splendid victories, our gallant officers were often sent forth, with well-earned reputations, to maintain the sacred honour of the British flag, with

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[a] In the action between the "President" and the "Little Belt," in 1811, the latter was heavily damaged, and had eleven men killed and twenty-one wounded; while, on board the "President," a boy only was killed, not a shot struck her hull, and only two hit her masts.—James' 'Naval History,' vol. vi. p. 10.

[b] On one occasion the gunners of a vessel mistook the elevated sight of their arms (carronades) for the point-blank line; and, when close to the enemy, fired at an elevation of 3½ degrees. The author has witnessed, and he could name distinguished authorities to prove the existence, formerly, of much more serious errors in practice.

crews on whom no reliance could be placed, excepting for courage and self-devotion; and under such circumstances it is not surprising that we were, in some instances, severely disappointed. The author trusts he may be allowed some credit for having suggested the remedy to the then existing defects in our naval system, which has since been so successfully adopted; and he takes occasion to assure the officers of the navy who may peruse this work, that any remarks on public events which he may think it necessary to make in the course of this treatise, are not quoted to criticise, but, on the contrary, to justify, or account for, operations which were always most gallantly undertaken, and which could not perhaps have been better executed, with the means at their command.

8. It remains only that we take special care to preserve the high position which we have struggled through years of difficulty to attain; that we not only secure it from decay, but also use the utmost diligence to improve it, by availing ourselves of all the resources of science as they arise, and acquiring those facilities in manual operations which continual practice alone can bestow.

9. It will not, perhaps, be considered improper here to make a few observations on the opinion that nothing which is not coarsely simple can be used in naval gunnery; and, consequently, that no delicate instrumental operations ought to be attempted. Nothing can be more unfounded than such a
opinion; instruments which may be considered complicated a
unmanageable by persons quartered at a gun for the first ti
are used with the utmost facility by well-formed artille
The difficulty which the author's father experienced, even f
officers, in procuring the adoption of gun-locks, and r
other improvements which he had made in naval ordnanc
proofs how far the want of some general system for the
vation of the science and art of gunnery causes impedime
the introduction of measures which tend to the advantage
service, and which, instead of being undervalued, we
eagerly received, were naval officers and seamen taugh
estimate them.

10. In the former editions of this work, the autho
out the important advantages which would result from

ening by theory and training by practice, during peace, a large proportion of those who are to serve our naval ordnance in war. He showed that, whatever plan might be adopted for the improvement of Naval Gunnery, it should be calculated to instruct officers, master-gunners,[a] gunners' mates, and their crews; and that no measure which provides only for the drill of the men, could effectually improve the service practice: the mere dexterity of a few privates will do little, unless directed by cultivated and well-exercised intelligence on the part of the officers commanding in the ship's batteries, and assisted by a good crew of practical gunners.

11. He observed, that to instruct the rising class of officers in gunnery, a short course of theoretical instruction, showing all the established principles of the science, should be introduced at the Naval College; and that gunnery should also be made an item in the examinations for promotion. To instruct a proportion of officers, midshipmen, master-gunners, gunners' mates, and some seamen, in the practice of gunnery, *Depôts of Instruction* should be formed. So much depends upon the nature and composition of these establishments, that the author must be permitted to show, at some length, the reasons which have guided him in making the following suggestions; and the objections which appear to him to attach, in great force, to some measures that have been contemplated.

12. It is assuredly important, and even indispensable, in establishing schools for instruction in the practice of Naval Gunnery, that the posts of instructors in them should, in consequence of the opportunities afforded to such persons for the acquirement of great proficiency and for originating improvements, be conferred on those only who are afterwards to practise, in the profession, on service, what they cultivate and teach during peace.

13. The fundamental principles, then, that should form the basis of any measure that may be adopted for the improvement of Naval Gunnery are, that no plan which does not provide for instructing officers, master-gunners, gunners' mates, and their

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[a] To avoid mistake, the gunners of ships are here designated *master-gunners.*

crews, as well as drilling seamen in the exercise, can effectually improve the service practice; and, in order to render permanent and effectual the benefits that would result from the formation of Naval Depôts of Instruction, a proportion of intelligent seamen should be engaged for a term of years, and formed into a permanent body, from which the important situations of master-gunners should be filled; and which, in a more extended form, might be made to furnish hereafter a considerable number of expert seamen-gunners to act as captains of guns; or, if not sufficiently numerous to do this, capable, at least, of soon drilling to the established system, the ordinary crews of those vessels into which these trained men may be draughted.

14. When the vessels which have been three years in commission are paid off, and the seamen dispersed, what permanent naval advantages do we reap from the instruction that may have been given? The instruct*ed* are thrown at large upon the world—the instruct*ors*, though improved by the lessons they have given, are still not real-service naval gunners; and it may happen that the system and expertness which they may have acquired, will, in numerous instances, be carried to the aid of foreign nations, at the very time we most require them ourselves. Ship after ship may be commissioned, and the crews drilled, but, on the expiration of their servitude, these are dispersed. All we can hope for from such a plan i that, by this mode of introducing successions of trained gunn into the merchant service, we *may* hereafter, in war, rec some for the Royal navy; but in the mean time the ri generation of naval officers, of whom but few can be emplo afloat, would be left uninstructed, master-gunners and t crews unimproved, and, most certainly, no permanent a tages gained.

15. Now, to remedy these serious objections, we should engage a certain number of seamen, expressly for the s of the gunner's crew, for periods of five or seven years; able at their expiration, attaching a small increase of every such consecutive re-engagement. The advantag out to volunteers should be, that master-gunners, g mates, and a certain number of seamen-gunners, wil

tually, be incorporated; and that a regular advancement in that department will hereafter take place according to merit; so that seamen-gunners may, if they can read and write, consider themselves in the certain road to the attainment, according to their merit, of the situations of gunners' mates, and master-gunners of ships. Seamen-gunners should receive superior pay, and share prize-money, as gunners' mates do now, or have some other rank superior to that of able seamen.

16. The practicability of forming such an institution resolves itself into this—whether, upon these advantages being made known, a sufficient number of volunteers can be procured to commence such an establishment.[a] The experiment might be easily tried; but the proposal should be accompanied with an explanation that the system provides, eventually, a term of relief, or residence on shore, for men so incorporated. If the experiment answer the confident and authorized expectation that may be entertained of its success, a selection of naval officers, the best practitioners of the late war, should be named to conduct the Depôts of Instruction; and the author has every reason to believe that some very distinguished officers would come forward to commence such a system.[b] In this way

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[a] It was suggested to the author by a gallant Admiral, that boys who may be educated at the Asylum, or by the Marine Society, might, after practice shall have made them able seamen, become very fit persons for service in this department.

[b] The following extracts are made from some of the very numerous letters which the author received, containing expressions of entire conviction of the necessity of adopting his plan: the letters are from naval officers of the first distinction, whose names the author is proud to quote. Those officers honoured him by advocating and urging the plan with all the weight of their influence, and were materially instrumental in its introduction and extension.

(Extract.)—SIR P. B. V. BROKE to SIR HOWARD DOUGLAS.

"Broke Hall, July 5, 1818.

"DEAR SIR,—As a brother officer, though charged with the same duties upon a different element, I trust you will excuse this my frank address [the author had not then made personal acquaintance with this eminent officer].

"Your obliging letter and treatise arrived this morning, and I am much flattered by your reference to me.

"I am a most anxious well-wisher of your plan. We are all, indeed, deeply indebted to an officer who takes such pains and bestows such ability upon an object so requisite to the support of our national honour.

(Signed) "P. B. V. BROKE."

(Extract.)

a number of trained men would always be retained in the service — successions of commanders, and many officers who

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(Extract.)—SIR P. B. V. BROKE to SIR HOWARD DOUGLAS.

"Broke Hall, September 23, 1818.

"MY DEAR SIR HOWARD,—A strong proof of the exigency of enforcing some improvement in our naval gunnery is the indifference with which the subject is regarded, after the useful lessons which the late war afforded us; but I hope your exertions will effect much. If you can get one small depôt established, it will soon create an excellence that will excite emulation.

"I am, my dear Sir Howard,
(Signed) "P. B. V. BROKE."

(Extract.)—SIR P. B. V. BROKE to SIR HOWARD DOUGLAS.

"Broke Hall, January 3, 1819.

"MY DEAR SIR HOWARD,—I thank you for your communication, but do most sincerely regret the contents of it; and it is mortifying to see that all our hopes in your spirited and assiduous endeavours are for the present suspended. We must hope that hereafter circumstances may be more propitious to the adoption of your plans.

"But I hope that, however great a sufferer from the non-adoption of your plans, I shall not suffer by their not being published, and request you will have the kindness to order some amanuensis to copy your work for me, reward him liberally, and favour me with an account of the expense. It is a curious plea that the present state of the country does not require the improvement proposed: it will be too late to teach our hands to war when the enemy is pillaging our trade, and Lloyd's in an uproar to have ships rigged and sent instantly to sea.

(Signed) "P. B. V. BROKE."

(Extract.)—SIR S. J. PECHELL to SIR HOWARD DOUGLAS.

"Stratford Place, 1818

"I gave your MS. to Sir Philip Broke to read, who might do more g than any other man, did he reside in London, with the views which he expressed.

"Sir Philip Broke has so completely reviewed your work, and bee decidedly of your opinion in every essential part of it, that there ren nothing for me to add but my most earnest wish that something shou done to rescue that part of our duty from the state in which it now is notwithstanding you will yet meet with much opposition in attempt carry your plans into effect, I sincerely hope that you will not lose si the object to which you have so ably drawn our attention; and I am in yet to hope that perseverance will overcome the prejudice you have encounter.

(Signed) "S. J. PECH

(Extract.)—SIR S. J. PECHELL to SIR HOWARD DOUGLAS.

"Albany, June

"The old Flag Officer has done what even you could not effect, tl to the extent that either of us could wish; but within these fev cannot be employed afloat in a limited peace establishment, would, at the trifling expense of full pay, be improved in this important branch of their military duties; master-gunners and gunners' mates would be trained; and a permanent stock of seamen-gunners brought up, to fill hereafter these important offices; and should it be extended ultimately in the manner here proposed, it would furnish, besides, a considerable number of very expert captains of guns.

17. In the earlier editions of this work (see the pages from

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order has been given to establish a gunnery school on board the 'Excellent' at Portsmouth.

(Signed) "S. J. PECHELL."

[The expression "the old Flag Officer" in the above extract alludes to a celebrated pamphlet which had been recently published, urging the immediate adoption of the author's plan. That pamphlet was attributed at the time to Admiral, the late Sir Charles, Penrose; but it is now known to have been written by an able and gallant officer who, fortunately for the service, and happily for his friends, is living—Rear-Admiral Bowles, C.B. The author's plan was also strongly urged in the leading articles of the 'Times' newspaper of the 17th, 20th, and 24th of May in the same year, 1830.]

(Extract.)—SIR S. J. PECHELL to SIR HOWARD DOUGLAS.

"Admiralty, November 3, 1831.

"We are now likely to do something more. Sir James Graham has approved of the plan, and has appointed the 'Excellent' for this service; and I am sure you will not refuse me your assistance in drawing up a prospectus for our future sea-gunners.

"I cannot help congratulating you on seeing your labours brought to a satisfactory result, and likely to confer so much benefit on the country.

(Signed) "S. J. PECHELL."

(Extract.)—SIR S. J. PECHELL to SIR HOWARD DOUGLAS.

"Admiralty, February 22, 1832.

"I enclose you my compilation [a prospectus] from your book for the establishment on board the 'Excellent,' and request you will be kind enough to revise, add to it, or correct it, as you may judge fit. The plan is yours, and I may indeed say, the whole of it is yours, as anybody may see in a moment by turning over the leaves of your book. [See Appendix A.]

(Signed) "S. J. PECHELL."

(Extract.)—SIR S. J. PECHELL to SIR HOWARD DOUGLAS.

"Admiralty, February 10, 1832.

"After writing to you I almost felt ashamed of having troubled you upon the subject, when I found everything I wanted ready cut and dry in your own work. I had, therefore, nothing to do, taking, as you did, a twenty-eight-gun ship establishment to begin with.

(Signed) "S. J. PECHELL."

17 to 24 and page 28 in those editions) there are given in detail estimates of the composition and strength of the proposed establishment, and also of the expense which would attend its formation, together with indications of the subjects which should constitute a course of practical education for young officers, master-gunners, gunners' mates, and seamen-gunners: these subjects comprehend the details of practical gunnery with the different natures of naval ordnance, both on shore and afloat, and the laboratory operations required for the service; but the proposed measures having been carried into effect, and the system of instruction being now fully organized, it is unnecessary to repeat here what was then pointed out. The prospectus originally drawn up by Sir S. J. Pechell, in conformity with the author's suggestions, and transmitted to him for revision, in that distinguished officer's letter of the 22nd February, 1832, will be given at length in the Appendix. (App. A.) The following remarks, which contributed in a great degree to the adoption of measures for the systematic cultivation of naval gunnery, are, on that account, re-stated in this place.

18. As soon as one set of seamen are returned complete in exercise and practice, they should be transferred to commissioned ships, and should there drill the seamen engaged in the ordinary way, according to the general system; so that in this respect these would be well trained; and all the permanent advantages of the proposed system would be so far gained.

19. Fresh seamen should be engaged as gunners, and drawn in to the Depôt of Instruction in proportion as trained men ar turned over to the guard-ships.[a] These again should, by d grees, transfer to the cruisers a certain proportion of the traine gunners that will have been received from the depôts; whi however, should, together with the guard-ships and h cruisers, always retain a sufficient number of trained men newly commissioned ships, in the event of a sudden armame In this manner vast facilities and advantages would be ex

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[a] The author's recommendation to increase the number of seamen-gu has met the approbation of our neighbours. M. Grivel, one of the distinguished commanders in the French navy, refers in a recent publ to a former edition (1851) of this work in support of his suggestion augmentation of that class of seamen on board the ships of war of his n

enced in fitting ships, and in rendering them more immediately efficient. The plan now suggested would provide people not only qualified to assist in fitting the ship, but also to assist in working her;—not only qualified to drill to gunnery the fresh hands, but to examine and arrange all the ordnance equipment, and very soon to make that ship, if properly commanded, a *good man-of-war.*

20. In all departments of warlike organization, depôts are allowed to be the very hearts of the system, by which improvement is cultivated, circulated, and established. In all services this is recognised and observed; no body can be permanently good, no system uniform, without them. It is to this general measure that the service-efficiency of every branch of our army is mainly to be attributed. It is this which supports the uniform systematic excellence of the whole machine, however remote some of its parts may be. It is a similar system, connected with the naval profession, which has made the marines what they are, and which has so much improved—perfected, indeed — the Marine Artillery. Detachments of the Marine Artillery are embarked on board the ships of a squadron sent out on a cruise of exercise and practice; and it was no uncommon thing for naval officers fitting out ships to apply for detachments of this corps to drill their seamen to the gun exercise. If such detachments had been drawn from a permanent body composed of *seamen* gunners, trained by *naval* officers, instead of marines, there would have been no comparison between the influence of the two systems on the practice of Naval Gunnery. For the same reason that the Marines have their divisions, the Royal Artillery its schools of practice, and every regiment its depôt, naval gunnery should have its permanent seat of instruction, and store of trained men.

21. The Marine Artillery has been raised to a condition of great excellence by its zeal, talent, and gallantry, and has certainly performed all the service that was contemplated at its formation. The author has witnessed its efficiency on service, and bears willing testimony to all the talent it has put forth, and all the distinction it deserves. It is well constituted, thoroughly instructed, and ably commanded. It is either a corps of good infantry, of scientific bombardiers, or expert field-

artillerymen; and it should be allowed to retain all these characters, by being kept for mortar service afloat, or for land-artillery service in desultory coast operations.

22. The advantages that would result from such an establishment are beyond calculation. These depôts would become the resorts of zeal and talents—the nurseries of improvements; and numbers of young naval officers of all ranks would resort thither at their own expense. Such is precisely the opportunity which the naval service wants in this branch of the profession. Improvement may thus be cultivated without pursuing it through other departments:—Naval officers would find a field opened to them, which is now occupied by others. Naval Gunnery would become, as it most certainly should be, an organized department of the naval service, under the direction and control of the Admiralty; and the author feels most certain that this simple measure would lay the foundation of a system which would soon be carried to perfection by the professional genius and zeal which it would call into action.

23. The merits of this plan do not depend upon the limited extent to which we may be obliged to confine it at present, on account of the difficulty of making financial provision for a more general operation.—If it be plainly calculated to do some good, it should not be rejected because, for contingent reasons which attach not to its merits as a system, it cannot, at present, yield its full benefits. The adoption of a good sound system is the question at present under consideration, not its immediate extension. If we found our measure upon a good professional principle, the superstructure may be raised gradually, in proportion as we may require it. The question for consideration is, whether the plan which is suggested does not provide a good professional system for instructing officers, midshipmen, master-gunners, and gunners' mates;—for training a proportion of se men as captains of guns, as well as for drilling seamen engag in the ordinary way: whether such a measure would not en nently tend to encourage the professional cultivation of artille knowledge in a permanent institution, which may hereafter l carried to any extent which circumstances may demand. If promise such advantages, it will be cheaply purchased by expense that may attend it.

24. Were this an experimental measure that could not be commenced without first committing the country to vast preparatory expense, we might hesitate about making the trial; but the system may be instituted at a cost that would not amount to the expense of adding a twenty-gun ship to our establishment. The items of the expense of one depôt were severally estimated by the author and given in the former editions, but, as the question relating to such expenses, though important at the time, has now been decided, it will be unnecessary to re-state either the items or the amount.

25. The author hopes he has succeeded in convincing the reader that the improvement of naval gunnery will mainly depend upon the character of the depôts of instruction. Whether seamen be raised in the ordinary way for three years, and drilled as at present, or be engaged for a longer term, and trained as naval gunners in the manner here proposed, there can be no reason why they should be taught by any but the members of the profession to which the practice really belongs.

26. Such were the observations made by the author, in the first edition of his work, on contemplating the state of gunnery in the British navy at that time. Political circumstances and financial considerations prevented the British Government in 1817 from immediately adopting the proposition which, in that year, was presented by the author to the Admiralty; but, in 1830, the former having materially changed, and the latter no longer existing, a commencement was made by the Naval Administration to put the proposed plan into execution.

27. In that year Lord Melville, to whom the former edition of this work was dedicated, by an Admiralty "Minute," dated June 19, directed that a gunnery-school should be formed on board the "Excellent," on a limited establishment. It was placed as a temporary measure under the superintendence of the late Captain George Smith, Commander of H.M.S. "Victory," an ingenious and zealous officer, well known as the inventor of the moveable lever target.[a] In 1832 the system for gunnery

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[a] This contrivance was intended for the instruction of seamen-gunners in the practice of naval gunnery at sea, without the consumption of ammunition, when, from the floating motions, the ships fired from and at, are more or less unsteady—an ingenious expedient, devised, as Captain Smith communicated

struction was extended and permanently established by Sir James Graham, first under Captain Sir Thomas Hastings, and, after his appointment to the important office he now holds, successively under Captain, now Rear-Admiral Chads, and Captain, now Rear-Admiral Sir Thomas Maitland, to all of whom the naval service and the country are deeply indebted for the zeal and ability with which, aided by a staff of meritorious officers, the courses of study relating principally to Naval Gunnery are unremittingly carried on, and the institution brought into so much practical efficiency.

28. The gunnery establishment now consists of the "Excellent," which is under the command of Captain R. S. Hewlett, R.N., C.B., and is stationed at Portsmouth, and the "Cambridge," under the command of Captain A. W. Jerningham, R.N., which is stationed at Devonport. Each of these ships has a gun-boat attached to it, for the performance of the exercises in firing at targets outside of the harbour.

The total complement of the "Excellent" consists at present of 702 persons, including the staff of the ship; of these, 480 persons are under instruction, and are to be discharged into sea-

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to the author, to explain and illustrate the observations contained in pages
226 and 227 of the 'Naval Gunnery,' 2nd edition, by giving the target an
artificial motion whilst the gunner is taking his sight. This motion is stoppe
by a line, leading to the target, connected with the trigger-line; and thr
there is exhibited, relatively with the line of sight through the centre of th
wooden gun, any error which the gunner may have made, in pulling th
trigger-line at the proper instant to hit the centre of the target.

On Captain Smith's appointment to the superintendence of this comme
ment of a system of which he, in several interviews with, and letters t
author, had declared himself a zealous and earnest well-wisher, he ad
to the author a congratulatory letter, of which the following is a copy

"H.M.S. Excellent, Portsmouth H
July 14, 1830.

"SIR HOWARD,—I take the earliest opportunity, after having heard
return to England, to inform you that the Establishment which yo
long desired to see in our Navy has commenced on the limited plar
honour to submit to you; and, if I may be allowed to use a famil
as *Ce n'est que le premier pas qui coûte*, I trust you will have e
gratification of seeing the system extended as widely as you can
have clearly demonstrated the necessity of it, and in such langu
fail in its effect.

"I have the honour to be,
"Sir Howard,
"Your most obedient and much obliged
(Signed) "G

going ships in proportion as they become qualified. There are, besides, 19 lieutenants, including the one commanding the "Stork" gun-boat, of whom 6 are supernumeraries, allowed in lieu of mates, of which latter class none can at this time be obtained. Of those 19 lieutenants, 15 are studying in order to qualify themselves for becoming gunnery officers. The "Excellent" has also now 25 marine cadets: these live on board the ship; but those who may pass their examinations, and may be recommended for the marine artillery, will go to the Naval College and study for that corps.

The complement of the "Cambridge" consists now of 621 persons, of whom 480 are being qualified to become seamen-gunners. It is anticipated that the gunnery establishment will soon be able to supply to newly commissioned ships, one if not both captains to every broadside gun.

29. In 1839 the building which had been vacated, in consequence of the abolition of the Naval College for the education of young gentlemen destined for the naval service, was appropriated, in combination with the Gunnery-school on board the "Excellent," to the important purpose, as suggested by the author in 1817 (see Art. 16), of accommodating and instructing naval officers of all ranks on half-pay, who might be desirous of availing themselves of the great advantages which those institutions severally and conjointly tender to officers, when not otherwise employed, to improve themselves in the various branches of nautical science and practice which enter so largely into the qualifications indispensable to an accomplished, skilful, and experienced naval officer.

30. The vast importance of these Establishments in promoting the efficiency of the naval service will be immediately appreciated from the following outline of their constitution, and of the professional objects for which instruction is there given. The Naval College is an establishment for twenty-seven officers of all ranks, on half-pay, from Captains to Lieutenants; for Marine officers previously to their entering the Marine Artillery, and for twenty-five Mates. The two last classes of officers go through a course of gunnery on board the "Excellent," previously to entering the College; and the Mates compete for a Lieutenant's commission, which is given at Christmas and at Midsummer to

him who has attained the greatest proficiency. All the above classes of officers study, under a very able professor, the higher branches of mathematics, including Astronomy. Their course also includes the theory and practice of Steam Engineering, with Mechanical Drawing, Fortification, and Gunnery.

The half-pay officers remain at the College from twelve to eighteen months, and the others, twelve months.

It is now regulated that all Acting Lieutenants, Acting Mates, and Midshipmen, while undergoing examination must live in the College, under strict rules with respect to leaving the building, and returning to it at night. The students are borne on the books of the "Excellent" for commissions, and are consequently under martial law, though many of them belong to no ships. The warrant officers trained on board the "Cambridge," when about to pass their examinations, are also obliged to live in the College, a measure which is found to be attended with the most beneficial results in every respect.

31. The establishment includes twenty-five Cadets for the Marine forces, who may remain two years unless they attain the required proficiency, and can undergo the examination, in a shorter time. Their course of study comprehends Fortification, Gunnery, History, and the French language.

Field Works are thrown up on a small island in the harbour, for the purpose of training the officers and men, and also for the service of field guns. On the same island there is a small laboratory, where all the students go through a course of instruction in making rockets, tubes, cartridges, fuzes, &c. Field-practice with shot and shells is carried on by them at South Sea.

It is most gratifying to find that the present Board of Ad
miralty has manifested, as did the late Board, an anxious de
to support the authorities of the gunnery establishment in ca
ing out the measures recommended by those authorities for
improvement of their peculiar and very important service.

32. Besides the regular duties there are prosecuted, und
direction of the Commander of this Institution, experim
the most important nature, whenever the prospect of ben
the service requires that such should be made. Among
may be included experiments for the determination

relative values of different natures of ordnance for the projection both of solid and hollow shot; the extent of the ranges of projectiles; their powers of penetrating into materials; their crushing and splintering effects when fired against wood and iron; and the effects of ricochets from land and water. It ought to be added, that other nations, particularly France, have, since 1815, carried on elaborate and highly scientific courses of experiments, with the view of improving their naval-gunnery practice. The details of these experiments, with the investigations founded on them, have been published; and, to the experiments conducted on board the "Excellent," in conjunction with those at Woolwich and at Shoebury Ness, we are indebted for the verification (in some instances the disproval) of the advantages ascribed to the discoveries of foreigners. In these operations a vast amount of science and practical skill has been brought to bear upon every object of national utility within the limits of their scope.

33. Since the institution of the school of naval gunnery on board the "Excellent," the total number of able seamen entered as gunners amounted in 1851 to about 2500. Of these upwards of 2100 passed examination, and obtained certificates of qualification to serve as captains of guns, gunners' mates, and gunners of ships. Of that number 273 were, at different times, appointed as gunners, and 500 as gunners' mates; while no less than 1140 well-trained seamen-gunners were then serving in the British navy as first and second captains of guns, or in other important stations.

34. Up to that time, 70 or 80 lieutenants and 150 mates and midshipmen, of those who had at different times been on the establishment of the "Excellent," passed their examinations, and obtained certificates of proficiency in the theory, practice, and manual exercise of naval gunnery; of whom about sixty were then serving as gunnery-lieutenants, mates, and midshipmen, on board of ships in commission: indeed so zealously had officers of all ranks availed themselves of the advantages of resorting to Portsmouth for improvement, that about 460 officers of different ranks, post-captains, commanders, and lieutenants, passed their examinations, and obtained certificates of qualification according to their different attainments in naval gunnery.

35. In July, 1858, the Committee on Naval Gunnery, of which Sir Thomas Maitland, late Captain of the "Excellent" and head of the gunnery establishment, was the Chairman, addressed to the Lords of the Admiralty a letter calling their attention to the necessity of supplying in time of peace at least one captain certified to be duly qualified for the performance of his important duty, for every gun on board a ship of war; it being the unanimous opinion of the Committee that without such an arrangement no amount of proficiency in fighting the guns can be depended upon.[*] The Committee observed that though men may be quickly taught to work guns, yet a captain of a gun cannot be efficient without careful training and a certain amount of actual practice. The Committee added that the French have for some years adopted this plan, and that unless we do so we shall meet them at a great disadvantage in the event of a war suddenly breaking out.

Sir Thomas Maitland, also, in a letter addressed in April, 1859, to Sir John Packington, then First Lord of the Admiralty, observed that the number of heavy guns actually on board ship, at that time, was about 5000, so that under the existing establishment of captains of guns we could only make sure of 300 of them being efficiently used in action. It is true that there are also about 400 first-class seamen and gunners' mates; but most of these are required to work in the magazines during a[illegible] action, that being a duty which cannot be confided to ignora[illegible] men.

In the service of the Land Artillery not even a 6-pound[illegible] gun is brought into action but under the charge of a prope[illegible] qualified non-commissioned officer; yet, strange as it may seem, in the naval service we trust to chance for obtaining a man capable of taking charge of our guns in action. A newly-com-

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[*] Extract from a Report of the Committee on Gunnery respecting Captains of Guns, July, 1858 :—

"The Committee consider it their duty *at once* to call their Lordships' serious attention to the necesity of supplying a *certified* qualified captain for every gun put on board a ship in time of peace, as they are unanimously of opinion that without this arrangement no positive amount of proficiency [or efficiency] in fighting guns can be calculated upon. Men may quickly be trained work guns, but the captains [of the guns] cannot be efficient without car training and a certain amount of actual practice."

missioned ship receives from the gunnery establishment only about three per cent. of her company. At the commencement of the Russian war (1854) two-thirds of our captains of guns in the newly-commissioned ships had never fired a shot; and, when the war was over, one-half of them were still inefficient. There is, no doubt, great truth in the assertion of Sir Charles Napier that he could not answer for his ships in action against the trained crews of the Russian ships of war; and it is fair to presume that if the gallant Admiral had had one certified captain for each gun, his fleet would have been fit to go into action after 14 days' drill, even if none of the other men had been previously trained to the guns.

36. It has been alleged that, in the British naval service, certified captains of guns are not required, since all seamen are trained to work the guns; but to this it may be replied that the duty of the captain of the gun in pointing and firing is far more intricate, and requires a much greater amount of judgment and mechanical skill, than that which is sufficient for merely running out or training the gun. It has been also objected that the captains of guns, when they get old, are in the way of the younger and more active men: daily experience, however, refutes the objection, as the practised eye of a rifleman even beyond the age of 45 years is found to be far superior in accuracy to that of a younger and therefore a less experienced soldier. Lastly, it has been said that commanders of ships can train their own captains of guns: and this would undoubtedly be true if they had the time, and were prepared with a fixed course of instruction for their guidance; but, in the event of a war breaking out, the first great battle would most probably be fought before the captains of guns so taught would be efficient, and even before the commanders of ships had found out what men were best qualified for instruction. Our enemies are quite prepared to meet us on the ocean, but months would elapse before our captains of guns would acquire the efficiency which would enable them to cope on equal terms with their opponents, who were qualified men before the ships in which they serve were commissioned.

37. In a letter addressed subsequently (April 29, 1859) to the Admiralty, acknowledging that every effort is being made by the Board of Admiralty to increase the establishment of the

gunnery ships, Admiral Sir Thomas Maitland observes that the two gunnery ships do not afford sufficient means, at a short notice, to supply a number of large ships with captains of guns, and that those which they do supply are generally men of inferior abilities. Sir Thomas adds that, in order to obtain certified captains of guns, it would not be necessary that these should be raised on board the gunnery ships; and that their Lordships have only to issue orders that there should be selected, for captains of guns, the most intelligent petty officers and able seamen of the fleet, men not above 30 years of age, and who have entered for continuous service: these should be instructed and certified according to the "Regulations" laid down in the Revised Gunnery Instructions Book, section IV., p. 126. This standard of qualification had been drawn up by the Gunnery Committee as the minimum consistent with the requisite efficiency; and no captain of a gun should be considered duly qualified till he has received his acting certificate in accordance with this standard. Sir Thomas expresses his opinion that nothing but a fixed standard like that which is here proposed will meet the exigencies of the service, and he infers the necessity of it from the fact that no two officers are of the same opinion with respect to what constitutes efficiency. He proposes that the captains of guns so formed should, when they return home, be sent to the gunnery ships, in order to be perfected in their duty, and to have their certificates confirmed.

The same officer further stated that, besides increasing the gunnery establishment in the home ports, it would be advantageous to have one or two cruising ships for gunnery exercise on the ocean. This important measure was adopted by the Board of Admiralty but very imperfectly by appointing a gun-
boat as a tender to each of the two gunnery ships for the purpos
intended. But these are not cruizing ships, and very insufficien
for the purpose. In the French service two frigates of instructio
(see note, page 24) are appropriated to this important duty. Si
Thomas Maitland, in the letter above quoted, further recommen
that some advantages should be held out to officers and first-
seamen in order to induce them to join the gunnery ship
present it is a positive disadvantage to an officer to be appo
to the "Excellent," and the inferior seamen who now offer t

selves would be better away. The gallant Admiral refers to the fourth edition of this work for an account of the time necessary for the formation of a land-service artilleryman, leaving it to be inferred that a still longer time would be required in order to make a man a proficient in the service of artillery at sea. Whatever measures may be adopted to improve or extend the gunnery establishment should be put in execution as soon as possible, if we would place the service of the country on a par with that of France in respect of its efficiency in ocean warfare.

The recommendations of Sir Thomas Maitland met with the approbation of the Admiralty Board; and in May, 1859, the Lords Commissioners issued a circular, dated April of that year, directed to Flag-Officers, Commanders-in-Chief, Captains, and Commanders of Her Majesty's ships, in which the number of men of that class allowed to each ship in the British Navy is prescribed to be as follows:—

		Guns.	Men.	
Seamen-Gunners, one for each gun.	For a First-rate	120	120	One Seaman-Gunner per gun.
	" Second	100	100	
	" Third	70	70	
	" Fourth	60	60	
	" Fifth	40	40	
	" Sixth	20	20	
	Sloops	15	15	

Their Lordships further desired that Commanding Officers of ships should read, and make known to the several ships' companies, the provisions of the Circular, so that young intelligent petty officers and able seamen may be induced to qualify themselves to become *Acting* Seamen-Gunners. Men volunteering are to be examined by a gunnery officer according to the Instructions laid down in the New Gunnery Book.

Any seaman-gunner who may have previously declined to continue to serve as such at the expiration of his time, may be permitted to re-enter for another period of five years with the certificate he last held, provided he be not more than 37 years of age.

In the Circular above referred to (dated April 13, 1859) it is directed that the extra pay of seamen-gunners shall be increased as follows:—

The pay of seamen-gunners of the 1st class, from 2*d*. to 4*d*. per diem.
" " " 2nd " 1*d*. to 2*d*. "

It is further directed that all men who after this date shall qualify themselves for seamen-gunners, or, abroad, as acting seamen-gunners, shall be allowed to reckon (from the date of such qualification, and while serving as seamen-gunners or acting seamen-gunners) time in the proportion of six years for every five that they have served, towards a long-service pension; fractional parts to be allowed for broken periods in the same proportion. The same advantage to be allowed, from this date, to seamen-gunners or acting seamen-gunners now serving, providing, in the case of acting seamen-gunners, that they are confirmed as seamen-gunners on their return to England.

Something more than this is required to be done in order to insure an adequate supply of captains of guns for an augmented number of ships in commission in time of war. No doubt the crew of a ship well commanded and well officered may, during a period of three years in commission, be as well trained to the exercise of the guns as if on board the gunnery ships; and that many of the seamen acting as captains of guns may, in that time, be made fully proficient in their duties; but when such ships are paid off, these men will be dispersed, so that the country will gain nothing by their proficiency,

Now, what is wanted is, that all those captains of guns who may prove their proficiency as such on examination by a committee of gunnery officers, should, if they are willing to engage for a term of years to serve in the gunnery establishment on an advance of wages, be allowed to receive first or second certificates according to their qualifications; and thus, being added to the Depôts of gunners in the gunnery ships, they would be disposable for service in sea-going ships as occasion may require. In this manner all ships of war would become training-schools as well as the gunnery ships, to supply newly-commissioned ships with well-instructed gunners. For this purpose it would be necessary that the Admiralty should grant the necessary funds to give to men so trained to serve as captains of guns, the same extra pay as gunners which is granted to those who obtain certificates of competency in the "Excellent." Unless suc funds be granted, it is clear that the seamen so trained will b lost to the service. Such loss was incurred at the termination the late Russian War in 1854, when hundreds of well-traine seamen-gunners, who might have been retained in the service for future exigencies, were paid off with the rest of the crews. It is a fact which the author (and he was the first to propose the augmentation of the gunnery establishment) records with great pain that it is not even now adequate to furnish a captain to each gun for the ships in commission, whilst the French have extended their gunnery establishment sufficiently to furnish three trained gunners per gun for every ship afloat. The crews (*equipage de ligne*) are always ready to man the ships of war as soon as they are commissioned for service.

38. The recent augmentations of the Royal Artillery were made, as stated in Parliament, because none of our foreign garrisons were well provided, and some very inadequately, with this most essential description of troops; and also because the gunners disposable at home were not only insufficient to furnish more than at the rate of one artilleryman for every three guns in our coast defences, forts, and arsenals, as they now exist, but absolutely incapable of furnishing a supply of artillerymen for the additional armament required to man the numerous defensive works which it would be necessary to construct on the occurrence of any serious alarm. In addition to the above reasons for so great an increase in the land-service artillery, it was stated that six years are required to instruct land-service artillerymen, and render them practically efficient. The complements of seamen-gunners for our ships now in commission are too limited; and a long time would elapse before new levies of seamen could be properly trained to the guns, in the event of any emergency which might require an extension of our naval force. Though we have an establishment for instructing seamen-gunners during peace, in the details of their duty, it is on a scale too contracted to be effectual in war. As our land-service artillery has been augmented, so the number of seamen under instruction in naval gunnery should be increased to an extent which may suffice to furnish at least 5000. One thousand of these should be always available for embarkation at the home ports, as recommended by the Royal Commission for Manning the Navy (1859). And it must be remarked, and provided for accordingly, that the rifled cannon now introduced into the service are of descriptions which absolutely require a higher degree

of skilful training of the captains and loaders of the guns than heretofore. This may be done by retaining the most expert of the men that have been instructed, and keeping them in active employment in sea-going ships and gunnery frigates.[a] We may thus have available at any time a number of men well-practised and ready for any emergency; whereas, by casting them loose on the world, the means devoted to the purposes of their instruction are expended in vain, and the ends for which the expense is incurred are defeated, while the men are liable to be picked up and employed for the benefit of rival nations.

39. The late addition to the gunnery establishment is a step in the right direction; but much yet remains to be done in order to attract seamen to, and retain them in, that important branch of the service. From the subjoined table it will be

A TABLE of the RATE of WAGES in the ROYAL NAVY per MONTH and per YEAR, under the OLD and NEW REGULATIONS.

RATING.	Under the Old Entries.		Continuous Service, or Entry for 10 Years.		Difference in favour of Continuous Service per Year.
	Per Month of 31 Days.	Per Year.	Per Month of 31 Days.	Per Year.	
	£. s. d.	£. s. d.	£. s. d.	£. s. d.	£. s. d.
Chief petty officers ...	3 2 0	36 10 0	3 9 9	41 1 3	4 11 3
First-class working petty officers	2 14 0	31 18 9	3 2 0	36 10 0	4 11 3
Second-class working petty officers.........	2 9 1	28 17 11	2 16 10	33 9 2	4 11 3
Leading seamen	2 6 6	27 7 6	2 14 3	31 18 9	4 11 3
Able seamen............	2 1 4	24 6 8	2 9 1	28 17 11	4 11 3
Ordinary seamen	1 13 7	19 15 5	1 18 9	22 16 3	3 0 10
Second-class ordinary seamen	1 8 5	16 14 7	1 11 0	18 5 0	1 10 5
Boys (first-class), and naval apprentices...	0 18 1	10 12 11	0 18 1	10 12 11	No diff.
Boys of the second class	0 15 6	9 2 6	0 15 6	9 2 6	No diff.

Seamen-gunners, who are men trained in the "Excellent," receive 4d. per day in the first class, and 2d. per day in the second class, in addition to all other pay of their ratings. Also five years service are allowed to be counted as six, for a pension.

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[a] Frigates of instruction for seamen-gunners in the French Navy are appropriated to that important purpose, and occasionally accompany their squadrons and fleets on sea-going service. Thus the "Amazone," frégate d'instruction, formed part of Admiral La Lande's fleet in the Mediterranean, in 1840.

The "Minerve" 1st-class frigate was specially commissioned for L'Ecole des Matelots Canonniers, in 1848.

The

seen that, according to the present regulation, those seamen who obtain certificates of the first and second classes receive, respectively, only 2*d.* and 1*d.* per day above the pay due to their ratings, but which is now raised to 4*d.* and 2*d.* This is not sufficient to induce seamen to enter the service for the purpose of being trained as gunners rather than as mere seamen; nor is the amount of pension awarded to the class of trained gunners sufficiently liberal. The government and the country should consider what would have been the state of the naval service if the Establishment for training seamen-gunners had not been formed, and the deficiencies even now experienced from its inadequate extension.

40. When the war with Russia broke out, in 1854, the naval force in commission was vastly and suddenly increased. The total number of guns carried by the ships in the Black Sea Fleet was 1394, and those in the Baltic Fleet 2200. Supposing the ships' batteries are manned on one side only, half the sum of these, or 1797, is the number of guns on the fighting sides of the ships; and for this vast force we had only 610 men fit to serve as captains of guns in depôt, as none could be spared from the ships previously in commission. This inadequate number furnished only one trained seaman to each gun, as its captain, whereas there should be three, as in the French service; the captain, the man under him, with the man who serves the vent-tube and lock. Had the Establishment for trained gunners been increased, as urged by the author a few years since, and as recommended by Sir Thomas Maitland (see Art. 37), how different would have been the effective condition of the fleets!

41. It should be remembered that, when emergencies shall arise, we shall require both *gunners* well qualified to cope with opponents trained in all the improvements which the practice

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The Russians have long since adopted the French practice of forming what are called *Equipages de ligne* (ships' crews); of these they have 46, each consisting of 1195 men: viz., 27 in the Baltic and at Archangel, 16 in the Black, and 3 in the Caspian Sea. Each "Equipage" is divided into four companies, of which three form the quota assigned to ships of three decks, two-and-a-half to ships of two decks, and one-and-a-half to frigates of 60 guns. Nor are the Russians less active than other maritime powers in teaching the science and improving the practice of naval gunnery. It is scarcely necessary to observe that, on a recent occasion, they gave ample proof that they can effectually handle those destructive weapons which have been introduced into the warlike navies of other nations within the last forty years.

with solid shot has everewhere attained, and *bombardiers* highly expert in the more difficult and delicate operations of shell-firing —a practice which, if not carried on with the utmost skill and care, may be attended with accidents of a nature capable of causing the loss of a ship, or even of compromising victory in a general action.

42. The extensive establishments at the five principal naval arsenals of France for the organization of *Equipages de ligne* (ships' crews) (Ordonnance of the 11th Oct. 1836), as well as the establishment for the instruction and training of Matelots Canonniers, will hereafter be described in detail. From these reserves, together with the extensive establishments of Marine Artillery and Marines, a very considerable number of ships of the line, frigates, and other vessels may be promptly manned and speedily prepared for service. This would be done by immediately embarking the regulated number of companies, each composed of six petty officers, thirteen marine apprentices, and thirty seamen, and the regulated number of Matelots Canonniers.

The government of the United States is only now beginning to take measures for training its seamen systematically in the practice of gunnery. The Secretary of the Navy, in his annual report (1856), after referring to the gunnery-practice ships in the British Naval Service, states that an effort is being made to commence a system of gunnery education in the United States; the "Plymouth," sloop of war, has been fitted up under Commander Dahlgren as a gunnery ship, and the hope is expressed that there will be turned out, annually, a certain number of seamen thoroughly trained to the management of heavy ordnance in storm or calm.

A STATEMENT of the COMPARATIVE PAY of NAVAL GUNNERS and ABLE SEAMEN in the United States' and the British Navies in 1859.

Pay per Month.	United States' Navy.	British Navy.
	£. s. d.	£. s. d.
Gunners' mates	5 0 0	3 12 0
Seamen gunners, called quarter gunners in the United States' navy	4 0 0	2 17 5 first-class. 2 13 3 second-class.
Able seamen	3 12 0	2 9 1

This includes the 4*d*. or 2*d*. per day granted by Circular, April 18, 1859.

PART II.

ON THE THEORY AND PRACTICE OF GUNNERY,

MORE PARTICULARLY APPLIED TO THE SERVICE OF THE NAVAL ORDNANCE.

43. THE discoveries made by Robins, Hutton, and others in the science of gunnery have, within a few years, been so much the subjects of elementary instruction in the public seminaries of Great Britain for the education of men intended to enter the military and naval services of the country, and an artillerist has now in so high a degree the power of attaining the pure science of his profession, that it may seem unnecessary to dwell at length on the mathematical theory of projectiles. This subject will, therefore, be briefly introduced in notes; and it is intended, in the text, merely to exhibit the formulæ which comprehend the rules employed in the practice of gunnery, and to explain the manner in which those rules are deduced from the theory.

44. The theory of gunnery, in its present state, is admitted to be insufficient to serve alone as a basis for the practice of the artillerist; yet, as it may be not unreasonably expected that the theory will ultimately be carried to a degree of perfection corresponding to that which has been attained in other departments of physical science, it should be borne in mind that this object can be gained only by a diligent cultivation of the theory itself; and it may be added that it is only a scientific member of the profession who can direct experiments tending to useful results, or can advantageously introduce in formulæ the data which the experiments furnish.

45. While the processes to be followed in investigating the laws of projectile motion in resisting media were known only to a few men of superior scientific attainments, it happened unavoidably, the guide to a correct and improved practice being wanting, that the most indispensable precepts relating to

construction, armament, and equipment were violated, and the most obvious results of experimental research were unseen or disregarded.

46. A knowledge of the principles of gunnery is more essential to the naval artillerist than to an officer in any other branch of the service;—to him it may indeed be said to be absolutely necessary—and it cannot be doubted that he ought to avail himself of every means in his power to study the theory which should form the ground of his practice. It is true that the construction of a gun and the regulation of its equipment depend not always on an individual officer, but are determined by the authorities in the proper department; it is also true that tables of the ranges of shot, with different charges of powder and different elevations of the "arm," have been formed from experiments, and published by authority, for the guidance of the artillerist in like circumstances; but these tables, are, even now, not sufficiently extensive to meet the vast variety of cases in which, afloat or on shore, the officers of our navy may be called upon to act; and, the charges, the elevations, and even the windages remaining the same, the ranges continually differ in consequence of variations in the quality of the powder, the state of the atmosphere, the figure of the shot, and many other circumstances.

47. A familiarity with all the details of the theory of projectiles can be acquired only by the aid of works professedly treating of dynamics in its highest branches; but a course of study carried on to an extent which the reading of such works implies may not be within the reach of every officer; and, at present, it is perhaps unnecessary. A certain knowledge, however, of the principles is indispensable for all, in order to enable them to comprehend the deductions made from the theory, and apply the formulæ to such novel cases as may arise in the course of their practice.

48. The numerical determination of points in the curve described by a projectile in a resisting medium, even when the analytical formulæ are given, is a work of so much labour that scarcely any practical artillerist would be disposed to execute it for a particular case which may occur, and such officer, confining himself to the subject of ranges only, would probably

prefer making approximative interpolations between the ranges which have been experimentally determined; yet even this comparatively simple process cannot be effectively accomplished without a knowledge of the principles on which the ranges are investigated; and an officer of the artillery should no more be unacquainted with these than with the important discoveries which, in gunnery, relate to construction and armament. It is, in fact, of the utmost importance that officers should be familiar with the velocities due to the charges they use, with the principles on which those charges have been regulated, and with the effects which may result from variations in their quantities or qualities. It is particularly essential that those naval officers at whose discretion and on whose application the equipment of vessels with respect to the nature of gun is frequently regulated, should know the laws of the action of powder in guns of different lengths, and with charges of different quantities, also the effects of a plurality of shot as well as of single balls, or shells, of different weights. Lastly, officers should be acquainted with the laws of the penetration of shot of different sizes, when fired at different distances, into materials of different kinds, as well as with the effects of the air's resistance on projectiles of different magnitudes and forms when discharged with different velocities.

49. Persons unaware of the force with which a military projectile, when impelled with great velocity, is resisted in its passage through the air, and imperfectly acquainted with the mathematical processes by which the trajectory, or path, in a resisting medium may be approximatively determined, still imagine that the laws of the flight of such projectile may be deduced from the well-known properties of the parabolic curve, which it would describe in vacuo. This opinion is, however, unfounded, and the results obtained from those properties are seldom of use in the practice of gunnery; yet, as the parabolic theory affords useful deductions in some cases, and a knowledge of it constitutes a step in the ordinary courses of military instruction, that theory is briefly explained in the subjoined note.[a]

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[a] Let A, Fig. 1, Plate I., be the centre of gravity of the projectile at the mouth of a piece of ordnance; let A X be a horizontal, and A Y a vertical

50. But no artillerist requires now to be told that the deductions from the parabolic theory are without value in practice,

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line, both passing through that point; also let A T, a tangent to the curve at A, be the direction in which the shot is discharged, so that T A X is the angular elevation of the piece. Let this angle be represented by a, and let the initial velocity of the shot be represented by v: let t be any time reckoning from the instant of the discharge, also let x, y be the horizontal and vertical co-ordinates of any point in the curve.

Now, if the force of gravity did not exist, the shot would move with uniform velocity in the line A T, and if b were its place at the end of the time t, we should have

$$A b = t v, \quad A R = x = t v \cos a, \quad b R = t v \sin a:$$

but, by Dynamics, the deflexion b P produced by gravity in the time t is expressed by $g t^2$. We have therefore

$$P R = y = t v \sin a - \tfrac{1}{2} g t^2.$$

Now, from the first equation, we have $t = \frac{x}{v \cos a}$;
and, substituting for t this value, we have

$$y = x \tan a - \frac{g x^2}{2 v^2 \cos^2 a}:$$

again, by Dynamics, $v^2 = 2 g h$ (h representing the height due to the initial velocity), therefore the equation to the trajectory becomes

$$y = x \tan a - \frac{x^2}{4 h \cos^2 a}; \quad . \quad . \quad . \quad . \quad . \quad . \quad (A)$$

and, by the theory of curves of the second order, this is the equation to a parabola, the axis of the curve being parallel to A Y.

When $y = 0$, we have, first $x = 0$, and secondly $x = 4 h \sin a \cos a$; or, by trigonometry, $= 2 h \sin 2 a$. The first value of x corresponds to the point A, and the latter to the point I: this last expresses the value of the range on a horizontal plane.

Differentiating the equation (A) and making $\frac{d y}{d x} = 0$, we have $x = 2 h \sin a \cos a$, the half-range (= A M), and substituting this value of x in (A), we get

$$y = h \sin^2 a$$

for the greatest vertical ordinate (= M K), and K is called the vertex of the curve.

Since $x = t v \cos a$, we have

$$\frac{d x}{d t} = v \cos a;$$

that is, the velocity of the shot in the horizontal direction at any point in the curve is constant.

Again, since $y = t v \sin a - \frac{1}{2} g t^2$, we have the velocity, in a vertical direction, at the end of a given time t,

$$\frac{d y}{d t} = v \sin a - g t.$$

From these values of $\frac{d x}{d t}$ and $\frac{d y}{d t}$ we have the velocity at the end of a given time t, in the direction of the curve

$$= \left\{ v^2 - 2 v g t \sin a + g^2 t^2 \right\}^{\frac{1}{2}};$$

except when the initial velocities of projectiles are less than two or three hundred feet in a second, when the resistance of the air is very small. In such a case, indeed, the propositions of gunnery may be solved, by the parabolic theory, with tolerable accuracy; but, with greater velocities, the conclusions obtained from it are grossly erroneous. It will neither serve to determine the range, when the elevation and initial velocity are given; nor if the time of flight were observed and the range measured, could the initial velocity be computed from those data.

51. The determination of the velocity of shot at the moment of being discharged from a piece of ordnance, the charge of powder being given, would be an easy deduction from the known theory of forces, were it not that much uncertainty exists respecting the value of the expansive force of fired gunpowder; and it was to ascertain that value, by comparing the mathematical expression for the initial value of shot with velocities obtained from experiment, that Mr. Robins first invented the Ballistic Pendulum, by which such velocities can be measured with great precision.

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but, if θ represent the angle which a tangent to the curve at any point makes with a horizontal line, the velocity at that point in the direction of the curve will be expressed by $\frac{dx}{dt}.\frac{1}{\cos\theta}$, or $\frac{v\cos a}{\cos\theta}$; that is, such velocity varies inversely as the cosine, or directly as the secant of the inclination of the curve, at the given point, to the horizon.

From the value of x we have $t = \frac{x}{v\cos a}$, and when $x = 4h\sin a\cos a$, that is the whole range, the value of t becomes

$$\frac{4h\sin a}{v}, \text{ or } \sin a\sqrt{\frac{8h}{g}};$$

this is the expression for the whole time of flight, and it evidently varies with the sine of the given angle of elevation.

Since the product $\sin a\cos a$ remains the same for any given value of a and for its complement, it follows that there are two elevations (a and $90^\circ - a$) of a piece of ordnance which, with the same initial velocity, give the same horizontal range.

The elevation of a piece being the same, the horizontal ranges ($2h\sin 2a$) vary with the heights due to the initial velocities; or, since $h = \frac{v^2}{2g}$, with the squares of the initial velocities; lastly, the initial velocities being equal, the horizontal ranges vary with the sine of twice the given elevation, and such range is evidently a maximum when a, the elevation, is 45 degrees.

52. The experiments of Mr. Robins formed an era in the theory of gunnery, but, having used only such shot as could be discharged from musket-barrels, it became desirable that experiments of the same nature should be made on a much larger scale than the means of a private individual could afford, and the prosecution of this important subject was entrusted to Dr. Hutton, professsor of mathematics in the Royal Military Academy, to whom the country is so much indebted for the high state of theoretical knowledge which the British artillery possesses. These experiments were commenced in the year 1775, and a copy of the report, being presented to the Royal Society, was honoured with the gift of the annual gold medal. Dr. Hutton carried on a second series of the experiments in the years 1783-4-5, &c.; and Dr. Gregory, his successor in the chair of mathematics at the Academy, was, in 1817, conjointly with General Millar and Colonel Griffith, charged with the superintendence of a corresponding series, in which a pendulum weighing 7000 lbs. was employed. It should be observed that experiments having the like object in view, but with a different kind of machine, were, in 1764, carried on by the Chevalier d'Antoni, at Turin, and the results at which he arrived differ but little from those subsequently obtained by Dr. Hutton.

53. The Ballistic Pendulum, Fig. 2, Pl. I., consists of a large block of wood, suspended by iron rods, so as to vibrate on a horizontal axis upon receiving the impact of shot projected into it. In order to measure the arc of vibration, Dr. Hutton applied a pointed piece of iron, as at P, to the inferior surface of the block, so that its lower extremity might, during the vibration, trace a curve line on a bed of soft grease which filled a groove in the circular piece A B of wood. The number of degrees in the act of vibration, or the chord of that number of degrees, was measured on a scale of chords which was laid down on the machine; and, from thence, the places of the centre of gravity and the centre of oscillation, together with the momentum of the inertia of the pendulum being previously found, the velocity of the shot at the moment of impact could be determined.

54. In conducting the experiments at L'Orient, from 1842

to 1846, the French engineers made use of a pendulum consisting of a suspended gun in combination with a suspended receiver (*récepteur*), corresponding to the block in the English pendulums; and, in 1843, the United States' government caused a series of experiments to be made, under the direction of Brevet-Major Mordecai, with an apparatus constructed on the same principle as the French machine. It consisted of a gun (a 24-pounder or a 32-pounder) suspended between two piers by a horizontal axis turning on *knife-edges*; and of a hollow frustum of a cone of cast iron suspended in a similar manner; the axes of the gun and cone, when both were at rest, being in the same horizontal line. The hollow frustum was filled with sand, in bags, to receive the impact of the shot; its front being covered with a plate of iron having in the centre a perforation, which was covered with sheet lead, and through this the shot passed after being discharged from the suspended gun. The whole weight of the gun-pendulum was 10,500 lbs., and that of the receiver pendulum 9358 lbs. The distance of the centre of gravity in each, from the axis of suspension, was about 14¾ feet; and the sensibility of the pendulums was such, that when set in motion in an arc of 12 degrees, the receiver-pendulum continued to vibrate about 24 hours, and the gun-pendulum about 30 hours.

55. The distance of the centre of gravity G, Fig. 2, Pl. I., from the axis of suspension at C, in the ballistic pendulum is, in some cases, found experimentally by balancing the whole apparatus, in two different positions, on an edge of a triangular prism; but the most accurate process for its determination is (while the machine is suspended on its horizontal axis at C) by a weight at the end of a string attached near P, and passing over a pulley, to draw the block up till its vertical axis C P is in a horizontal position. Then the known weight of the whole pendulum being supposed to act at G, the required place of the centre of gravity, and being represented by W; also P representing the weight which, by experiment, keeps the machine in *equilibrio* in a horizontal position; we have, by the nature of the lever,

$$P.CP = W.CG; \text{ therefore } CG = \frac{P}{W}.CP$$

Thus the required distance of the centre of gravity from the axis of suspension is known.[a]

56. The centre of oscillation, in a vibrating body, is that point in which, if the whole quantity of matter could be concentrated, the time of a vibration about the same axis of suspension would be equal to that of the given body. In order to obtain, experimentally, the distance of the centre of oscillation from that axis, let the body, when suspended freely, be made to perform vibrations of small extent on each side of a vertical plane passing through the axis of suspension, and let the number of such vibrations which are made in a given time, as one minute, be counted. Then, the number being represented by n, since, by Dynamics, the lengths of pendulums are inversely proportional to the squares of the number of vibrations performed in a given time, we have, l the length of a mathematical pendulum vibrating seconds in the latitude of the place of experiment being known,[b]

$$n^2 : (60)^2 : : l : l';$$

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[a] The position of the centre of gravity in each of the pendulums used in the United States' experiments was found by balancing the machine, in different positions, on a steel bar; but the method employed by the French artillerists was nearly as follows:—The axis of the bore being in a horizontal position, a weight w sufficient to cause that axis to take a position, as A B, Fig. 3, Plate I., inclined to the horizon in a certain small angle A D E, represented by θ, was applied as at H, under one extremity of the piece; the centre of gravity of the whole, which previously was in a vertical line C Z passing through the axis C of suspension, was consequently made to describe an arc subtending an equal angle Z C D. The same weight was then removed to the opposite extremity K, of the piece, by which means the centre of gravity was made to describe an arc subtending an angle θ' on the other side of the vertical line. Then, W being the weight of the pendulum with its gun or mortar; l the length of the pendulum, or the perpendicular distance from the axis of suspension to a line H K, parallel to the axis of the bore, and joining the points H, K, at which the weight w was attached under the piece, if a be the length of that line, also if G represent the required distance of the centre of gravity from the axis of suspension; we shall have

$$G = \frac{w}{W} \cdot \frac{a - l \sin(\theta + \theta')}{\sin(\theta + \theta')}.$$

In the investigation of this formula, θ and θ' being small angles, cos θ and cos θ' are, each, considered as unity; and sin $(\theta + \theta')$ is put for sin θ + sin θ'.—('Expériences d'Artillerie exécutées à L'Orient,' Paris, 1847.)

The formula for G in the work just quoted (page 8) is more complex than that which is above given, in consequence of the introduction in the form of an additional weight called the *Compensateur*, which is employed in ord to insure a perfect horizontality of the axis of the bore when an experiment to take place.

[b] $l = 39.13929$ inches in the latitude of London.

l being the length of the equivalent mathematical pendulum or the required distance (C O, Fig. 2) of the centre of oscillation from the axis of suspension: this distance is supposed to be measured on a line passing through the axis of suspension and the centre of gravity in the body.[a]

57. The centre of oscillation being found, the momentum of inertia with respect to the horizontal axis of suspension may be readily obtained thus:—

Let l be the distance of the centre of oscillation from the axis of suspension; G the distance of the centre of gravity from the same axis; m the mass $\left(= \frac{w}{g}\right)$ of the body, w representing the body's weight, and g (= 32.2 feet) the force of gravity; then, by Dynamics,

$$l = \frac{\int r^2 d m}{m \mathrm{G}};$$

and $\int r^2 \, d \, m$ (the required momentum of inertia) $= \mathrm{G} \, m \, l$ or $\mathrm{G} \, l \frac{w}{g}$.

58. If the block of a ballistic pendulum, when at rest, be struck at any point in its front by a shot projected horizontally against it, the line of projection being also in a vertical plane perpendicular to the axis of suspension, the angle through which the vertical axis of the pendulum is made to recoil by the impact may be measured by the scale on the machine; and this angle, with the other data obtained in the manner just stated, will afford the means, by a comparatively simple process, of obtaining the required velocity of the shot. The formula for this purpose is

$$v = \frac{\sqrt{\{(\mathrm{G\,W} + w\,h)(\mathrm{G\,W}\,l + w\,h^2)g\}}}{w\,h} 2 \sin \tfrac{1}{2}\theta;$$

in which v is the required velocity of the shot at the instant of striking the pendulum;

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[a] The observed number of oscillations should, in strictness, be reduced to the number which would be performed by the body in an equal time if the vibrations were infinitely small. For this purpose the observed number n should be multiplied by $\left(1 + \frac{a}{8\,l}\right)$, a being the height of the observed mean arc of vibration, or the vertical distance from its highest to its lowest point.

G, the distance of the centre of gravity of the pendulum from the axis of suspension;
W, the weight of the pendulum;
w, the weight of the shot;
l, the distance of the centre of oscillation in the pendulum from the axis of suspension;
h, the distance, in a vertical direction, of the point of impact from the axis of suspension;
g, (= 32.2 feet) the force of gravity; and
θ, the angular extent of a vibration on either side of a vertical line drawn through the axis of suspension.[a]

If the distance of the point of impact from a horizontal line passing through the centre of oscillation be very small; then h may be considered as equal to l; and the above equation will become

$$v = \frac{2\,(\mathrm{G\,W} + w\,l)}{w} \sin \tfrac{1}{2}\,\theta \sqrt{\frac{g}{l}}\,;$$

or (G′ being the distance from the axis of suspension to the common centre of gravity of the pendulum and shot)

$$v = \frac{2\,(\mathrm{W} + w)\,\mathrm{G}'}{w\,l} \sin \tfrac{1}{2}\,\theta \sqrt{g\,l}.$$

But $2 \sin. \frac{1}{2}\theta\sqrt{g\,l} = v'\,l$, the linear velocity of the centre of oscillation; therefore

$$v = \frac{\mathrm{W} + w}{w}\,\mathrm{G}'\,v'.$$

In these formulæ for v, W G and l may be considered as representing, respectively, the weight of the augmented pendulum, and the distances of the centres of gravity and oscillation from the axis of suspension.

In the investigations leading to the formulæ no notice is taken of the resistance of the air against the face of the pendulum when made to vibrate; but it is shown by Dr. Hutton (Tract XXXIV. Art. 27) that the diminution of the velocity on this account does not exceed $\frac{1}{3577}$ of the whole;

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[a] The investigation of the above formula for v, and also that of the formula for w' in Art. 59, are given in the fourth edition of this work, but these are now, for the sake of brevity, omitted.

and even this is, in part, corrected by the mechanical method employed in determining the centre of oscillation. It is proved also by Dr. Hutton that no sensible error in the computed velocity of shot arises from the time (about $\frac{1}{300}$ of a second in the pendulum which he employed) during which the shot is penetrating into the block.

It is evident, other things being equal, that the velocity of the shot varies with sin $\frac{1}{2}\ \theta$, or with the chord of the arc of vibration.

59. In the United States' pendulums, after l had been determined, as above mentioned, an additional weight (667 lbs.) was applied under the gun and block, by which the distance from the centre of oscillation to the axis of suspension was rendered equal to the distance of the line of fire, and point of impact, from that axis. This weight, representing it by w', is expressed by the formula—

$$w' = \frac{G'\ W'\ (l-l')}{b\ (b-l)};$$

in which W′ is the weight of the original pendulum; w' the additional weight to be applied;

G′ and G the distances from the axis of suspension to the centres of gravity of the original and of the augmented pendulum;

b the distance from the same axis to the centre of gravity of the additional weight;

l' and l the distances from that axis to the centres of oscillation in the original, and in the augmented pendulum respectively.

60. The initial velocity of shot has been determined by firing the shot directly against one end of a hollow cylinder closed at the extremities, while the cylinder is made to revolve uniformly on its axis, the shot being fired as nearly as possible parallel to the axis. The rule for determining the velocity by such a machine is very simple. Suppose the shot were to enter the nearest face of the cylinder at *a*, and to emerge from the farthest face at *b* (*b* being, by the revolution, brought opposite to *a* during the time that the shot is passing through the cylinder). Let the length of the cylinder be 24 feet; let the

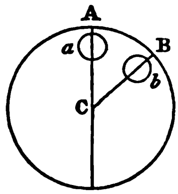

Fig. 1.

angle A C B be 30 degrees, and let the time of the cylinder's revolution on its axis be $\frac{1}{8}$ of a second: then

$$360° : 30° :: \tfrac{1}{8} : \tfrac{1}{96} \text{ of a second};$$

and the last term is the time in which the shot was passing in a straight line through the cylinder, that is 24 feet; therefore 24 × 96, or 2,304 is the velocity of the shot in feet per second.

61. The distance of the ballistic pendulum from the muzzle of the gun being necessarily from 30 to 50 feet, in order that the block may not be affected by the flame arising from the discharge, the velocity of the shot at the moment of leaving the gun is greater than that which is obtained from the formula in Art. 58; and different formulæ have been proposed for the purpose of ascertaining one of these velocities from the other, or the velocity lost by the shot in passing from the gun to the pendulum: before stating these, however, it will be proper to show in what manner may be obtained the coefficient of the square of the velocity in the expression for the retardative force arising from the resistance of the air.

62. Since the absolute resistance of any medium against a spherical body moving in it depends upon the surface which is acted on during the motion, upon the density of the medium, and upon some function (suppose the square) of the velocity: let r be the semi-diameter of the body, δ the density of the medium, v the velocity, and let π represent 3.14159 (half the circumference of a circle whose radius is unity). Then, by Dynamics, $r^2 \pi \delta v^2 k'$ will denote the resistance, k' being a constant coefficient, which can be determined only by experiment. But the mass of the shot, supposed to be a solid sphere, being $\frac{4}{3} r^3 \pi \delta'$, in which δ' represents the density of the shot; the retardative force arising from the resistance of the air will become $\frac{3\, k' \delta v^2}{4r\, \delta'}$, which may be represented by $\frac{k\, \delta}{r\, \delta'} v^2$, k being a fraction whose value must be found by experiments. Much doubt exists concerning its true value; but, according to the best experiments which have been made, it should be expressed by .22 (a foot being the unit of measure as well for r as for v). Th

specific gravities of the air and the shot may be substituted for δ and δ' respectively in the above formula.

63. The formulæ alluded to in Art. 61 are obtained from the usual differential equation of motion

$$\frac{d^2 x}{d t^2} = -f,$$

in which f may represent the retardative force arising from the resistance of the air. Then, if the resistance be considered as proportional to the square of the velocity, it may be represented by $c\,v^2$ or $c\frac{d x^2}{d t^2}$ (in which c is put for the coefficient $\frac{k\,\delta}{r\,\delta'}$ above); and we have

$$v = \frac{V}{e^{cx}}, \text{ or } v = V\,e^{-cx} \quad . \ . \ . \ . \ (a)$$

In these expressions, V represents the initial velocity, or the velocity of the shot at the muzzle of the gun, x the distance of the gun from the pendulum, v the velocity at the instant of striking the pendulum, and e ($=2.71828$) is the base of the Napierian logarithms.

Dr. Hutton, making the resistance of the air proportional partly to the square and partly to the first power of the velocity, investigated a formula which is equivalent to

$$x = p \text{ hyp. log. } \frac{V-q}{v-q};$$

whence

$$v = \frac{V-q}{e^{-\frac{x}{p}}} + q. \quad . \ . \ . \ . \ (b)$$

In these expressions p is put for $\frac{w}{.000007565\,g\,d^2}$, ($w =$ the weight of the shot in pounds, and d = its diameter in inches) and q for 231. (Hutton's 'Tracts,' Tract XXXVII., Arts. 78, 79.)

But the officers of the French school at Metz, making the resistance proportional, partly to the square, and partly to the cube of the velocity, have more recently proposed the formula,

$$v = \frac{V}{(1+\alpha V)\,e^{\gamma x} - \alpha V}; \qquad (c)$$

(See the 'Aide Mémoire d'Artillerie Navale,' 1850) in which (v, V and x being expressed in English feet) $\alpha = .0007$ and γ

varies with the different natures of shot; for a 30-pounder shot (French), corresponding very nearly to an English 32-pounder shot, it is equal to .0001034.

For a 32-pounder shot, whose semidiameter is 3.1 inches (=.2583 feet) when the initial velocity, V, is 1600 feet per second, and x is 50 feet, we obtain, from the first formula above, $v = 1588$ feet. From the formula of Hutton we have, in the same circumstances, $v = 1580$ feet; and from the last formula, $v = 1579$ feet: consequently, in a distance equal to 50 feet, such a shot will lose about 20 feet, or $\frac{1}{80}$ of its original velocity. It is evident from the first of these formulæ for v, that, other things being equal, the velocity retained by a shot after having described a given distance in air will be greater as the initial velocity, and also as the diameter or the weight of the shot, is greater.

64. Means being thus found of obtaining by experiment, nearly, the velocity by which a shot is projected from a piece of ordnance, it is proper next to have an expression for the velocity in terms of the charge of powder employed. This subject has been investigated by Dr. Hutton (Tract XXXVII., Art. 160), and his result, when modified so as to introduce in it the weight of the gun and its carriage, is expressed by an equation equivalent to

$$V = \sqrt{\left\{\frac{w}{w+w'} \cdot \frac{2gpr^2\pi}{w'+q}\left(\frac{\lambda' n}{M} \text{ common log. } \frac{\lambda}{\lambda'} + \lambda' - \lambda\right)\right\}}.$$

In this equation p (=2125 lbs.) represents the pressure of [illegible] atmosphere on a square foot, g the force of gravity (=32.2 fe[illegible] and $\pi = 3.14159$.

r denotes (in decimals of a foot) the semidiameter of the shot, w' its weight, including the wad, and w the weight of the gun with its carriage.

λ represents the length of the bore of the gun, λ' the length of the charge in the bore, and q one-third of the weight of the charge.

M (=.43429) is the modulus of the common logarithms, and n is an abstract number expressing the number of times that the pressure arising from the expansion of fired gunpowder exceeds the pressure of the atmosphere. Dr. Hutton found the value of n to be very variable, increasing with the length of the gun; and from a mean of his experiments he assumed it to be 2200.

The experiments of Dr. Gregory, in 1815 and 1816, make n equal to 2250; that is, he found the force of fired gunpowder to be equivalent to 2250 times the pressure of the atmosphere.[a]

In this formula the measures of length are all expressed in feet, and the weights in pounds avoirdupois.

65. But, in the employment of the formula, this value of n

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[a] The centre of gravity of the charge moving in the bore with about one-third of the velocity of the ball, the weight of the latter during its movement in the bore may be considered as increased by one-third of the weight of the charge, supposing this to move with the same velocity as the ball; therefore the accelerative force of the gunpowder on the ball, when in contact with the charge, will be represented, in terms of the force of gravity, by

$$\frac{g n p r^2 \pi}{w' + q}.$$

Now, let x be, at any instant, the distance of the centre of the ball from the extremity of the charge, during its passage along the bore; then, the accelerative force of the fired gunpowder on the ball being inversely proportional to the space it occupies in the bore, $\frac{g n p r^2 \pi \lambda'}{(w'+q)x}$ expresses the accelerative force on the ball when at a distance x from the charge; but the retardative force of the atmosphere on the ball and charge while in the bore is $\frac{g p r^2 \pi}{w' + q}$; therefore, finally, the accelerative force on the ball and charge is

$$\frac{g p r^2 \pi}{w' + q}\left(\frac{\lambda' n}{x} - 1\right).$$

Making (by Dynamics) $\frac{d^2 x}{d t^2}$ equal to this expression for the force; and multiplying both members by $2\,d\,x$, we have

$$\frac{2 d x d^2 x}{d t^2} = \frac{2 g p r^2 \pi}{w' + q}\left(\frac{\lambda' n d x}{x} - d x\right)$$

Integrating between $x = \lambda'$ and $x = \lambda$, we have

$$\frac{d x^2}{d t^2}(= \mathrm{V}^2) = \frac{2 g p r^2 \pi}{w' + q}\left(\lambda' n \text{ hyp. log. } \frac{\lambda}{\lambda'} + \lambda' - \lambda\right):$$

therefore the velocity of the shot at the muzzle of the gun is expressed by

$$\sqrt{\left\{\frac{2 g p r^2 \pi}{w' + q}\left(\lambda' n \text{ hyp. log. } \frac{\lambda}{\lambda'} + \lambda' - \lambda\right)\right\}}.$$

But the accelerative force of the fired powder should be further diminished in the ratio of the sum of the masses of the gun, with its carriage and the shot, to that of the gun and its carriage. If, therefore, this condition be included, the first factor under the radical sign should be multiplied by $\frac{w}{w + w'}$. If, also, $\lambda' n$ be divided by M (the modulus of the common logarithms), the common logarithm of $\frac{\lambda}{\lambda'}$ may be substituted for the hyperbolic logarithm of that fraction; and thus is obtained the equation for V in the text.

should be diminished on several accounts. First, because of the thickness of the bag containing the powder, it should be diminished in the ratio of the area of a section of the bore to that of a section of the powder: now the thickness of the bag being about $\frac{1}{40}$ inch, the areas of the sections are to one another (R being the radius of the bore in inches), as R^2 to $R^2 - \frac{1}{20} R$, nearly, or as 1 to $1 - \frac{1}{20 R}$ nearly; therefore, on this account, the above value of *n* should be diminished by a fractional part of it, which is expressed by $\frac{1}{20 R}$. Secondly, it should be diminished on account of the windage of the gun: now Dr. Hutton estimated that the loss of force occasioned by windage was one-third of the whole force when the lunaric area between a section of the ball and a section of the bore was one-tenth of the latter; therefore, considering the loss as proportional to such lunaric area (*r*, the semidiameter of the shot, being here expressed in inches),

$$\tfrac{1}{10} : \tfrac{1}{3} :: \frac{R^2}{R^2 - r^2} : \frac{10 R^2}{3(R^2 - r^2)};$$

and, on this account, the above value of *n* must be diminished by a fractional part of it, which is expressed by $\frac{3(R^2 - r^2)}{10 R^2}$. Lastly, it should be diminished on account of the loss of force by the escape of powder from the vent: now, the semidiameter of the vent being .1 inch, if we consider the lost force to bear, to the whole force, the ratio that the area of the vent bears to a section of the bore, the value of *n* must, on this account, be diminished by a fractional part of it, which is expressed by $\frac{1}{100 R^2}$.

The sum of the three corrections is

$$\frac{30(R^2 - r^2) + 5 R + 1}{100};$$

and this expression denotes the fractional part of *n*, by which *n* is to be diminished.

66. Since the weights of the shot and charge are small compared with that of the gun with its carriage, a near approximation to the initial velocity will be obtained by omitting, in the expression for V, the terms $\frac{w}{w + w'}$, and *q*. The equation then

becomes, ommitting also the two last terms because of their small effect on the value of the velocity,

$$V = \sqrt{\left\{\frac{2 g p n r^2 \pi \lambda'}{w' M} \text{ com. log. } \frac{\lambda}{\lambda'}\right\}}.$$

67. A gun suspended from a horizontal axis, like the block of wood in a ballistic pendulum, has long been occasionally employed to determine, by the angular extent of its recoil, the velocity with which a shot is projected by a given charge of powder; and in the experiments alluded to in Art. 54, a gun-pendulum, as it is called, and a ballistic pendulum, were combined for the purpose of comparing together, shot being projected from the former, the initial velocities determined from the recoil of the one and the impact on the other. The formula employed for computing, from the recoil, the velocity of shot at the instant of leaving the gun-pendulum was (V representing that velocity)

$$V = \frac{2 \sin. \frac{1}{2} \theta \, W \, G \sqrt{g l} - l' c N}{w' l' \frac{R^2}{r^2} + \frac{1}{2} c' l'};$$

in which W is the weight of the gun-pendulum, including that of the shot, and w' that of the ball and wad.

G is the distance from the axis of suspension to the centre of gravity of the pendulum.

l is the distance from the same axis to the centre of oscillation, and l' the distance from that axis to the axis of the gun.

c is the weight of the charge, and c' that of the bag.

θ is the angular extent of the vibration from the vertical position.

R the radius of the bore, r that of the shot, and g the force of gravity.

N represents the velocity communicated to the pendulum by a unit of the charge. (In the United States' experiments it is estimated at 1600 feet).

When the centre of oscillation is in the axis of the gun, we we have $l' = l$; in which case

$$V = \frac{2 \, W \, G \sin \frac{1}{2} \theta \sqrt{\frac{g}{l}} - c N}{\frac{R^2}{r^2} w' + \frac{1}{2} c'}$$

68. The force of fired gunpowder is, however, still very im-

perfectly known; and the results of experiments with the gun-pendulum are very frequently at variance with those obtained from the ballistic pendulum. By French artillerists the initial velocity of a shot, the axis of the bore being horizontal, has been expressed by a formula, which, when reduced, so that the required velocity shall be given in feet per second, is

$$4200\left(\log.\frac{\lambda}{\lambda'}\right)^{\frac{1}{2}}.\left[\log.\left(1+\frac{c}{w}\right)\right]^{\frac{1}{2}}.$$

The measures of length in this formula are in feet, and the logarithms are those of the common kind. ('Account of Experiments carried on at Gavre,' chap. xix. sec. 7.) It must be observed, however, that the results obtained from this formula are, in general, less than those given by experiments made in England with the ballistic pendulum.

69. The experiments of Sir Benjamin Thompson (Count Rumford) have fully proved that the ignition of gunpowder does not take place instantaneously, and that the whole of the charge in a gun is never in a state of inflammation within the bore, though it is presumed that 8 ounces may be all ignited in $\frac{1}{250}$ of a second. Further experiments have also shown that, for every nature of gun, there is a certain charge which produces a maximum of initial velocity, so that if a greater quantity were employed the velocity would be less: the reason is, that, besides the greater quantity of powder which is thrown out of the gun unfired, the powder which is actually ignited takes effect on the shot during a shorter time than it would, if, from a smaller quantity of powder being employed, the motion of the shot in the bore were less rapid. The charge of powder which would render the initial velocity a maximum may be found, mathematically speaking, by differentiating the second member of the equation for V, in Art. 64, considering λ' (the length of the charge) as variable, omitting the two last terms within the brackets $\lambda' - \lambda$ as very small, and making the result equal to zero. There is thus obtained

$$\text{com log }\frac{\lambda}{\lambda'} = \text{Modulus of com log; whence } \lambda' = \frac{\lambda}{2.71828};$$

that is, the length of the charge producing the maximum velocity, with the same gun, is equal to about one-third of the length of the bore.

The charge which produces a maximum velocity is, therefore, greater as the gun is longer, but the increase is found to be not in so high a proportion as that of the length of the gun (Hutton's 'Tracts,' vol. iii. p. 78); and Dr. Hutton's experiments have shown that, on account of the rapid diminution of high velocities by the resistance of the air, there is little advantage in point of extent of range by increasing the charge beyond what is necessary to communicate a certain velocity to the ball.[a]

70. The force exerted by fired gunpowder on a shot varies with the square of the velocity of the fluid, that is, of the ball, which it impels; and that force being also proportional to the quantity of fluid acting at once on the ball, it follows that the square of the ball's velocity, in the gun, varies with the quantity of fluid acting on the ball, that is, with the square of its diameter; and from this law it may be proved that the decrements of the initial velocity of shot in consequence of windage are nearly proportional to the differences of the diameters of the shot in the same gun. From thence may be obtained the equation

$$V = \frac{v - v'}{d - d'}(D - D') + V',$$

expressing the velocity which a shot would have if the windage were zero. Here V denotes such velocity; D the diameter of the bore of the gun, or of a shot which would occupy the bore without windage; d, d', D' the diameters of different balls, and v, v', V' their velocities on being projected from the same gun.

71. The charge being supposed to have a cylindrical form,

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[a] Major Mordecai, of the United States' artillery, states that an addition of nine calibres to a gun of sixteen calibres' length adds only one-twelfth to the velocity of a 12-lb. ball, when fired with a charge of 2 lbs., and one-eighteenth when fired with a charge of 4 lbs. It is observed also that, by increasing the charge beyond one-third of the weight of the ball, the recoil is increased in a much higher ratio than the initial velocity of the ball. It may be added, that for every purpose on service, even for that of breaching, the advantage gained by using a charge greater than one-third of the weight of the shot is unimportant, and does not compensate for the inconvenient recoil, or the destructive strain on the gun and carriage. The initial velocity of shot from 6-pounder and 12-pounder guns, with charges of 1¼ lb. and 2½ lbs. respectively, is about 1450 feet; and this is considered quite sufficient for field service. The initial velocity of canister and spherical case-shot, fired from field-howitzers with the service-charge, is about 1000 feet; and that of shells from howitzers is about 1175 feet.

and the density of the powder being constant, it follows that (Arts. 64, 66) varies with the weight of the charge; hence th formula for V, Art. 66, indicates that the initial velocities shot vary, nearly, as the square root of the weight of the charg directly, and as the square root of the weight of the sh inversely. These laws have been confirmed by the results experiments,[*] and M. Piobert has proposed, for the purpose determining the initial velocity of shot, when its weight and the of the charge are given, the empirical formula—

$$V = v \frac{\sqrt{\log.\left(1 + \frac{c}{w}\right)}}{\sqrt{\log.\left(1 + \frac{c}{b}\right)}};$$

in which v represents the experimented initial velocity of a shot whose weight is b, and V is the required initial velocity of a shot whose weight is w'; the weight c of the charge being the same for both.

Major Mordecai, of the United States' artillery, has found that the rule agrees nearly with his experiments when the charges do not exceed one-third of the weight of the ball, and the gun has not less than sixteen calibres in length; for higher charges he does not consider it sufficiently correct. If the factor $\frac{v}{\sqrt{\log.\left(1 + \frac{c}{b}\right)}}$ be represented by m, he finds that, with a 32-pounder gun, the charge being one-third of the weight of the shot, and the windage .16 inch, m=5200; with a 24-pounder, the charge being one-third and the windage .14 inch, m=5400.

In the British artillery service, use is frequently made of the empirical formula—

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[*] In the experiments made at Washington with the gun and ballistic pendulums combined for the purpose of ascertaining the initial velocities produced by equal charges of powder in the same piece of ordnance on balls of different weights, it was found that, with a 24-pounder gun and a charge of 4 lbs. of powder, the windage being .175 inch, the initial velocity of a shell filled with lead and weighing 27.68 lbs. was 1325 feet; of a marble ball weighing 9.29 lbs., was 2154 feet; and of a lignum vitæ ball weighing 4.48 lbs., was 2759 feet. The two first of these velocities are, in accordance with the formula, nearly in the inverse ratio of the square roots of the weights of the shot; but the two last are nearly as the cube roots of the weights inversely.

$$V = 1600\sqrt{\frac{a\,c}{w'}},$$

in which c is the weight of the charge, and w' that of the shot; a is a coefficient to be determined by experiments. Those of Dr. Hutton indicate that a varies between 2.1 and 2.5 as the length of the gun, and also as the ratio of the weight of the charge to that of the shot increases. The experiments of General Millar, in 1817, show that, with a windage equal to .202 inch, the value of a should be 2.8, and that on reducing the windage to .075 inch it should be 3.55. On computing the initial velocities of the shot from the ranges obtained in the experiments made at Deal in 1839, and also from those of the practice on board the "Excellent" from 1837 to 1847, the mean values of a for different windages were as follow:—

Windages.	Values of a.
.233 in.	3.2
.2	3.4
.175	3.6
.125	4.4
.09	5.

From these, by means of the formula for V, Art. 70, it is found that when the windage is zero, $a = 6.66$; and it may be observed that the numbers in this table are nearly conformable to the law of the decrements of velocity, as stated in that article.

For carronades, in which the windage varied from .061 to .078, the mean value of a was 4.5.

72. Gunpowder when ignited expands with equal forces in every direction, and consequently it acts equally upon the bottom of the bore and upon the ball during the passage of the latter along the cylinder, supposing it to fit tightly. Hence, neglecting the allowance which should be made for the frictions of the ball and of the gun-carriage, the velocity of the recoil will be, to that of the shot, inversely as the weight of the gun to that of the shot: that is, if V represent the initial velocity, in feet, of the shot, w the weight of the shot, and W the weight of the gun with its carriage, the velocity of the recoil, in feet per second, will be expressed by $\frac{V\,w}{W}$.

Thus, supposing the initial velocity of a 24 lb. shot to be 1600 feet per second, and the weight of the gun with its carriage to be 57.7 cwt. or 6462 lbs., we shall have 5.9 feet per second for the velocity of recoil.

73. In contemplating the nature of the resistance to the flight of shot or shells it must be remarked that, in the motion of a body through the air, no particle of that fluid can be disturbed without moving others to a considerable distance about it, while the displaced particles take time to fall back into the space which they before occupied. As the moving body passes on, there is left behind it a kind of vacuum more or less complete according to the degree of the body's velocity; and when the ball moves quicker than the air can rush into the space left behind, the vacuum becomes perfect. Now there is a certain limit to the velocity with which air can rush into a vacuum, viz., about 1300 or 1400 feet in a second,[*] and, consequently, when the velocity of a ball is greater than this, it is manifest that the resistance will be very great; for there being then no pressure of the fluid behind the ball, while that which is in its front is in a state of condensation from the particles there not being able immediately to escape, the ball will be resisted by the whole pressure of the condensed air on its fore part.

74. The resistance, besides depending on the velocity, diameter, and the weight of the projectile, is affected by so many circumstances which cannot be duly estimated, that experiment alone can determine it, and this only to a certain extent. If shot could be discharged so accurately as to hit a ballistic pendulum at considerable distances, the loss of velocity occasioned by resistance might be easily found; but such a degree of accuracy cannot be obtained, and the ballistic experiments have hitherto only furnished us with these results at different distances as far as 300 feet, beyond which shot cannot be directed with sufficient accuracy to hit the block.

75. The method of determining the resistance of the air by the ballistic pendulum did not, it was found, answer with velocities under 300 feet in a second, on account of the balls re-

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[*] 1366 feet, when the barometer stands at 30 inches.—See Hutton's 'Tracts,' vol. iii. p. 195.

bounding from the block instead of entering into it. To ascertain the resistances to smaller velocities, Mr. Robins had recourse to experiments with his *whirling machine* (Fig. 4, Pl. I.). This ingenious contrivance consists of a brass barrel, D C, moveable on its axis, and furnished with friction-wheels so as to reduce the friction to an inconsiderable quantity. A light, hollow cone, A F G, is placed upon the barrel, with the vertex A in the termination of the axis; a fine wire, A H, supports the arm, G H, upon which the body, whose resistance is to be tried, is fixed. A silk line is wound upon the barrel, and thence leads, in a horizontal direction, to the pulley L, over which it is passed, and a proper weight M hung to its extremity. If the weight M be left at liberty, it will descend with accelerated motion, causing the body P to revolve with increasing velocity, until the resistance on the arm G H, and on the body P, become nearly equal to the weight M, when the motion of both will be nearly equable. Thus, when the machine has acquired an equable motion, which it usually does in five or six turns, ascertain first, by counting a number of turns, in what time one revolution is performed. Then remove the body P and the weight M, and find, by trials, what smaller weight will cause the arm G H to revolve in the same time as when P was fixed to it; and the difference of the two weights is, obviously, equal, in effort, to the resistance of the air on the revolving body. Reducing this weight in the ratio of the length of the arm to the semidiameter of the barrel, we shall have the absolute quantity of resistance.

76. With this machine, Mr. Robins ascertained that the resistance of the air to a 12 lb. iron ball, moving with a velocity of 25 feet in a second, is not less than half an ounce avoirdupois; and that the resistance of the air, within certain limits, is nearly in the duplicate proportion of the velocity of the resisted body, that is, as the square of the velocity.

A light, hollow globe, the size of a 12 lb. shot, was fixed at the end of the arm, and a weight of 3¼ lb. hung at M. Ten revolutions being first made, the succeeding twenty were performed in 21½″. The globe was then removed, and a thin plate of lead, equal in weight to the globe, placed in its room; when it was found that a weight of 1 lb. caused the arm to move quicker than before, making twenty revolutions in 19″, after ten turns had been suffered to elapse. Now twenty revolutions in 21½ seconds, the radius of revolution being 51.75 inches, give a velocity of 25¼ inches in a second; whence it is evident that the resistance on the globe is not less than the effect of 2¼ lb. placed at M; and, the radius of the barrel being, nearly, $\frac{1}{50}$ part of the radius of the circle described by the centre of the globe, it follows that the resistance of the globe is not less than $\frac{1}{50}$ part of 2¼ lb. or $\frac{1}{50}$ of 36 oz., which is nearly ¾ of an ounce.

In a second experiment, weights in the proportion of 1, 4, 9, 16, were hung on at M; and, after ten revolutions, the following observations were made:—

With ½ lb. at M, the globe turned	20 times in 54½".
That is	10 times in 27¼".
With 2 lb., it turned	20 times in 27½".
With 4½ lb.	30 times in 27½".
With 8 lb.	40 times in 27½".

Thus it appears that the revolutions in the proportions 1, 2, 3, 4, correspond to resistances in the proportions 1, 4, 9, 16, which shows that the resistances are as the squares of the velocities.

77. From this machine, and from the ballistic pendulum, the following useful results have been obtained:—

1. When the motions are slow, the resistance to balls of equal magnitude and weight is nearly proportional to the square of the velocity, conformably to the elementary theory of resistances in fluids; for, in this, it is assumed (the balls having equal diameters and densities or weights) that the resistance depends on the number of fluid particles displaced by the moving body in a given time, and on the reaction of each particle against the body, both of which effects vary with the velocity of the body. But the exponent of the power of the velocity expressing the resistance gradually increases as the velocity increases; and, when the shot moves at the rate of 1400 or 1500 feet per second, that exponent attains a maximum, being then 2.125; beyond such velocity its exponent decreases.

2nd. If balls have equal weights, but different diameters, and move with equal velocities, the resistance varies nearly with the surfaces or with the squares of the diameters, increasing a lit above that proportion when the diameters are considerab

Hence, if the velocities also are different, the resistance is proportional to the surface and to the square of the velocity; or, r representing the semidiameter of the shot, and v the velocity, the resistance varies with $r^2 v^2$.

3rd. If balls have equal diameters and different weights or densities, the resistances vary directly as the squares of the velocities, and inversely as the weights; or, w representing the weight, the resistance varies with $\frac{v^2}{w}$.

4th. Projectiles terminating with conical or conoidal heads in front experience less resistance than bodies with flat or with hemispherical ends, the diameters being equal.

5th. The resistances experienced by bodies, in moving through fluids, are considerably affected by the forms of the posterior surfaces of bodies; and much useful information on this subject is contained in the 'Nautical and Hydraulic Experiments' of Colonel Beaufoy, London, 1834.

78. When a body descends in air from a state of rest, its velocity increases for a time by the action of gravity on it; but, since the resistance of the air increases also while the velocity increases, it must at length become equal to the accelerative power of gravity, which is constant; after which, the body will move uniformly with the velocity acquired at that time- This is called the *terminal velocity* of the body.[a] Making therefore, for a solid shot, the expression $\frac{k\,\delta}{r\,\delta'}v^2$ (Art. 62) equal to g, the force of gravity (= 32.2 feet), we have

$$v^2 = \frac{r\,\delta'\,g}{k\,\delta}, \text{ or}$$

$$v \text{ (the terminal velocity)} = \sqrt{\frac{r\,\delta'\,g}{k\,\delta}}; \quad . \quad . \quad . \quad (a)$$

and from either of these equations we have

$$k = \frac{r\,\delta'\,g}{v^2\,\delta}.$$

It being supposed that the value of k is known, we have a formula for computing the terminal velocity, and conversely,

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[a] In strictness, a terminal velocity is never exactly attained; but, in a short time from the commencement of the descent, the body acquires a velocity which is extremely near being uniform.

if the terminal velocity were known, the value of k might be found.[a]

79. It has been observed (Art. 62) that the formula for the absolute resistance of the air against a spherical body moving in it is represented by $r^2 \pi \, \delta \, v^2 k'$; the resistance is, therefore, directly proportional to the square of the diameter of the shot and to the square of the velocity. Hence the resistance which would be experienced by a shot of any magnitude, and moving with any given velocity, may be found by proportion, if the resistance actually experienced by a ball of given dimensions, and moving with a given velocity, be considered as known. Now, from experiments both with the ballistic pendulum and the whirling machine, Dr. Hutton formed a table (Tract XXXVII. Art. 17) of the resistances experienced by a ball 2 inches in diameter, moving with different velocities from 5 feet to 2000 feet per second. Therefore, the actual resistance experienced by such ball, when moving at the rate of 1000 feet per second, for example, being 22.63 lbs., if it were required to find the resistance experienced by a 24 lb. ball, whose diameter is 5.6 inches, when moving with a velocity of 1600 feet per second, the proportion to be used would be

$$(2 \times 1000)^2 : (5{\cdot}6 \times 1600)^2 :: 22{\cdot}63 : x;$$

the last term x expressing the required resistance in pounds.

If the given velocity is one which may be found in Dr. Hutton's table, the resistances will be proportional to the squares of the diameters merely. No notice is here taken of the continual diminution of density which takes place in the atmosphere from the surface of the earth upwards; but when bodies fall from great heights, also when they are projected

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[a] Since, by Dynamics, $\frac{v^2}{2g}$ expresses the height due to the velocity v, it follows that $\frac{r\delta'}{2k\delta}$ is the height due to the terminal velocity of a shot.

The weight of a solid shot in the British service being, to that of a shell, as 1·42 to 1; the terminal velocity of a shell will be expressed by the second member of the equation,

$$v = \sqrt{\frac{r\delta' g}{1.42\,k\,\delta}}\,; \quad . \quad . \quad . \quad (b)$$

and the height due to the terminal velocity of a shell by $\frac{r\delta'}{2.84\,k\,\delta}$.

vertically or at considerable angles of elevation, it becomes necessary to attend to that circumstance.

80. It is proved by writers on pneumatics that the densities of atmospherical strata, of equal and indefinitely small thicknesses, reckoning from any point down towards the earth, form an increasing geometrical series of terms, while the depths of the strata, from the same point downwards, constitute an increasing arithmetical series; and Dr. Hutton has shown by an approximative process (Tract XXXVII. Art. 60) that the density of the air at any distance x, in feet, from the surface of the earth upwards, may be represented by $\frac{c-x}{c+x}$, in which $c = 55000$ nearly.

81. From the formulæ which have been given above (Art. 78), it is evident that the terminal velocity of a body descending in a resisting medium may be computed when the value of a certain constant k is known: but, as the terminal velocity of a shot takes place when the absolute resistance which it experiences in the medium is equal to the weight of the shot, it follows that the terminal velocity of a shot may be found from the table of resistances given by Dr. Hutton (Tract XXXVII. Art. 17). For, assuming that the resistances are as the squares of the velocities, if we select from the table a resistance, 0.71 lb., which differs but little from the weight 17.477 oz. (= 1.092 lb.) of the shot on which the table is formed, and take out the corresponding velocity; the terminal velocity of the same shot may be found by proportion, thus:—

$$.71 : 1.092 :: 200^2 : 61504,$$

and the square root of the last term (= 248) is the terminal velocity of the shot.

But, from the formula (a) Art. 78, other things being equal, the terminal velocities vary with the square roots of the diameters of the shot; therefore, if it were required to find the terminal velocity of any other shot, another proportion must be made: thus if, for example, it were required to find the terminal velocity of a 24 lb. shot whose diameter is 5.612 inches, that of the above shot being 2 inches, we have

$$\sqrt{2} : \sqrt{5.612} :: 248 : 415.43;$$

and 415.43 is the terminal velocity of the 24 lb. ball.

The height due to the terminal velocity may be found by the usual formula $h=\frac{v^2}{2g}$: and, in this manner, Dr. Hutton's table (Tract XXXVII., Art. 69) was formed.

The terminal velocity of a shell is easily derived from that of a solid shot of equal diameter; and for this purpose, agreeably to the formula (*b*) Art. 78, Note *a*, p. 52, it is only necessary to divide the terminal velocity of the shot by $\sqrt{1.42}$; or, which is equivalent, multiply it by 0.8392.[a]

82. The subject of the penetration of shot into materials is one of considerable importance in the theory of gunnery; and

$$p=\frac{2v^2 r\delta}{3Rg}$$

is a formula expressing the depth to which shot, on striking with a given velocity, will penetrate into an object whose resisting force is supposed to be known. In this formula (the measures of length being expressed in feet)

p represents the depth penetrated;
v the velocity of the shot at the instant of striking (in feet per second);
r the semidiameter, and
δ the density of the shot; also
g (=32.2 feet) denotes the force of gravity.

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[a] The celebrated Carnot, in his proposition for defending places by means of vertical fire, has entirely overlooked the effect of the resistance of the air in producing the terminal velocities of falling bodies; and the author, in his 'Observations' on Carnot's work, has endeavoured to expose the fallacy of a system erroneous in principle; any application of which must, for other reasons also, be either enormously expensive or extremely insecure.

The wall which that engineer proposed to be built in the main ditch of a fortress, at the foot of the rampart, being covered by a counterguard, would no doubt form a serious obstacle to the besiegers, supposing it to be entire at the time of an assault: but the author early foresaw that this would not be the case; and it was in consequence of his representations that His Grace the Duke of Wellington, when Master-General of the Ordnance, caused a trial to be made in order to determine whether or not it was possible to breach the wall by a fire of heavy ordnance directed over the covering-work. For this purpose, in 1823, a construction similar to that proposed by Carnot was executed at Woolwich; and in the following year, after six hours' firing of solid shot from eight 68-pounder carronades, and live shells from three 8-inch and three 10-inch howitzers, at the distances of 400 and 500 yards, a practicable breach 14 feet wide was effected in the wall; the tops of the counterguard and of the work in rear were also entirely degraded by the shot which struck them.

If the above formula be put in the form $p = \frac{2 v^2 r \delta g}{3 \text{R} g^2}$, the specific gravity ($s$) of the shot may be substituted for δg. The value of R must be determined by experiment. When the resisting material is the same,

$$p \propto r v^2 \delta; \text{ or } p \propto \frac{r v^2 s}{g} \quad . \quad . \quad . \quad (a)$$

also, when shot of the same density is used, and the resisting material is the same,

$$p \propto r v^2; \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (b)$$

or, in the last case, the depth penetrated varies with the diameter of the shot and with the square of the velocity at the instant of striking.

From the hypothesis of M. Poncelet, that the resistance of a material struck by a shot is proportional to the square of the diameter of the projectile, and from a comparison with the results of experiments, it has been found ('Expériences d'Artillerie exécutées à Gavre,' chap. 21, sect. 3) that the depth of penetration into oak may be expressed by a formula which, when transformed so that the penetration shall be obtained in English feet, is

$$4.612 \, r \delta \log. \left\{1 + \frac{v^2}{1076696}\right\}, \quad . \quad . \quad (c)$$

v being, in feet per second, the velocity of the shot at the time of impact, r the semidiameter of the shot in decimals of a foot, and δ the specific gravity of the shot, that of water being unity.[a]

83. The differential equations for the determination of the trajectory of a shot, in a medium which produces a resistance proportional to the square of the velocity, may be seen in the

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[a] The volume of the space penetrated by a shot in any material is frequently represented by the *vis viva*, or active force of the shot in motion; in which case it is proportional to the product of the mass of the shot multiplied by the square of its velocity. That is, w' representing the weight of the shot, v its velocity, and g (=32.2) the force of gravity, the volume of penetration varies with $\frac{w'}{g} v^2$; or, r being the semidiameter, and δ the density (for which may be substituted the specific gravity) of the shot, it varies with $r^3 v^2 \delta$.

The co-efficient in the formula (c) in the text is conformable to the recent experiments indicated in the 'Aide Mémoire d'Artillerie Navale,' Paris, 1850.

'Journal de l'Ecole Polytechnique,' tom. iv., art. *Ballistique;* in Poisson's 'Traité de Mécanique,' tom. i. no. 211, and in many other treatises on Dynamics; they are not capable of being integrated in finite terms, but the values of the co-ordinates, for a number of points in the curve, may be determined by the method of quadratures, as it is called, in which the differences in the density of the atmosphere at different heights may be introduced, and thus the curve may be approximatively traced. An example is given in Le Gendre's 'Exercises de Calcul Intégral,' tom. i. p. 330.

When, however, the elevation of the piece of ordnance is small (not exceeding 10 degrees), the equation to the trajectory is comparatively simple; and in treatises on Dynamics it has the form

$$y = x \tan a - \frac{1}{8\,c^2\,h \cos^2 a}(e^{2\,cx} - 2\,c\,x - 1),$$

in which x is the horizontal and y the vertical ordinate of any point in the curve, the origin being in the axis of the bore at the muzzle of the gun; a is the angular elevation of the gun, h the height due to the initial velocity of the shot, e $(= 2.71828)$ the base of the Napierian logarithms, and c is put for $\frac{k\,\delta}{r\,\delta'}$, the co-efficient of the square of the velocity in the expression (Art. 62) for the retardative force arising from the resistance of the air, or (Art. 78, Note *a*, p. 52) half the reciprocal of the height due to the terminal velocity of the shot.

The following more simple expression for y, which is sufficiently accurate for small elevations, is obtained by substituting for e^{2cx}, its development by Maclaurin's theorem; extending the series to the fourth term only, since c is a very small fraction, and h is very great compared with x:—

$$y = x \tan a - \frac{x^2}{4\,h \cos^2 a}\left(\frac{2}{3}cx + 1\right),$$

or

$$y = x \tan a - \frac{g\,x^2}{2V^2 \cos^2 a}\left(\frac{2}{3}cx + 1\right);$$

V representing the initial velocity.

81. If the range on a horizontal plane were alone required, it might be obtained from either of the above formulæ on

putting, for y, the height of the axis of the gun, at the muzzle, above that plane, prefixing to it a negative sign; the first equation for y in the preceding article may then have the form

$$e^{2cx}-1=(8c^2h\sin\alpha\cos\alpha+2c)x+8c^2hy\cos^2\alpha \quad . \quad . \quad (a)$$

When the horizontal plane passes through the axis of the gun at the muzzle, y being then zero, the same equation becomes

$$e^{2cx}-1=(8c^2h\sin\alpha\cos\alpha+2c)x \quad . \quad . \quad (b)$$

The second equation for y (Art. 83) gives, in the same case,

$$x=\frac{3}{4c}\left\{\left(\frac{32}{3}ch\sin\alpha\cos\alpha+1\right)^{\frac{1}{2}}-1\right\} \quad . \quad . \quad (c)$$

For the *point blank* range, when $\alpha=0$, or the axis of the gun is horizontal, y being the height of the gun above the horizontal plane on which the shot falls,

$$e^{2cx}-1=2cx+8c^2hy \quad . \quad . \quad . \quad . \quad (d)$$

The equations (a), (b), (d) being transcendental, the value of x, or the required range, can be obtained from either of them only by tentative processes.

85. If x represent the whole range, when consequently $y=0$, we have from the second equation for y (Art. 83),

$$\sin 2\alpha=\frac{1}{2h}\left(\frac{2}{3}cx^2+x\right);$$

whence h (the height due to the initial velocity)

$$=\frac{2cx^2+3x}{6\sin 2\alpha}:$$

or V (the initial velocity)

$$=\sqrt{\left\{\frac{gx}{3\sin 2\alpha}(2cx+3)\right\}} \quad . \quad . \quad . \quad (e)$$

Differentiating the same equation for y, we have, for the tangent of the inclination of the trajectory to the horizon at any point in the curve,—

$$\frac{dy}{dx}=\tan\alpha-\frac{cx^2+x}{2h\cos^2\alpha};$$

which, on putting tan α in the form $\frac{\sin 2\alpha}{2\cos^2\alpha}$, and substituting for sin 2 α the above value (when $y=0$), becomes at the furthest extremity of the range, θ representing the angle of descent,

$$\tan\theta = -\frac{4cx^2+3x}{12h\cos^2\alpha} \quad . \quad . \quad . \quad (f)$$

From the expression for the initial velocity above, we have

$$c = \frac{3}{2}\,\frac{V^2\sin 2\alpha - gx}{gx^2};$$

and from this formula, by means of experimental velocities and ranges, the value of c (the co-efficient of the air's resistance) may be found.

In the 'Aide Mémoire Navale' (p. 531) there is given an expression for y, which is equivalent to the second and third values of y in Art. 83, and differs from either of them only by the substitution of a constant K, for $\frac{c}{V^2\cos^2\alpha}$; this consequently restricts the application of the formula to the same piece of ordnance, with equal shot and equal charges. Here α is supposed to represent the true elevation of the trajectory at the mouth of the gun, which is always found to exceed by a few minutes the elevation of the axis of the piece.[a]

86. The time t, of describing any portion of the trajectory, reckoned from the instant of the discharge, is expressed by the equation

$$t = \frac{1}{c\sqrt{2gh}\cos\alpha}\left(e^{cx}-1\right):$$

and when for x is substituted the whole range, the value of t becomes the whole time of flight.

87. The longitudinal and lateral deviations of projectiles from

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[a] The following empirical formula is given in the 'Aide Mémoire Navale' (p. 535) for the ranges of shot when the elevation is between 10° and 30°:—

$$P\,(\sin 3\alpha)^{\frac{2}{3}} = X.$$

Where P is the range, when the elevation is 30°, considered as that wh produces a maximum range, and supposed to have been determined by exp ment; α is the given angle of elevation between those limits, and X is required range.

the object aimed at are presumed to depend on the following causes, independently, it must be understood, of the irregularities which may arise from the friction and rebounding of the shot against the surface of the bore:—First, the inequality of friction exercised on opposite sides of the shot's path by the air which it passes through; next, the want of exact sphericity in the shot; and, again, the want of perfect homogeneity, on which account the centres of gravity and of the figure are not coincident. To these may be added the diurnal rotation of the earth. The phenomena of rotatory motion in bodies have, during more than a century, been made the subject of mathematical investigation by many distinguished men of science, particularly in their relation to Physical Astronomy. The rotation of projectiles has been, in a manner purely analytical, treated by Euler and La Grange; but M. Poisson has made the rotations and deviations of military projectiles in particular, the subjects of three elaborate *Mémoires* in the 'Journal de l'Ecole Polytechnique,' tom. xvi.

88. With respect to the deviation caused by the earth's rotation, it is shown that when the line of aim is directed from north to south, and from south to north, the lateral deviations are westward and eastward respectively; and when directed from west to east, and from east to west, the lateral deviations are southward and northward respectively: that is, in all cases, towards the right hand of the soldier. M. Poisson shows that, in latitudes corresponding to the central parts of Europe, a 10-inch shell weighing 112 lbs., when fired in any vertical plane at an elevation of 45 degrees, with an initial velocity equal to 400 feet per second, will, on this account, at the distance of 1200 yards, deviate from the mark between 2 feet 10 in. and 3 feet 10 in. A 12-inch shell, weighing 200 lbs., fired at an equal elevation, with an initial velocity equal to 900 feet per second, will, at the distance of 4400 yards, deviate from the mark between 15 and 30 feet. Hence, in order to strike an object, the projectile should, if this cause of deviation were alone considered, be fired in a vertical plane, making with a vertical plane, passing through the piece and the object, an angle equal to about three minutes towards the left hand of the soldier.

89. In a Paper on the Deviation of Projectiles, by Professor Magnus, of Berlin, which is published in the Memoirs of the Royal Academy, Berlin (1852), and translated in Taylor's 'Scientific Memoirs,' May, 1853, the writer conceives that the observed deviations of shot having a movement of rotation on an axis, as well as of translation in space, may be explained by the direct resistance of the atmosphere combined with a rotation induced in the air immediately about the shot. M. Magnus observes, from experiments ingeniously devised, that, on one side of the projectile, the force arising from the motion of the air which is generated by the rotation has the same direction as the force of resistance arising from the reaction of the air in the motion of translation; and that, on the opposite side, these forces have contrary directions. When the reacting force is great, compared with the other, the effect on the shot is nearly the same as if the latter did not rotate on its axis: but, when these are nearly equal, a pressure of the air takes place on the side of the shot at which the direct motion of the shot is coincident with the movement of rotation; while, on the opposite side, the air, being expanded, is strongly driven off. Hence, supposing a spherical shot during its progressive motion to rotate so that the axis of rotation is always in a normal to the trajectory, and in a vertical plane; when the front of the shot turns from left to right, the observer being behind the gun, a decrease of pressure takes place on the right hand, and an increase on the left, and the shot deviates to the right; on the contrary, when the front of the shot turns from right to left, there is a decrease of pressure on the left, and an increase on the right, and the deviation is to the left.

A like explanation is given of the deviations produced when the axis of rotation is horizontal and perpendicular to the plane of the trajectory. If the upper hemisphere turns in the direction of the motion of translation, the projectile descends, and the range is less than if there were no rotation. If the upper hemisphere turns in a direction contrary to the motion of tr lation, the shot rises and the range is increased.[a]

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[a] The author trusts he shall be excused for mentioning in this place
in consequence of the above observations, together with what has been
where in this work stated concerning the importance of shot being fabri

These results are directly contrary to those at which M. Poisson has arrived in the *Mémoires* above referred to, where that distinguished mathematician has investigated the deviations of a spherical and homogeneous projectile which revolves on its axis during its motion of translation.

90. If the projectile be not spherical, and if it have that rotation on an axis which is produced by being fired from a rifled barrel, the deviations arise from two causes: the first is

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with the utmost attention to perfect sphericity, and uniformity of density throughout the mass, the attention of Mr. D. Napier, an eminent mechanician and manufacturer of steam-engines, was attracted to that subject as early as the beginning of the year 1831, as appears by a letter to the author bearing that date; and the circumstance led him to the invention of the ingenious method of forming leaden bullets for rifles or common muskets, by strong compression, from masses of solid lead which have previously been cast in the form of cylinders. By this process the air-bubble, and the irregular inequalities which always occur in bullets when cast, do not exist in balls so formed; one uniform density is produced in them, and the centre of gravity of the ball is coincident with its geometrical centre. It is easy to perceive how much the efficiency of infantry-fire, and indeed of any in which leaden balls are used, would be increased by the employment of missiles formed on this principle.

The following is a brief description of the process:—The lead is first formed by casting it in cylindrical ingots, each three feet long and three quarters of an inch diameter, and each of these is then passed between the circumferences of two pully-shaped rollers, those circumferences being notched for the purpose of holding and drawing the ingot or cylinder forward. By this operation, the cylinder is compressed in the direction of a diameter as much as a quarter of an inch, the diameter at right angles to this being correspondingly increased. The cylinder is then passed between two rollers similar to the former, but having on each of their circumferences a number of hemispheroidal indentations: the compression of the cylinder now takes place in the direction of the longest diameter, and the indentations just mentioned cause the cylinder to assume the appearance of a chain of bullets, each having the form of an irregular spheroid, and each being connected with the next by a flat portion of lead about a quarter of an inch thick, which is in part cut through by the machine. Each separate bullet is, lastly, received in a fixed die, and, a moveable die being forced down upon it, the third compression gives to it a perfectly spherical form, the bullets being now connected together only by a portion of lead about the thickness of a wafer, so that they may be easily separated from one another.

Simple musket-bullets, belted rifle-balls and the Minié shot are executed by the machine in like manner; and, since steam-power has recently been applied to this important purpose, it is hoped that the supply of balls so formed will be sufficiently ample to meet all the wants of the service.

It is worthy of remark that, in cast-iron solid shot there is a great want of that homogeneity which is essential to concentricity of gravity and figure: very few such shot, when floated in mercury, rest, as all of them ought to rest, indifferently in any position; but it is highly desirable that some mode should be discovered of obtaining perfect homogeneity, and the importance of this quality will be particularly shown hereafter in treating of the subject of excentric spherical projectiles.

due to the spiral movement, by which the axis of the shot and the axis of rotation are not coincident; and the other to the rotation of the shot. The effects of this rotation will be different according as the shot is compressed or elongated in the direction of the axis of the bore. The result of the investigations alluded to in Art. 87 is, that an elongated ball deviates to the *right* of the soldier when the rotation of the upper part is from left to right, and *vice versâ*. A flattened ball (one whose shorter axis is in the direction of the bore) deviates to the *left* when the rotation of the upper part is from left to right, and *vice versâ*.

91. When pointed, or cylindro-conoidal shot are projected from rifled cannon or muskets, it is observed that they have always a lateral deviation towards the right hand of the soldier, and never towards the left. The deviation is, however, always less than that of a spherical projectile fired from a smooth bore; and it is manifest that this is caused by the rifle-grooves having a direction from the left to the right of the soldier, in the upper part of the barrel. It would, however, be proper that experiments were made with barrels rifled in the contrary direction, or from right to left, in order to ascertain if the deviations would, or would not, in that case, be always towards the left hand.

M. Magnus, in the paper above quoted, describes some ingenious experiments from which he ascertained that the axis of an elongated cylindro-conical shot is not exactly in the direction of a tangent to the trajectory, but makes with it a small angle. He shows that, if the elongated shot had no rotation, the resultant of the air's resistance, passing through the axis between the centre of gravity and the apex, that resistance would tend to raise the apex above a tangent to the trajectory; and that, when a rotation towards the right is combined with the projectile motion, the apex is not elevated, but the longitudinal axis of the shot makes an angle with a vertical plane passing through the axis of the fire-arm, such that the apex is towards the right; the resistance of the air thus presses the centre of gravity towards the same side, or towards the right hand of the soldier, and causes the lateral deviation which is observed, at the time it causes the apex of the shot to tend below the dire of a tangent to the curve. Professor Baden Powell, in a P read at the Royal Institution in London, March, 1854, obse that the Minié projectile being hollowed at the base, its centre of gravity will be nearer the apex than in a solid shot; consequently that the resistance of the air may tend to depress the apex and cause a lateral deviation of the shot towards the left of the soldier.

92. Whatever be the causes which produce the lateral deviations of projectiles, the effects may be considered as being directly proportional to the velocity v of the projectile in its trajectory, and inversely proportional to its diameter $2\,r$, and its density δ; the deviating force is therefore represented by $k\frac{v}{r\,\delta}$, in which k is a constant depending on the state of the atmosphere and on the nature of the projectile; and the formula for the mean deviations resolved in vertical and horizontal directions is found to be, for each of those ordinates, at a distance x from the gun,

$$\frac{k\,v}{r\,\delta\,c^2\,V^2}\,(e^{cx}-c\,x-1),$$

in which V denotes the initial velocity, and c has the same value as above stated, Art. 83.

By deductions from experiments with various natures of French ordnance, it is found that, for solid spherical shot, k may be expressed by .00125, and, for hollow spherical shot, by .00135 ('Suite des Expériences d'Artillerie à Gavre,' Paris, 1844).

93. It has been stated that in the parabolic theory the angular elevation of the piece which gives the greatest range is 45 degrees: this is not the case when the shot moves in a resisting medium; for then the maximum range depends upon the resistance as well as upon the initial velocity. The best method of finding the elevation which would give the maximum range is to calculate, by quadratures or otherwise (see the works quoted in Art. 83), the ranges due to several different angles of elevation; and when, thus, two limits of the elevation have been found between which the greatest range is produced, the exact elevation required may be determined by the usual process of interpolation.[a]

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[a] By differentiating an equation of the trajectory, considering x and a (the horizontal co-ordinate and the angle of elevation respectively) as variable

In this manner it has been found, by the writer of the *Mémoire* on Ballistics in the 'Journal de l'Ecole Polytechnique,' tom. iv., that when the initial velocity is 1595 feet per second, the elevation which, by the formula, gives the greatest range is 31° 59′ 6″; but, in proportion as the initial velocity is diminished, the angle which gives the maximum range is greater. In fact, when the initial velocity was 500 feet per second, the elevation producing the maximum range was 42° 14′. This augmentation of the elevation, with the diminution of the velocity, is exactly what might be anticipated, since the resistance of the air would diminish with a diminution of velocity, and the trajectory would approach nearer to a parabolic form. It may be observed that, in the experiments made at Deal in 1839, the greatest ranges were obtained (conformably to the deductions from theory) when the elevations were 32°.

94. Writers on Dynamics have shown, that the ascending and descending branches of the trajectory are not similar to one another, as they are in the parabolic theory; the tangents at points in the ascending branch making smaller angles with a horizontal line than those at corresponding points in the descending branch. The former branch, if continued downwards, has an asymptote which is inclined to the horizon, and the latter has an asymptote which is in a vertical position. It follows that, when the axis of the gun is inclined to the horizon, the vertex, or highest point in the trajectory, is nearer to the remote extremity of the range than to the place of the gun.

95. The differences between ranges in a resisting medium and those which should result conformably to the parabolic theory are exhibited in the following table; and from these it appears that the ranges, instead of varying as the squares of the velocities (Art. 49, Note), are in a lower proportion than the veloci-

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quantities, and making $\frac{dx}{da}$ equal to zero, Dr. Robison obtained (*Encyc. Brit.*, 5th edit., Art. PROJECTILES) an equation equivalent to

$$\frac{4\,m\,h}{\sin a\,4\,(m\,h\sin a+1)}=\text{hyp. log.}\,\frac{4\,m\,h+\sin a}{\sin a}\;;$$

and the value of a obtained from this equation gives, approximativel elevation producing the maximum range. In this manner was forme table for maximum ranges given in Hutton's 'Tracts' (Tract. xxxvii., 118).

ties; while from 800 feet to 1600 feet (the most ordinary velocities with guns) the ranges are nearly as the square roots of the velocities.

The table, which has been computed from theory, exhibits the ranges corresponding to several given velocities with which a 24 lb. shot may be projected in a resisting medium, and also the ranges in vacuo, the elevation of the piece being in both cases 45 degrees.

Initial Velocities, in Feet per Second.	Ranges in Air, in Yards.	Ranges in Vacuo, in Yards.
200	350	415
600	1,760	3,731
800	2,230	6,632
1,000	2,650	10,362
1,600	3,754	26,528
2,000	4,340	41,450
2,600	5,180	70,050

From the experiments carried on at Deal in 1839 the range of a 56 lb. shot, with a charge of 16 lbs. (windage = .175 inch), consequently having an initial velocity of 1622 feet per second, and fired at an elevation of 32°, was 5720 yards. By the parabolic theory it would have been 24,475 yards, or nearly 14 miles.

96. Having given the principal formulæ for projectile motion, as well in air as in vacuo, it is intended now to offer a series of observations on the most important circumstances in the practice of naval gunnery, and to state the means by which the highest degree of efficiency in it may be attained.

These subjects are, for the sake of convenience, disposed under the following heads:—

I. The effect of Splinters.
II. The effects of Heavy and Compound Shot in increasing the force of Impact.
III. The employment of Double and Triple Shot in action.
IV. The effects of Windage on correct Firing, and on the Velocity of Shot.
V. Effects of the Length of Gun on the Velocity of Shot.
VI. On Recoil and Preponderance.

VII. The effects of Wads.
VIII. Penetration of Shot into Materials.
IX. On Cylindro-conoidal, and Eccentric Spherical Projectiles.

97. I.—*The effect of Splinters.*—It appears to have been a general rule to use the full charges of powder at the commencement of an action, and to reduce them as the guns became heated. This is a very proper precaution to guard against accidents in continued, quick firing; but a general rule to commence action with the full charges may, in some cases, interfere with the important effect that might be produced from splinters. The prodigious ravages occasioned by splinters, in naval actions, are such, that we should study as much as possible, consistently with other views, to reap the fullest effect from so destructive an agent; and this depends very much upon the degree of velocity with which the balls penetrate.

98. In close action, shot discharged from large guns with the full quantity of powder tear off fewer splinters than balls fired from the same nature of guns with reduced charges. This may be familiarly exemplified by firing a musket or a pistol charged with a bullet through panes of glass, at different distances, or with different charges. Superior velocity will make a clean round hole, without breaking or even cracking the plate; but a certain reduced celerity will dash the glass to pieces.

In firing into masses of timber, or any solid substance, that velocity which can but just penetrate will occasion the greatest shake, and tear off the greatest number of, and largest, splinters; for, as in the brittle glass, the parts struck by a solid shot, moving with great velocity, are driven out before they communicate motion to the circumjacent parts of the substance. This is particularly the case with respect to the impact of shot on plates of iron, as will be shown hereafter. Whereas by shot of inferior weight, or moving with less velocity, or by both of these circumstances duly combined, the rents, shakes, and ravages made in perforating timber will be more extensive; a greater numb
splinters, and those of larger size, will be torn off, and a
tures more difficult to plug will be made: while, in the pe
tion of iron plates, large and ragged fractures will be for

seams and rivets will be broken to a greater extent, and fragments will be driven on board, which are far more destructive of life than if the shot had been discharged with velocity sufficient to cause it to perforate both sides of the ship. In close actions with heavy guns, charges may therefore be, with advantage, greatly reduced. In fact, the velocities communicated to solid shot by charges exceeding one-third of their weight are too great to produce the maximum effect from splinters; and charges of one-sixth, from heavy guns, are found quite sufficient, at 600 yards, to drive single and even double shot through the thickest part of the side of any ship. Many other examples might be given here, but the subject will be fully treated in the section on the Penetration of Shot.

99. The above observations require, however, to be modified according to circumstances; their justness depending on the position of the enemy and on the degree of steadiness with which the firing is carried on during an action. If no greater force were wanted than that which is capable of penetrating the side of an enemy's ship with the greatest effect from splinters, those observations will hold good. Vessels armed with the heavier natures of guns, in close, steady, broadside action may certainly use reduced charges, if, as in attacking an enemy at anchor, the relative positions do not rapidly change: also, since the velocity of a shot from a 32-pounder, at close action, with a service charge, is more than sufficient to penetrate any mast, we are at liberty to sacrifice some of the superabundant power, by diminishing the charge, for the purpose of obtaining an increased effect from the splinters which may be driven off from masts, spars, or any other timber, as well as from the ship's sides. But, while we keep this object in view, we should particularly provide for the destruction of masts, dismounting of guns, and ruining of their carriages, breaking beams, and penetrating into masses of timber in firing obliquely, or at great distances (see Art. 107), in which cases full charges are required. Nothing, moreover, can be spared in force with any nature of gun up to the 12-pounder inclusive: with the higher natures, charges of one-quarter of the weight of the shot may be occasionally used with advantage, but in no case for raking or diagonal fire.

100. To increase still further the effect from splinters, *hollow*

shot have been proposed, and these may be used with great adadvantage from guns of large calibre. For whilst, by their magnitude, fractures or apertures of great extent may be made in the side of an enemy's ship, their relatively lower momenta, arising from the diminished weight, render them far more conducive to the formation of destructive splinters than solid balls of equal diameters. But it may be doubted how far hollow shot are sufficient substitutes for solid shot at great distances; the requisite accuracy and certainty of practice, that is, the greatest power of range with the least elevation, being attainable only by the heavier projectiles.

It may also be doubted whether or not we are right in the general adoption of shell-guns for the bow and stern armament of steamers, in preference to long and powerful solid-shot guns, possessing, in a higher degree, power of range, accuracy and penetrating force, in distant firing; and whether, in the armament of our navy in general, we have not so reduced the number of guns, in proportion to the *displacement*, in consequence of the introduction of shell-guns into the broadside batteries of some classes of ships (the "Thetis" and "Castor" class in particular), as to place those vessels in disadvantageous circumstances when opposed to such as, though equal to them in size, carry a greater number of guns, and which, consequently, possess a degree of superiority, from the power of making a plurality of discharges in a given time, and from the facility with which the less unwieldy guns may be worked relatively with the number of men forming the crew according to the present establishment. The "Thetis" and "Castor," the displacements of which are, respectively, 1528 and 1283 tons, carry only 36 guns; the "Indefatigable," with a displacement of 2043 tons, has only 50 guns; our largest frigate, the "Vernon," with a displacement of 2082 tons, carries only 50. Where are our 60-gun frigates? The French had (in 1850) twelve 60-gun frigates afloat, and five were being built: they had, moreover, twenty-five 50's. The number, names, and ratings of the ships vessels afloat, building, and in commission, have not been g in L'Etat Général de la Marine since 1850; but, according statement in L'Enquête Parlementaire, the French had, in fifty-six frigates and thirty-four corvettes. We had then twenty-six frigates above the class of 44 guns, and of this class only twelve! The war armament of the United States' frigate "Congress," and eleven others of that class, is upwards of 50 guns; and of the "Independence," 60; the peace armament of this ship is 54 guns. The first-class frigates in the Russian navy carry 60 guns; the second-class, upwards of 50. The Dutch have their 60-gun frigates, though in peace they carry only 50. In the Turkish navy there are ten of from 54 to 64 guns. In the French service, the razées carry 58. Our "Warspite," reduced from a 76, originally with a displacement of 2490 tons, but lighter now, at the load-line, by 2 feet 4½ inches, equivalent to 436 tons, carries only 50 guns. The "Arrogant," with a displacement of 1872 tons, far from retaining the full gunnery power due to that tonnage, is reduced to 46 guns.[a]

101. II.—*The effects of Heavy and Compound Shot in increasing the Force of Impact.*—To gain an increase of penetrating power, or to augment the force of the blows with which shots strike, balls made of heavy material may be used with advantage. A shell, filled with lead, will produce a greater blow than an iron shot of the same diameter, discharged with an equal quantity of powder; for the penetrating power, which (Art. 82) varies with the product of the density and the square of the velocity of the body, will, in this case, be proportional to the weight of shot. The former may also be made to range farther than the iron ball, from being better able to overcome the resistance of the air, and, consequently (see the equation for x, Art. 63), retaining longer the superior velocity communicated by a greater charge of powder.[b] From this an increase of accuracy also results, because the same range may be produced with less elevation; and accuracy is gained as elevation is reduced.

From experiments made in France it was found that a shell filled with sand, and weighing about 46 lbs., being projected with a charge of 9 lbs. from an 8-inch Paixhans gun, with an initial velocity of 1200 feet per second, and at an elevation equal to 1°, ranged twice as far as a shell filled with lead

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[a] An accurate account of the armaments of the British and foreign navies will be given in an Appendix.

[b] The like is evidently true in comparing the effects of solid and hollow shot.

weighing 75 lbs. when projected with a charge of 7 lbs., the initial velocity being 840. But, at an elevation of 3°, the ranges were nearly equal; and at 5° (the weights and charges being as before) the range of the shell filled with lead surpassed that of the other, amounting to 1800 yards, while the range of the shell filled with sand was only 1400 yards. This proves that great initial velocity is not alone essential to the power of range, but that much depends upon the weight, or inertia, of the shot, by which the velocity of projection is longer retained. We shall revert to this subject in treating of hollow shot.

102. Heavy, or, as they may be called, compound shot, may be used with great advantage against vessels constructed with sides so thick as to be proof against the known penetration of ordinary shot; for balls made of heavier matter (strong shells run full of lead) will penetrate farther, and be more formidable in every way. If the sides of such vessels be made of solid masses of timber only, then red-hot solid shot should be used; and if these lodge, the effect will be rendered the more certain; but as the furnaces for heating shot on board of ships cannot supply as many balls as may be discharged, cold shot must also be used. The effect of these will be more or less formidable, in proportion to their powers of penetration and their momenta, both of which will be greater with the compound heavy shot than with solid iron balls.

The weight of a 56-pounder shell, having its cavity filled with lead, is 65.443 lbs.; for the whole diameter being 7.475 inches, and the thickness of the metal one-sixth of the diameter, the weight of the shell itself is 38.827 lbs., while the weight of the solid ball of lead which occupies the cavity is 26.616 lbs. Now (Art. 71) the velocities of balls of equal diameter, but different weights, and discharged with equal quantities of powder, being inversely as the square roots of the weights, the velocity of a homogeneous 56-pounder shot will be to that of the shell when filled with lead, as $\sqrt{65.443}$ to $\sqrt{56}$; so that, the velocity of the solid shot with a charge of 14 lbs. being by computation 1 feet per second, the velocity of the shell filled with lead, the same charge, would be 1476 feet per second. But velocities of balls of equal weights being directly as the sq roots of the charges, or the charges being as the squares of velocities; if we increase the charge from 14 lbs. in the ratio of the squares of those numbers, we get 16.36 lbs. for the charge, which will render the velocity of the shell filled with lead equal to that of the homogeneous 56-pounder shot. This is a simple way of increasing the weight of metal, as it is popularly called; and on particular occasions it may be used with considerable advantage.

In the experiments made at Deal in 1839, to determine the ranges of homogeneous shot and of shells filled with lead from a 56-pounder, 11 ft. in length, 97 cwt. 2 qrs. 26 lbs. in weight, and with a windage of .175, it appears that with charges of 17 lbs., at an elevation of 15°, the first graze of a solid shot was 4001 yards, and at an elevation of 35°, 5200 yards; while, at the former elevation, the first graze of a shell filled with lead was 4029 yards, and at the latter elevation 5600 yards.[a]

In chasing, or in flight, heavy compound shot, fired from long guns with charges increased in the proportion just shown, will increase the power of range, and consequently the chance of carrying away a mast or a spar, at a very considerable distance.[b] For such special purposes as these, it may, therefore, be expedient to provide a few compound shot, with directions how to use, and injunctions to economize them.

103. Oblong shot of the kind formerly used, that is, of a cylindrical form and terminating at each end in a hemisphere, may still be used occasionally either against ships or in breaching batteries by land. The great uncertainty of such shot, however, from irregularities in their flight, would not, at great distances, be compensated by the advantages contemplated; but they might sometimes be used at moderate distances with great effect, particularly by vessels carrying only 9 or 12-pounder

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[a] At the siege of Cadiz, the French used shells filled with lead, which, discharged with a velocity of about 2000 feet per second from howitzers (one of which is now placed as a military trophy in St. James's Park), ranged to the distance of three miles. Greater ranges than this have been obtained with shells in experiments recently (1852) carried on at Shoebury Ness in this country. See Art. 193, p. 152.

[b] A very distinguished naval commander mentioned to the author that he knew a person who had served in an American privateer which, having been out of shot, and being unable to procure a supply of iron balls, used leaden shot as substitutes. This person always mentioned with great surprise the superior effect of leaden balls.

guns; for the weight of metal may thus be increased so much as to be capable of carrying away a mast, which a round shot, discharged from the same gun with equal velocity, could not bring down; and the oblong shot would make large irregular fractures in the side of an enemy's ship which it would be very difficult to plug up.

The windage of oblong shot should not be greater than .14 of an inch (the windage of a carronade), so that, in fact, a 12-pounder gun discharging a solid mass of iron of 24 lbs. weight (that of its oblong shot), with a charge of 4 lbs., would be capable of producing as great an effect as a 24-pounder carronade; and if the oblong shot were to strike with its larger dimensions, the effect would be much greater. For a 12-pounder, a shot of the shape above indicated, and exactly equal to the weight of two 12-pounder balls, should be 2.935 inches long in the cylindrical part, and the total length 7.338 inches. In close action the chance of hitting with separate balls is so great, that two round shot should then be preferred to a single oblong projectile; but when the distance is such, compared with the magnitude of the object fired at, that from the divergence of the balls, both cannot hit, it may frequently prove advantageous to increase the weight of metal with the smaller nature of guns in the manner proposed.

The proposition for using oblong shot is not new. Some very extensive experiments were made at Landguard Fort, in 1776, to ascertain the comparative ranges and accuracy of long and round shot with 42, 24, 18, and 12 pounders. It is not intended to notice the trials made with the three higher natures of ordnance, because it is not necessary to increase the momenta of their balls for any naval service, but some of the experiments made with the 12-pounder are given in the following table:—

Nature of Shot.	Weight of			Diameter of Shot.	Elevation.	Recoil.		First Graze.
	Powder.	Shot.						
	lbs.	lbs.	oz.	Inch.		Ft.	In.	Yds.
Round	5	11	8	4.3	P.B.	4	5	498
Long	5	24	3	4.4	P.B.	7	4	335
Round	5	11	9	4.3	1°	4	4	818
Long	5	24	3	4.4	1°	6	2	774
Round	5	11	10	4.24	5°	4	5	1,789
Long	5	23	3	4.4	5°	6	0	1,879

The weight of the oblong shot was more than double that of the ball, but the windage of the former was about one-tenth of an inch less. The ranges with the oblong shot were, of course, considerably less than with the balls; but it does not appear from these trials that the variations, or errors, were greater than they are with round shot; and it follows that, within the limit of elevation in the Table, we may, on suitable occasions, safely adopt a practice which would increase the effect in a considerable degree. Oblong shot would occasion great ravages in the revetment-wall of a fortress, and be more likely than round shot, by the great shake they would occasion, to bring it down after the part intended to be breached is disunited from the adjoining parts by round shot fired with full charges. There can be little doubt, also, that oblong shot are far preferable, in naval warfare, to bar-shot.

If an oblong shot, twice the weight of a round shot of equal diameter, be fired with the same charge, the velocity of the former will be less than that of the latter in proportion as the square root of the weight is greater. That is, the weights being as 2 to 1, the velocities will be as 1 to $\sqrt{2}$. But the effect of impact, measured by the volume of penetration, being as the weight of the shot and the square of its velocity (Art. 82, note), it follows that, with equal charges, the effect of the oblong shot will be just equal to that of a round shot of half its weight.

Oblong shot of the sphero-cylindrical form above noticed, when discharged from smooth barrels, wanting the adjuncts which give steadiness to an arrow, can never be made to describe plane curves in their flight; and it is but recently that the idea has been entertained of discharging oblong shot from rifled barrels: this fortunate discovery has led to the attainment of a great degree of precision in the practice with such missiles. This subject will be developed hereafter.

104. III.—*Employment of Double and Triple Shot in Firing.*—The reason which has been given for the occasional use of oblong shot leads to a consideration of the practice of firing two or more balls at once from the same gun, and it is here intended briefly to notice its defects as well as the case in which it may be advantageous.

It must be observed, first, that when two equal, or unequal, shot are projected at one time, they issue from the gun with different velocities which may be determined by the theory of the collision of bodies. Thus, the velocity communicated by the expansive force of powder to a single shot equal to either of the two if these are equal, or to that which is nearest to the charge if not so, being determined, suppose by the second formula in Art. 71 (the denominator under the radical sign being the weight of that shot), let that velocity be represented by V; then, e representing the force of elasticity, which from the results of some experiments may be expressed by the fraction $\frac{1}{9}$, if v represent the required initial velocity of the shot nearest the charge and v' that of the other; also, if w and w' represent the weights of those shot respectively, we have, by dynamics,

$$v = \frac{w - e\,w'}{w + w'}\mathrm{V} \quad \text{and} \quad v' = \frac{w + e\,w}{w + w}\mathrm{V}.$$

When the two shot are equal to one another, these formulæ become

$$v = \frac{1}{2}(1 - e)\,\mathrm{V} \quad \text{and} \quad v' = \frac{1}{2}(1 + e)\,\mathrm{V},$$

or

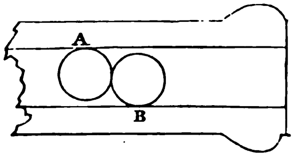
$$v = \frac{4}{9}\mathrm{V} \quad \text{and} \quad v' = \frac{5}{9}\mathrm{V}.$$

Now the velocity of a shot from a 32-pounder medium gun, whose length is 9 feet and weight 50 cwt., with a charge of 8 lbs., is, by computation, equal to 1693 feet per second (windage = .198); while with two balls and an equal charge the velocities would be 753 feet and 941 feet. The greatest of these velocities would, therefore (since the velocities are as the square roots of the charges), be the same as that of a shot propelled singly by only 2½ lbs. of powder. But the point-blank range of a 32-pounder gun, with a charge of 2½ lbs., would be less than 300 yards, while, with a charge of 8 lbs., it is 610 yards; thus, with the former charge and a single shot, or with the latter charge and two shot, there would be required an elevation exceeding one degree to obtain ranges equal to the point-blank range produced in a single shot by a charge of 8 lbs. In using two shot, therefore, there is a loss of accuracy, not only arising from the divergence of the balls, but also from the greater elevation which is required. This should deter us from adopting such practice, excepting at close quarters, when it is scarcely possible to miss; and never with carronades after one breeching (for they should always have two) is broken; nor, as in fighting the weather side, when the inclination is much in the direction of the recoil.

105. In practice with two shot there are some other causes of irregularity, which it is proper here to point out, that will further show how little it can be depended upon, excepting in close action. Besides a difference of range, frequently amounting to above a hundred yards, there is also a lateral divergence, which, in firing at ships, at long ranges, or at any objects whose magnitudes are not sufficient to subtend the divergence of the balls, incurs a considerable risk of missing entirely, and a certainty of not hitting with both. If the balls touch each other on quitting the gun, which very frequently happens, some deviation must arise, according to the nature of the collision. If it be direct, one ball will be accelerated, and the other retarded by the blow. But this will rarely happen—it is more likely that the blow will be oblique; from which both balls will diverge, very considerably, in directions compounded of the projectile velocity and the force and direction of the collision.

In firing two shot, another cause of deviation, still more destructive of accuracy, is operating during the passage of the balls along the bore; particularly when the windage is great. The shot nearest to the charge impelling the other will evidently be forced to one side of the cylinder, as at A, pressing the outward ball to the other side, B, of the bore. From this it is manifest that the outward ball B must receive an oblique impetus on its departure from the muzzle, which will disturb, from reaction, the direction of the other. This deviating cause may either operate vertically or laterally: in the former case it will affect the elevation, in the latter case the horizontal direction, of the shot's path; consequently errors

Fig. 2.



will exist in one direction, and commonly in both directions[a] at the same time.

106. It has been found, from experiments on board the "Excellent" (1847), that, in firing triple shot with three times the elevation required for a single shot, the balls took very good directions, but one fell rather short of the mark, and the others over or beyond, and that the carriage did not appear to be distressed. The gun used in firing the three shot was a 32-pounder, 9 feet 6 inches long, and weighing 56 cwt.; the charge was 6 lbs. It would probably be unsafe to fire three shot from a 32-pounder, weighing but 50 cwt., even though the charge were reduced to 5 lbs.; and if the charge were less than 5 lbs. the penetrating effect of the three shot would be uncertain, at least beyond 50 yards. It has been observed that, on running alongside of an enemy, the first broadside might be given with triple shot; and it is supposed that triple shot might answer the purpose against flotillas of gun-boats at distances not exceeding 400 or 500 yards.

107. After a few firings from the same gun a certain diminution of the charge becomes necessary; for, the gun being already heated, the powder on being introduced ignites more completely than at the commencement of the firing, and thus its expansive force is increased: hence considerable provision of reduced charges among the quantity of *filled* ammunition should always be made; it would even be convenient if some regulated proportions between the numbers of the full and of the reduced charges, to be used with single and with double shot, were made and adhered to. In the United States' service there are used two reductions of the full charge, or three charges in all, viz., $\frac{1}{3}$, $\frac{1}{4}$, and $\frac{1}{6}$ of the weight of the shot, and the cartridges of all three are painted with different colours. In the French service, of the total of filled ammunition, $\frac{2}{10}$ are full charges, $\frac{5}{10}$ are charges first reduced, and the remainder are still further reduced. Care should, however, be taken that the diminished charges are not rendered too low, since the penetrating force

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[a] It is said to be a rule in the naval service of the United States not to fire double shot, even at 400 yards, from guns of less calibre than 32-pounders (*Ward*, p. 82); and never with 32-pounders under 46 cwt. (Bureau of Ordnance, 1845).

may, at the same time, be so far reduced as to render the shot incapable of perforating a side of an enemy's ship. This circumstance occurred in the action between the "Shannon" and the "Chesapeake," on the termination of which some shot from each of the ships were found sticking in a side of the other. In this case either the charges were too much reduced, or the weight of metal projected was too great. Had these shot perforated the side which they struck, the most serious consequences might have ensued.

108. In all naval actions the essential point is to insure penetrating force sufficient to drive the projectiles through, or, at least, into the opponent's ship, whatever may be her position. This point appears to have been somewhat lost sight of on several occasions during the last great war; and it may be feared that, in carrying so far as is proposed the use of hollow shot and a plurality of projectiles, the momentum will be too much diminished, particularly in the employment of shell-guns. Naval actions are subject to such sudden and unforseen mutations in the positions of the contending ships, and are liable to such great alterations in the distances of the ships, that, until the affair becomes close and the struggle is near its termination, no two rounds can well be fired exactly under the same circumstances. An affair which had commenced in parallel order and in direct broadside battle, at well-ascertained distance, may speedily change, altogether, its circumstances and aspects. The enemy may be suddenly brought into a position in which he is exposed to oblique, diagonal, or raking fire; and for this an experienced commander should always be prepared. In every case he should ensure the penetration of his projectiles into and through the whole dimension of the enemy's ship, however she may be struck. Accordingly, he must not carry too far the theory that the greatest ravages which can be produced by a projectile on the object which it strikes is when the striking velocity is just sufficient to penetrate a stationary body, because if this be too strictly followed in direct action, there would be no perforation at all in the event of the enemy being struck obliquely. It is not possible to foresee, it would not be prudent to prescribe, what particular descriptions of projectiles or what particular charges may be required to take proper advantage of

different positions; but it has often happened that penetrating force has been improperly sacrificed to the practice of double or triple shotting; and thus when, by superior skill, the antagonist's ship has been suddenly brought to a position in which it is exposed to a diagonal or a raking fire, the penetrating force has not been sufficient to perforate it, or otherwise do upon it effectual execution. Seamen are prone to overload their guns with shot in close action; and many instances of this may be found in descriptions of naval engagements which might have terminated differently had the projectiles, which only stuck in the side, gone through the ship. This practice accounts, in some degree, as Captain Simmons observes in his 'Ideas as to the Effect of Heavy Ordnance, &c.' (page 69), for the comparatively little damage done to the hulls of line-of-battle ships in general actions.

109. In the action between the "Chesapeake" and the "Shannon," iron bolts, as well as chain and bar shot, were found sticking in without penetrating the side of the latter. Five 18-pounder round shot struck without penetrating into the "Chesapeake;" but all the 32-pound shot (carronades) that struck perforated the sides; none of these last struck the masts high up, and only one the bowsprit; but some 18-pounder round shot struck the masts 20 and 25 feet above the decks. So far it appears that the carronades were, probably in part owing to their small windage, truer than the 18-pounder guns.

The report from which these facts were taken was made by the carpenter of the "Shannon," by order of Lieutenant, now Rear-Admiral Wallis, an officer of the highest distinction and merit, who served on board the "Shannon" during the action. The effect of the shot on these ships, with respect to penetration, affords many useful practical deductions, and is therefore given in full in the subjoined note.[a]

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[a] An account of shot which entered His Majesty's ship "Shannon," in the action with the "Chesapeake," June 1st, 1813:—

Shot, round 32-pounder, cut away in the wake outer gammoning, 2 in. deep; grape, 7 in number, between 4 in. and 7 in. deep.

Foremast.—Shot, round 32-pounder, 4 in. deep, 15 feet above deck.

Mainmast.—32-pounder, main-deck, 1, depth 1½ in.; 18-pounder, 10 feet above deck, 1½ inch. deep; grape, 10 feet above deck, 2 in. deep; grape,

110. Double shotting may be used with all 32-pounder guns above those of 32 cwt., at distances not exceeding 400 or 500

1½ in. deep in different places; chain, 1, depth 1½ in., 15 feet above deck, 3 feet deep; grazes in several places, 1 in. deep.

Mizenmast.—32-pounder, round, 16 feet above deck, 3 feet split away in breadth, 5 feet up and down, and 6 in. deep; grape, 4 do. abreast, 3 in. deep.

Cutwater and Knee of the Head.—32-pounder, round, 2 in number, through; 18-pounder, round, near the same place; 32-pounder, round, in the hawse holes; hawse pieces split away under the knee; several grape 2 in. deep.

Bows.—32-pounder, round, through bows; knight-heads shot away; several grape through bulwark.

Between 1st and 2nd Guns.—18, round, through; 18-pounder, round, 2 in. deep.

Under Fore Chains, between 3rd and 4th Guns.—32-pounder, round, through forecastle; 6 grape, 2 in. deep.

Water's Edge, Fore Chains.—Shot, 18-pounder, through; chain, depth 3 in.; 2 grape, 3 in. deep; 1 bolt, iron, 10 in. deep, and 6 chain-plates.

Between 5th and 6th Guns in the Wale.—32-pounder, round, 2, 10 in. deep; 18-pounder, round, through; 2 grape, 4 in. deep; 7 grape, 5 in. deep.

Water's Edge, 7th Gun.—Chain, 1, 5 in. deep; 6 grape, 4 in. deep.

Main Chains, 8th and 9th Guns.—32-pounder, round, through; 1 canister, 6 in. deep; 18-pounder, round, 4 in. deep; 4 bar-shot, 8 in. deep.

Water's Edge, 10th Gun.—18-pounder, through; 12 grape, 3 in. deep; 4 chain-plates; 1 bolt, 3 in. deep; 6 grape, 3 in. deep; 32-pounder, round, through larboard side.

12th Gun, Water's Edge, Channel Wale.—18-pounder, round, through; 3 grape, 3 in. deep; 32-pounder, round, through; 4 grape, 2 in. deep.

13th Gun, Mizen Chains, Water's Edge.—Iron bolts, 2 in number, through 2 chain-plates; 5 grape, 2 in. deep.

14th Gun in the Wale.—18-pounder, round, through; 1 grape, 3 in. deep.

Quarter Gallery in the Wale.—32-pounder, round, through; 6 grape through.

Forecastle.—Grape shot, 20, through; larboard bumpin shot away; fore channel shot away; forecastle and waist hammock stanchions shot away.

Bulwarks—Quarterdeck.—Main chains or above, 32-pounder, round, through; 10 grape, 3 in. deep. Main chains much shot away; 18-pounder, round, through, 3 grape through. Mizen chains or above, 32-pounder, round, through; 10 grape through. Mizen chains, much shot away.

H.M.S. "Shannon."
(Signed) P. W. P. WALLIS, Commanding Officer;
Captain at Sick Quarters.

An account of shot which entered the sides of the American frigate "Chesapeake," in the action with His Majesty's ship "Shannon," June 1st, 1813:—

Bowsprit.—32-pounder, round, inside gammoning, 3 in. deep; outside do., 7 grape, 3 in. deep.

Foremast.—2 grape, 10 in. deep, 6 feet above deck; 4 grape, 4 in. deep, 20 feet above deck; 18-pounder, round, 4 in. deep, 20 feet above deck.

Mainmast.—18-pounder, round, 5 in. deep, 5 feet from main-deck; 9-pounder, round, 10 in. deep, 12 feet above quarter-deck; 2 grape, 10 in. deep, 20 feet above deck.

yards, but the most efficient practice with two shot is at 300 yards; the 32-pounders of 32 cwt. and 25 cwt. should not, how-

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Mizenmast.—7 grape, 3 in. deep, 10 feet above quarter-deck; 18-pounder. round, 6 in. deep, 12 feet above deck; 4 grape, 3 in. deep, 15 feet above deck.
1 *Fife Rail, Larboard Head.*—8 grape through.
under „ 4 grape through.
Bluff of Bows.—18-pounder, round, 6 in. deep.
Do. 4 18-pounders, round, 8 in. deep; 30 grape, 8 in. deep.
2nd and 3rd Guns under Fore Chains—in the Wales.—4 grape, 3 in. deep; 2 grape, 2 in. deep.
3rd and 4th Guns.—6 grape through; 8 grape, 3 in. deep.
4th Gun under Channel.—6 grape, 4 in. deep.
Fore-chain Plates.—Shot away.
6th and 7th Guns, between.—9 grape-shot, 3 in. deep.
7th Gun in the Wale.—18-pounder, round, through; 11 grape, 2 in. deep.
9th Gun under Main Chains.—5 grape, 2 in. deep.
13th Gun, side.—2 18-pounders, round, through.
Do., water's edge.—32-pounder, round, 2 through; 2 grape, 2 in. deep.
Aftermost Port, water's edge.—2 32-pounders, round, through; 18-pounder, round, through; 1 pump-bolt through; 3 grape, 2 in. deep.
Quarter Gallery, Foremast Wale.—3 32-pounders, round, through; 10 grape through; frame-work all carried away.
4 feet abaft After Port.—2 32-pounders, round, through; 3 grape, 2 in. deep.
9 feet abaft After Port.—2 32-pounders, round, through.
3 feet above Water's Edge, in the Run.—32-pounder, round, through.
2 feet from Stern Ports—2 feet above Water's Edge.—18-pounder, round, 14 in. deep; 32-pounder, round, through; 12 grape, 3 in. deep; stern-ports, 2 18-pounders, round, 3 in. deep.
Starboardside Counter.—7 planks, through; stern ports carried away; grape, 10, through.
Upper Counter.—18-pounder, round, through.
Bulwarks:—
Forecastle.—60 grape, through; 2 18-pounders, round, through.
Above Chains.—5 grape, through 3 chain-plates.
Main Chains.—5 grape through.
Mizen Chains.—12 grape, 3 in. deep.
Abaft Ditto.—18-pounder, round, through; 6 grape, 3 in. deep.
United States' Frigate "Chesapeake."
(Signed) P. W. P. Wallis, Commanding Officer.

[It is remarkable, that there was found sticking in the "Chesapeake" a pump-bolt which had been fired from the "Shannon," no doubt without authority. It is stated in James' 'Naval History,' vol. vi. p. 201, that the "Shannon's" main-deck guns were loaded alterately throughout the broadside with two round shot and a keg containing 150 musket-balls, and with one round and one double-headed shot. Seeing that no vestiges or impressions of double-headed shot were found in the "Chesapeake," the author applied to the gallant and distinguished officer who instituted and certified the above surveys, for information which might account for this discrepancy. Captain Wallis states, in reply, that no double-headed shot were fired from the "Shannon;" that the main-deck guns were loaded alternately with two round shots, and with one round shot and grape; that kegs of musket-balls were not fired as stated; that only a few of these were provided for the boat's ever, be so used beyond 200 or 250 yards. Shell-guns of 65 and 60 cwt., of the old construction, cannot use double shot beyond 200 yards; and at that distance they can only use hollow shot, with a charge of 5 lbs.

With charges of 6 lbs. for the 32-pounders of 56 cwt. and 50 cwt.; of 5 lbs. for those of 45 cwt. and 42 cwt.; 4 lbs. for those of 32 cwt., and 3 lbs. for those of 25 cwt., the guns recoiled with a considerable degree of violence; the charges, therefore, have been reduced to 5, 4, 3, and 2½ lbs. respectively. With these charges the recoil was found to be easy; the guns may be fired throughout an action without injury to their tackling, or to the ring-bolts, and at 400 yards the penetration is sufficient.

With double loadings of round-shot and grape, when the shot is put in first, the projectiles range more together than when the reverse process is used; such loading requires, however, more elevation to be given to the gun than when single shot are used, on account of the grape-shot impeding the flight of the other.

A double load of grape from the same gun ranges tolerably well together for 300 yards. With a double load of case-shot, even with half a degree more elevation than when a single load is used, a great many balls will not range above 100 yards to the first graze; within this extent they lose much of their velocity, and few reach an object at 200 yards.

A 32-pounder gun of 56, or of 50 cwt., double shotted with charges of 6 lbs., requires, at 400 yards, 1½° of elevation; at 300 yards 1°, and at 200 yards half a degree; and, in general, half a degree must be added with any double loading, to the elevation required with single shot.

For round and grape, at 400 yards, there is required 1½° of elevation, and at 200 yards half a degree. These projectiles range well together at a target, but they should not be used at a greater distance than 150 yards, on account of their dispersion,

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12-pounder carronades. Whether any musket-balls were put into the quarter-deck guns, he (Captain Wallis) could not say; but he thinks not. The "Chesapeake" fired round shot, grape, canister, double-headed, star, chain-shot, and other missiles, such as iron bolts and bars, about three feet long, bound together, and buck-shot in her musket cartridges.—AUTHOR.]

and the differences of their striking velocities and penetrating forces.

With single grape (a plurality of projectiles) at 400 yards, the elevation required is 1°, a full charge of powder being used. With double grape, at 400 yards, and the reduced charge, the elevation required is 3½°; at that distance double grape scatters so much as to make very bad practice.

111. There is some difference, particularly with heavy guns, in the times required for loading with single and with double shot; and when vessels are engaged so closely as to be within double-shot action, and, consequently, the most rapid firing should take place, it is evidently of the utmost importance to reduce as much as possible the time of loading. Other things being equal, a ship which can, in the shortest time, give a second broadside, will have a great advantage over her opponent; and, in order to effect this, it is recommended to have ready a few rounds of double shot sewed up in thin canvas, with a little oakum between the shot, and the whole secured by a line passed round between them, no wadding being used.

112. IV.—*The effects of Windage on Correct Firing and on the Velocity of Shot.*—Windage is the difference between the diameter of the shot and the calibre of the piece of ordnance; and its amount for different natures of ordnance is given in Table XXIV., Appendix B.

From experiments which have been made on this important subject it appears that very great differences in the initial velocities of shot arise from very small differences in the windage: that, with the degree of windage formerly established in the British service, no less than between one-third and one-fourth of the powder was lost; and that, as balls are often less than the regulated size, it frequently happened that half the force of the powder was lost by unnecessary windage.

113. In the account of the Artillery Practice carried on at Gavre, between the years 1830 and 1840, there is given a method of determining by experiment, approximatively, and from an empirical formula, the effect of windage on the initial velocity of shot. In this it is shown that a windage equal to .0512 inch reduces the initial velocity in the ratio of 1.14157 to 1, and

a windage equal to .3189 inch reduces it in the ratio of 1.6377 to 1; comparison being made, in both cases, with a velocity resulting from the windage being zero.

114. From subsequent experiments at L'Orient with the 30-pounder long gun, it appeared that the loss of velocity on account of windage was independent of the weight of the projectile, and was proportional to the lunaric area between a great circle of the shot and a transverse section of the bore. Now R being the semidiameter of the bore, and r that of the shot, $\frac{R^2-r^2}{R^2}$ will express the ratio between the lunaric area and the area of a section of the bore; and the loss from windage may be represented by

$$K.\frac{R^2-r^2}{R^2},$$

K being a constant which depends on the charge.

Major Mordecai found, however, that the above formula does not give results in accordance with his experiments at Washington; and he agrees with Dr. Hutton in considering that the loss of velocity by windage is proportional to the linear value of the windage, or to the difference between the diameters of the bore and shot. (See Art. 70.) He also found that, with a given windage and corresponding charges, the loss of velocity decreased as the calibre of the piece was increased.

In some experiments which were made in Sweden in 1846, with cylindro-conoidal shot projected from a rifled gun, the loss of velocity occasioned by windage was, in part, avoided by pasting paper round the shot. The initial velocities of balls strapped to sabots are rather greater than those of balls without sabots, probably because the force of the charge is increased in consequence of the escape of the gaseous fluid, by the windage, being in a great measure prevented.

115. The prejudicial effect which great windage has upon accuracy arises from the reflections of the ball in passing along the bore. These will manifestly be greater in proportion as the difference between the diameter of the shot and the calibre of the gun increases. From these reflections a shot acquires a sort of zigzag motion, and does not generally quit the cylinder

in the direction of its axis. If the last bound be upon the lower part of the bore, the angle of the shot's departure will be increased; if above, diminished: these affect the length of range. If the last reflection be on either side, right or left, of the bore, the direction will be altered; and in every case the friction arising from these rubs will give the ball an irregular whirling motion, productive of inequalities in the resistance of the air, unless the rotation be at right angles to the direction of the projectile's flight. A high degree of windage may have been necessary when guns were imperfectly bored, and shot incorrectly cast; but proofs of the accuracy of both are now so rigid, that no allowance need be made for any errors of construction.

116. It is well known that the diameter of the shot is the datum from which the quantity of windage and the calibre of the gun were originally determined. Thus the diameter of the shot was supposed to be divided into 20 parts—one of these was allowed for windage, and the calibre of the gun made equal to the sum of that diameter and windage. Thus the diameter of a 24 lb. shot being 5.547 in., $\frac{1}{20}$ of it, or .277, was allowed for windage, and $5.547 + .277 = 5.824$ in., was the calibre of the gun.

This degree of windage was exclusively observed, till the proprietors of the Carron Company, availing themselves of the discoveries made in the ballistic experiments in favour of reduced windage, determined to apply the principle in the construction of their carronades; but as no alteration was made in the windage for guns (which should have been done by increasing the diameter of the shot), the Carron Company lessened the calibres of their new ordnance, to admit ordinary shot with reduced windage, by which great confusion and complications arose in the windage, not only of shot but of shells also. The shells for guns were of the same diameter as the shot, but carronade shells were smaller by about .1 of an inch. Now if carronades admit ordinary shot, there can be no reason why their shells should be smaller;—that is, there can be no reason why the windage should be greater for a shell than for a shot. This indeed is practically admitted by the windage allowed for mortars and howitzers, which is only .15 of an inch for all natures, excepting the $4\frac{2}{5}$ inch, which is .2 inch. The considerations which should be provided for in determining the degree of windage are, 1stly, the expansion of shot by a white heat; 2ndly, the incrustation of a little rust; 3rdly, the foulness of the cylinder in continued firing; and 4thly, the thickness of the tin straps for wooden bottoms.

117. The degree of expansion of shot by white heat is found to be about $\frac{1}{70}$ of the diameter of the shot for a 24-pounder; $\frac{1}{76}$ for a 16-pounder; and $\frac{1}{82}$ for a 6-pounder.

The calibre of a French 24-pounder is 5 inches, 7.625 lines, and the windage (= 1.5 lines) or about $\frac{1}{45}$ of the calibre of the gun.

The calibre of a French 8-pounder is 3 inches 11 lines, or 47 lines; and the windage is one line, or $\frac{1}{47}$ of the calibre of the gun.

If then the windage must be proportioned to the shot or gun, it may safely be decreased to $\frac{1}{40}$, or at most to $\frac{1}{35}$ of the calibre. These degrees of windage, and the corresponding diameters of balls, are shown in the following table; in the seventh column of which the present degree of windage is inserted to show the differences.

Nature of Gun.	Calibre of Gun.	Windage $\frac{1}{35}$ of Calibre.	Diameter of Shot $\frac{34}{35}$ of Calibre.	Windage $\frac{1}{40}$ of Calibre.	Diameter of Shot $\frac{39}{40}$ of Calibre.	Present Windage $\frac{1}{20}$ of Shot's Diameter.
Prs.	in.	in.	in.	in.	in.	in.
42	7.018	.2	6.818	.175	6.843	.33
32	6.41	.183	6.227	.16	6.25	.3
24	5.823	.166	5.657	.145	5.678	.27
18	5.292	.151	5.141	.132	5.16	.25
12	4.623	.132	4.491	.115	4.508	.22
9	4.2	.12	4.08	.105	4.095	.2
6	3.668	.105	3.563	.092	3.576	.17
4	3.204	.092	3.112	.08	3.124	.15
3	3.013	.086	2.927	.075	2.938	.14
1	2.019	·058	1.961	.05	1.969	.09

118. But it may be asked, why should the difference between the diameters of the ball and cylinder, which may be necessary to permit the shot to enter freely, vary with different cylinders? The impediments to its entrance bear no relation to the magnitude of the cylinder or ball, excepting the expansion of the latter by heat; and that, in the largest balls, is

only, on an average, $\frac{1}{70}$ of the calibre, or $\frac{1}{2}$ of the proposed windage $\frac{1}{35}$. The windage of carronades recognises this reasoning; for it is fixed at .15 of an inch for the three higher natures, viz. for 68, 42, and 32-pounders; .14 is allowed for 24-pounders; .12 for 18 and 12-pounders; and .15 is the allowance for the windage of all the higher natures of mortars and howitzers.

Suppose the windage of a 24-pounder carronade (.14 of an inch) were adopted for all the higher natures of ordnance; this in the 24-pounders would be $\frac{1}{43}$ of the calibre; but the French allowance is only $\frac{1}{45}$ of the calibre in the 24-pounders. Now no degree of foulness from quick firing, and no coating of rust that should be suffered to remain, or can well remain on a shot, is equal to .07 (about $\frac{1}{15}$) of an inch, which a windage of .14 would allow. If, therefore, we adopt .14 for the windage of heavy guns, we proceed upon a certainty in the improvement; but, perhaps, .13 of an inch is windage sufficient for all natures of guns and carronades, from the 68-pounder carronade to the 12-pounder inclusive; and downwards from the 9-pounder gun inclusive, .1 or .11 may be recommended.

This important reform would admit of a considerable saving of powder; for those velocities which at present require charges of $\frac{1}{3}$ the weight of the shot, might be produced with smaller quantities of powder. We should also have greater accuracy in practice, and consequently greater effect; but a series of experiments should be made, before this scale is altered, to ascertain whether shot of the proposed magnitude will roll freely home, repeating these trials with a great many new shot, and in a great many guns. Also trials should be made with the new shot heated to white heat, and with cold shot under the various circumstances of foulness from quick firing, and the incrustations of rust.

119. But whether a new scale of windage be adopted or not, it is important that shot be protected as much as possible from those vicissitudes which are continually operating to diminish their size, and consequently to increase the windage. Every possible precaution, therefore, should be used to keep shot from rust by painting or greasing them, and to keep them as dry

as possible—perhaps some better way of storing them might be found than throwing them promiscuously into the shot-lockers. When shot are cleaned, the rust should be carefully rubbed off, and not *beaten* off with hammers. This mode of cleaning shot, as practised in the arsenals, should be strictly prohibited; and also the more destructive method of putting a number of rusty balls into a rotatory machine, in which they are literally ground to very reduced magnitudes, and the windage prodigiously increased. It is useless to consider the effects produced by a minute regulation of windage so long as such practices continue. These precautions should be strictly observed, for if the degree of windage demand rigid and nice restriction, it is no less important to secure it from increasing, and this can only be done by carefully protecting the shot from all destructive agents and operations.

120. The preceding remarks (Arts. 114-119) on windage, having been brought under the consideration of the Master-General of the Ordnance in 1817, his Lordship referred the paper to the consideration of a select committee of artillery officers, who stated in their Report that "they were very desirous that experiments should be made with a view to ascertain to what extent the benefits which the author of this work had anticipated could be realised." The committee, therefore, proposed to the Master-General to be permitted to make a course of experiments on this subject, commencing with field artillery, and for that purpose recommended that a proportion of shot of various increased magnitudes should be provided. These measures having been approved, a course of experiments, founded upon the suggestions communicated by the author, was instituted accordingly.

After repeated trials with a 6-pounder, a 9-pounder, and a 12-pounder, at 300, 600, and 1200 yards, it was proved, "that, with charges of powder one-sixth less than usual, the larger shot, and smaller windage, produced rather the longest range."

Recourse was also had to the ballistic pendulum, to discover the proportional excess of momentum of the larger balls over the smaller; and the result, after a very satisfactory course of experiments, assisted by the scientific research and well-known mathematical abilities of the late Dr. Gregory of the Royal Military Academy, corroborated the trials by ranges, leaving no doubt of their accuracy.

In consequence of these trials the Committee fixed the quantity of windage for field guns at one-tenth of an inch, the same as had been suggested by the author (Art. 118).

Now it is clear that this improvement may either be applied to save one-sixth part of the quantity of powder provided for field-service, without diminishing the power of range, and consequently to economise, without detriment, the means of transport of ammunition; or the alteration may be applied to produce longer ranges, if this be preferred to the economical consideration. This preference has, very properly, been given, and the established charges adhered to accordingly.

121. A great collateral advantage has followed from this correction of windage. It was at first apprehended that the increased effects arising from the additional weight of shot and diminished windage would injure brass guns; but it is quite the reverse. With the reduced quantum of windage, guns are much less injured and will last much longer than formerly; and this has been so well ascertained that, in consequence of this correction, it is now proposed to abandon the wooden bottoms to which shot were fixed for the purpose of saving the cylinder, substituting for them the paper cap taken off the end of the cartridge. This being put over the ball is quite sufficient to keep it from rolling or shifting; whilst, by supporting or fixing it thus, the centre of the ball coincides with the axis of the cylinder, and the space for windage is reduced to a complete annulus, which admits of the percussion from the charge being equally received, and which prevents, or very much reduces, that injury, or indentation, which the cylinder receives when the ball touches it on the lower part only; for when the space for windage is all above, the action of the powder is exerted in a manner to produce that effect on the bore, near the seat of the ball, which is soon discovered in brass guns. With iron guns the expedient of putting a paper cap over the ball is of less importance as far as the preservation of the bore is concerned, iron guns being not so susceptible of injury as those of brass; but with respect to accuracy

of fire, the expedient will not fail to be productive of good effect, and it is important that it should be adopted in Naval Gunnery.

122. Experiments were also made for the purpose of ascertaining what advantage would arise from diminishing the windage of heavy iron ordnance in the manner proposed.

For this purpose larger shot, having various degrees of diminished windage, were fired from an iron 24-pounder, ship or garrison gun, with the service charge and with reduced quantities of powder; when it appeared so advantageous that the benefits arising from a reduced rate of windage should also be extended to the higher natures of guns, that the Committee recommended a diminution of windage to .15 of an inch for all natures of siege and garrison guns from the 12-pounder upwards.

The importance of this measure is perhaps sufficiently established by this decision; but as it is moreover necessary, in cultivating improvements in practical science, to consult the experience of actual service as much as possible, and to state any strong facts that may have occurred to guide and support us in such pursuits, it is important to exhibit here the opinion given by a late very gallant and highly distinguished artillery officer[a] in a letter on this subject, and to show upon what solid grounds that opinion was formed.

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[a] Lieutenant-Colonel Sir Alexander Dickson, K.C.B., who commanded the battering-train at all the sieges in the Peninsula.

"Most fully," says this officer, "do I subscribe to your proposal for diminishing the windage of our ordnance, by casting shot of a larger size than the present. Experiments are certainly necessary to ascertain how small this windage may be made with safety; but the regulation on this head, as practised by the French, affords an excellent scale to follow, and the rates you propose, of .13 inch for heavy ordnance and .1 inch for light ordnance, would, I am convinced, answer perfectly well, and be conducive to future accuracy.

"I remember a very convincing proof of the advantage of high shot, which I think is worth mentioning.

"The battering-train was assembled at Almeida previous to the siege of Ciudad Rodrigo, and there being a great deficiency of transport to bring forward the shot from the rear, it became a very important object to collect as many as possible from the shot belonging to the fortress, of which there was a considerable quantity, and of an infinity of calibres. In order, therefore, to obtain every shot that would answer, gauges of the full diameter of our 24-pounder bore were used, and every shot was selected as serviceable that passed through these gauges; so that many of the highest balls chosen would not, when heated, go into the gun; and this I ascertained by trial. When this

123. There could be no doubt of the advantages, in accuracy of practice, and either in economy of powder or in increase of effect, that would result from extending this improvement to naval guns; but here we were met by a very formidable obstacle, which, so long as it was permitted to exist, prevented the adoption of the improvement both in the naval and in the land-service artillery. This obstacle arose from our having adopted a nature of ordnance (carronades) of smaller calibre than guns of the same nature. From this extraordinary anomaly it resulted that shot for carronades, considerably above guage, were received in the arsenals and distributed in the service. Ships were actually sent to sea stored with new and perfectly clean shot, which, when required for use, were incapable of being introduced into the carronades, the incrustation of rust, which in those days was permitted to form itself on the shot in the racks, being frequently thicker than the amount of the windage.

The matter could not rest thus. Land-service shot of magnitudes corresponding to the windage, .15 of an inch (the quantity fixed by the Committee for siege and garrison ordnance), cannot be issued to the navy, because they cannot be used with carronades; and as this species of ordnance is frequently used in land-batteries also, two sorts of shot were rendered necessary for land-service. The only perfect remedy for these evils was to re-bore, or *ream out*,[a] all existing carronades to equality with the calibres of guns; to introduce one uniform system of windage for all natures of ordnance; and, consequently, to have but one scale for the gradations of shot.[b]

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operation had been completed, the selected shot were again tried with a gauge rather smaller than the ordinary 24-pounder shot gauge, and all that went through it were rejected as too small. The number of very high shot, however, amounted to two or three thousand; and as I know they were brought forward in the latter part of the siege, it has always been to the use of these shot that I have attributed the singular correctness of the fire in making the smaller breach; for although the battery was from 500 to 600 yards distant from its object, every shot seemed to tell on the same part of the wall as the preceding one. Now, this was not the case in firing with common shot at such a distance; for some struck the wall high and others low, although the pointing, as the best gunners have assured me, was carefully the same.

[a] A term for scraping out.

[b] The author proposed the measure to the late General Millar some time

Great objection was at first raised to the proposition, but it was soon afterwards carried into effect. The advantage thus obtained seems to have led to the practice of boring up the old guns to the next higher calibre; in order that, with a diminution of windage, the weight of metal projected might be increased. To the first of these objects the bored-up guns owe their success, and the favour with which the expedient has been received.

We shall, hereafter, inquire whether bored-up guns are efficient substitutes for new ordnance of the calibre to which they have been enlarged, and whether they are not still to be considered as imperfect guns which, however useful they may be as garrison artillery, should, except on particular occasions, be abandoned as naval ordnance.

124. The differences between the calibres of guns and carronades of corresponding natures are shown in the following table:—

Nature of Ordnance.	Gun.	Carronade.	Difference of their Calibres.
	Calibre, in.	Calibre, in.	in.
42-pr.	7.018	6.84	.178
32-pr.	6.41	6.25	.16
24-pr.	5.823	5.68	.143
18-pr.	5.292	5.16	.132
12-pr.	4.623	4.52	.103

To equalize the calibres of guns and carronades, therefore, the thickness of metal of the latter would only be reduced by half the differences in the last column of the preceding table,

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before the publication of the first edition of this work; and a letter, of which the following is an extract, forms part of a considerable correspondence which took place on the subject.

Extract of a letter from the late Major-General Millar to Sir Howard Douglas, dated Woolwich, March 2nd, 1817.

"I have well considered the subject, and agree with you that the only radical way to overcome the difficulty about windage is to bore up the carronades as you originally suggested. In forwarding your idea I have proposed to General Sir Thomas Blomefield to have one prepared in this way, to show the committee when they meet, as a matter of experiment, to ascertain the practicability of the proposition, and what may be the cost should the measure be generally adopted."

or about .07, or .08 of an inch. This trifling reduction of metal in the chase only might certainly be made without incurring any greater risk of bursting than at present: for it is a fact pretty well known, that although numerous accidents have occurred in action from the bursting of guns, yet carronades have never been known to fail; they break their breechings, draw their bolts, and split their sides, but do not burst; and this power of resisting their charges may be verified by referring to the original proof returns.

The weight of metal required to be taken out in order to enlarge the calibres of carronades to an equality with guns of the corresponding natures is very small; and though such diminution of weight is not in itself desirable, it cannot be objected to, considering the advantages to be derived from the equilization of windage.

125. When the first edition of this work was published, our arsenals were stored with vast numbers of carronades which it would have been wasteful to condemn and expensive to replace, while many circumstances were favourable to the measure of enlarging the calibres. First, it was found that the calibres of great numbers of carronades had become so enlarged by rust and wear that they could be rendered serviceable only by being reamed out; and, secondly, to enlarge them by boring, it was found unnecessary to transport them to the boring-houses, for machines were devised to perform the operation as they lay on the skids. It may be added that a change, which had been suggested by the late General Millar, had then been made in the chambers of carronades by forming there a hollow frustum of a cone, connecting the cylindrical bore with the hemispherical bottom of the chamber. The existing carronades were, therefore, bored up and chambered in this manner; but being still, in some measure, an imperfect nature of arm, their retention in the service was always viewed as a temporary measure, to be abandoned when more perfect ordnance could be substituted for them.

126. The chamber is a recess formed to contain the charge of powder, at the lower extremity of the bore of a piece of ordnance, in the direction of the axis and of less diameter than the bore. The conical, or gomer, chamber was proposed ex-

pressly for mortars, with a view of placing the centre of gravity of the projectile in the common axis of the chamber and bore; a position which, on account of a mortar having considerable elevation, the shell necessarily takes in descending on the conical surface. This puts the projectile, till it begins to move by the force of the powder, in contact with the conical contraction of the chamber, and allows the windage, in a plane passing through the centre of the shell perpendicularly to the axis of the bore, to assume a form correctly annular, consequently it enables the whole charge to act directly upon the projectile. But this is not the case when a piece of ordnance is in, or nearly in, a horizontal position, since then the projectile rests on the lower part of the bore, and the space between its surface and that of the bore takes a lunaric form, so that the axis of the charge does not pass through the centre of the projectile.[a] On this account, and because, in horizontal firing, the cartridge, on being rammed home, is apt, when reduced charges are used, to shift from its place in the conical chamber, the French reject the gomer form for howitzers, and make the chamber perfectly cylindrical. This is the case with the Paixhans gun, which is employed in the naval services both of France and of the United States, and the diameter of the chamber is equal to that of the bore of a gun of the next lower calibre.

Even the cylindrical chamber is attended with some disadvantages; it must be large enough to contain the full charge, and, therefore, when reduced charges are used, there will be a void space between the powder and the ball, which will affect unfavourably both the extent of the range and the accuracy of the firing.[b] The same space is occupied by a quantity of the

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[a] In order to remedy this defect, it is the practice on board the "Excellent" to set the shot well home with a wad, thus forcing it up the lower part of the conical surface, and, as far as possible, into the chamber.

[b] This is a fact well known to all who have had much experience in mortar and howitzer practice; and the author has found the defect so great, that in order to remedy it, he was long since led to insert, between the charge and the shot, a tompion, or piece of wood having the form of the unoccupied part of the chamber. This expedient appears to have been adopted in the French artillery service; and it has been ascertained that a tompion so placed has caused an increase in the initial velocity of the shot.—'Expériences d'Artillerie exécutées à Gavre, 1830-1840.' *Première partie*, ch. xii. sect. v., p. 61. Paris. 1841.

ignited fluid before the projectile is moved, and this increases the velocity of the recoil. It may be added that the ordinary sponge cannot, at the same time, clean the bore and the chamber of a piece of ordnance; and thus accidents from explosions are very likely to occur in using it. The evil may, in a great measure be obviated by the employment of a sponge of a conical form, nicely fitting the chamber and carefully used; the extremity of this entering the contracted space at the bottom of the bore, and being carefully turned on its axis, more completely removes the residuum of the charge. Yet the most efficient form for a broadside gun is evidently that in which the diameter of the bore is equal throughout its whole length, it being understood that there is a sufficient thickness of metal at the lower extremity of the gun to resist the charge.

127. With respect to the quantity of windage which may be considered proper for all natures of iron ordnance from the 12-pounder upwards, there cannot be any doubt that .15 of an inch, as already voted for siege and garrison ordnance, would be quite sufficient. Consulting experience on this head, we know, that .14 of an inch is the quantum regulated for the 24-pounder carronades. We are equally certain that this allowance has been very rigidly observed; for any departure from it would be an abandonment of the principle which renders carronades so efficient, with such small charges. We know also that the windage of all French iron ordnance, reduced to English measure, is only .133 of an inch; and the American windage is rather a copy of the French practice than of ours.

128. It has been apprehended that any diminution in the windage of naval guns would occasion more frequent accidents from bursting than at present. This opinion is founded upon the fact, that the action of the charge is increased by its taking place in a more confined space than when the windage is greater. To this it is only necessary to reply, that the danger cannot be greater than at present, if the economical tendency of the measure be taken advantage of as it ought to be; for satisfied, as appears from what has been said, that the velocities of shot, according to our present practice, are quite sufficient

(rather, indeed, too great than too little), and knowing that the increased action in the same charge when inflamed in a more confined space, would communicate greater velocity than with the present windage, we should, in reducing it, diminish also the charges to such quantities as should be proved by experiment to be capable of maintaining the practice given in our present tables, and put the savings of powder in the pockets of the public. In this way, guns would not be more liable to burst than with the present system, if shot be carefully proved.

129. The preceding observation introduces an important remark on the modes of *gauging shot.* With ring-gauges, shot not perfectly spherical may pass in one direction, or section, but not in all; and may therefore jam in rolling into the cylinder of the gun. Shot-gauges should therefore be cylindrical, as in the French service; for balls which roll freely through gauge-tubes, cannot possibly jam in the cylinder of the piece, if it be perfect.

130. What has been said on the subject of windage shows that very minute differences in the magnitude of the shot produce, by the variations in the quantity of windage, very great differences in the practice. It follows, therefore, that to preserve shot as much as possible in their primitive magnitude and condition, is no less important than the nice and very minute investigations from which the proper dimensions of balls have now been determined; and, consequently, that it is of vast importance to protect shot on board of ships from the destructive effects of rust. The ease, and trim, and sailing of vessels, do not admit of their shot being stowed, in large quantities, any where above the water-line or near the extremes. The great store of shot, therefore, must be in the lockers, where they are at present kept; and *there* it is impossible to prevent their becoming, in some degree, corroded by rust: but a sufficient number of balls for at least fifteen double-shotted rounds, should always be kept on deck. Now these balls being the first for use, should be preserved from rust as effectually as possible, and cleaned with every degree of care. Shot from the lockers should not be used till the deck shot shall have been expended, and the uppermost balls in the lockers should be frequently examined, cleaned from rust, and greased or painted:

by such means, together with frequent inspections, an enlargement by rust would be effectually prevented. This would contribute much to accuracy of practice; for, considering the prodigious resistance of the air upon the surface of a cannon-ball, moving with the usual service celerity, it is evident that the most minute protrusion or inequality on that surface must occasion a very irregular whirling motion, and consequently a great deviation from the intended direction.

131. V.—*The effects of the length of Gun on the velocity of Shot.*—It is known, both from theory and practice (Art. 64, and Art. 69, Note), that, with equal charges, and guns of equal weight, but of different lengths, the velocity of the shot increases with the length of the bore, but in a small proportion only—the velocity varying, as appears from experiments, in a ratio between the square and cube roots of that length; and again, experience shows that the velocity of the ball increases with the charge up to a certain amount, which depends on the nature of the gun; and that, by further increasing the charge, the velocity gradually diminishes till the bore is quite full of powder, the recoil always increasing with an increase of charge. These circumstances lead us to consider the relative merits of long and short guns.

The partiality in favour of short guns for naval service had its origin in a misapplication of some of Mr. Robins's maxims and observations. That distinguished civilian, by whom the theory of gunnery has certainly been much improved, having had no practical knowledge of artillery service (as he observes in the preface to his 'Proposal to Lord Anson,' printed in 1747), it is not surprising that the maxims which he deduced from his own investigations should frequently tend to a diminution of that accuracy and practical efficacy which persons better acquainted with the profession would have studied to increase.

132. Mr. Robins says, that neither the distance to which a bullet flies, nor its force at the end of its flight, are much increased by very great augmentations of the velocity with which it is impelled; and therefore that, in distant cannonade, the advantages arising from long guns and great charges are but of little moment. Another of his maxims is, that whatever opera-

tions are to be performed by artillery, the least charges with which the object in view can be effected should always be preferred.

In conformity with these maxims, Mr. Robins became a great advocate for reducing the length and weight of guns, for the purpose of enabling ships to carry ordnance of larger calibre.

Mr. Robins also asserts that the objections which attach to short guns in batteries on shore, viz. ruining the embrasures, hold not at sea, where there is no other exception to the shortness of the piece than loss of force, which, in the instances here proposed, is altogether inconsiderable; but this is a very erroneous conclusion, for with carronades it is frequently impossible to place them so that, when fired, the flash should not burn the rigging, or fire the hammocks in the barricade, without bringing the vent under the rail over the port, so as to expose the hammocks to the vent-fire, and the lock to injury when the piece is fired under depression. This is a very serious and a very well-supported contradiction of Mr. Robins's conclusion; and the danger and inconvenience arising from the shortness of carronades have been so often noticed, that it would be very expedient to make hereafter the 24, and particularly the 32-pounder carronade, a little longer in bore, and to add something to the flash-rim.

133. The advocates for the short-gun system support their theory by quoting the deductions from the ballistic experiments from which it appears that the superior velocity of shot discharged from long guns is reduced to an equality with the velocity of balls from short guns, after passing over certain spaces, and that the extreme ranges do not much differ; but the main principle which should govern our choice of naval guns is, to prefer those which, with equal calibre, possess the greatest point-blank range; and the practical maxim for using them should be, to close to, or within that range, and depend upon precision and rapidity of fire. This is the most simple and the most efficacious use of artillery: it avoids all the difficulty of determining, and the uncertainty in regulating elevation, and it is therefore of the greatest importance in naval gunnery.[a]

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[a] Dr. Hutton found that, with a gun of 20 calibres in length, the velocities continued to increase with the increase of charge till the latter amounted to

134. In the maxims above alluded to, the advantages arising from the superior accuracy of long guns at moderate distances appear to have been overlooked. From experiments carried on at Sutton Heath in 1810, it was found that the greatest point-blank range of a 24-pounder, whose length was 9 feet 6 inches, was, to the first graze, 275 yards, and the mean of three such ranges from the same gun was 248 yards; while the least point-blank range of a 24-pounder, whose length was only 6 feet 6 inches, was, to the first graze, 200 yards, and the mean of three such ranges with the same gun was 222 yards. The charge was the same (6 lbs.) in all the cases. Again, from the Deal practice in 1839, with 32-pounder guns of the same length respectively as the 24-pounders just mentioned, with equal charges (6 lbs.) and equal windage (.175), the elevation being 1 degree, the range of the longer gun was 853 yards, while that of the shorter one was only 734 yards. A superiority of range with the longer guns does not always take place, but the above circumstances will serve to show that, at moderate distances, a long gun might be laid point-blank, while a short one might require an elevation of half a degree.

135. A comparison of the point-blank range of Sir William Congreve's 24-pounder with a gun of equal calibre and of the old pattern, appears at first sight to militate against the above conclusion; but on examination it will be found that this is not the case. The first of these guns, which weighs 40½ cwt., is 7 feet long, and, from its great thickness about the chamber, the *dispart*[a] subtends an angle of not less than 5 degrees. The other, which weighed 50 cwt., was 9 feet 6 inches long. The windages were equal, and the charges one-third of the weight of the shot; and from experiments made at Sutton Heath in 1813, the point-blank ranges of the Congreve gun varied between 505 and 640 yards, while those of the heavier gun were about 370

⅞ of the weight of the shot, and occupied ¼ of the length of the bore; after this the velocities decreased. With a gun of 15 calibres in length, a charge equal to ½ the weight of the shot, and which occupied .275 of the length of the bore, gave the greatest velocity.

[a] The difference between the semidiameter of the gun at the base-ring and at the swell of the muzzle. This, the length of the gun being the radius, is the tangent of an angle varying generally from 1° to 2½°, which the line of metal makes with the axis of the bore.

yards. The Congreve gun was also tried with two 24-pounders of Sir Thomas Blomefield's construction, one 8 feet and the other 7 feet 6 inches long, and weighing respectively 43 cwt. and 40 cwt.; and at point-blank ranges, the first graze of each of these two last was between 370 and 400 yards. To Sir William Congreve certainly belongs the merit of having first proposed a different distribution of the metal in his guns, adding much to the part about the place of the charge, and diminishing the quantity in the chase. He also placed the trunnions farther back than they were in the old ordnance of a corresponding nature; but his assumption that "the propelling or reacting power of a piece of ordnance may be increased by augmenting the quantity of metal about the charge, though a greater quantity be taken from the other parts, and consequently that a lighter gun may have a greater propelling power than a heavier one, by a judicious distribution of the metal,"[a] is not supported by facts. In the extreme ranges of the shot, the advantage was invariably in favour of the 50-cwt. gun; and with elevations of 2½ and 5 degrees, at which trials were made, the excess of graze was sometimes on the side of the Congreve gun, and sometimes on that of the others. The presumed superiority of the former at the first grazes, when fired point-blank, is ascribed to the *liveliness* of its recoil and to the preponderance of metal at the breech, by which, in being fired, the muzzle of the gun is thrown up. (Captain Simmons, 'A Discussion on the present Armament of the Navy,' p. 10.)

136. With respect to Mr. Robins' maxim (Art. 132), that the force of a ball, at the end of its flight, is not much increased by great augmentations of the velocity with which it is impelled, it may be observed that, if the force of impact alone were the object, in naval actions, the full charges of powder need seldom be used. A charge equal to one-sixth of the shot's weight would be sufficient to drive a ball from any large gun through the side of a ship at 1100 yards; but with this small charge the gun would require twice as much elevation to produce such a range as would be necessary with the full charge, and thus the accuracy of the fire would be sacrificed. To ensure this great object, the

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[a] See 'A concise Account of the new Class of 24-pounders proposed by Sir William Congreve,' 1831; *Introd.*, p. i.

charge should be such as will allow the elevation to be the least possible; nor should reduced charges be employed unless the action take place within point-blank range or at close quarters.

The superiority of long guns over short ones, in respect of extent of range, is so considerable that a well-commanded vessel fitted with long guns, will, by keeping at a distance just within the range of such guns, have great advantages over a vessel of superior rate, if fitted only with short guns of equal and even larger calibre.

137. The preference which, during the war between 1793 and 1815, was given to guns of reduced lengths, less weight relatively to that of the shot, and to comparatively low charges of powder, is, even now, not wholly abandoned. The cause of the preference at the time lay in the practice which then prevailed of pointing guns by the *line-of-metal,*[a] as it is called, which, on account of the dispart, makes a greater angle with the axis of the gun as the latter is shorter; thus causing the axis to be more elevated, and consequently the range to be greater than when a longer gun is used. In former editions of this work the author objected to this cause of preference, on the ground that the greater elevation induces less accuracy in the practice; and in fact the method of pointing by the line-of-metal is now abolished in the British artillery, the tangent-scale being generally introduced; the *ligne de mire,* however, is still, or was till very recently, retained in the French naval service, the artillerymen allowing for the angle of the dispart according to the elevation or depression of the piece.

138. In determining the preference which should be given to guns of different lengths, weights, and calibres, and in estimating the charges proper for them, the most important point to be kept in view is the degree of probability of striking an object at a distance which allows the projectile to retain sufficient force for producing the most destructive effects.

139. Exclusive of errors in pointing and laying guns, and those caused by occasional variations in the state of the atmosphere, the irregularities which are produced while the shot is in the bore, by friction, rotation, windage, and the imperfect influ-

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[a] A line drawn from the top of the base-ring to the top of the muzzle.

ence of the charge, with many other circumstances, combine, in unknown and variable degrees which theory cannot determine, to affect the probability of striking the object aimed at; and it is only by extensive experience, or by reference to tables exhibiting the mean results of numerous trials under many different circumstances, with all the natures of ordnance in use in the service, that correct judgments can be formed with respect to the probable deviation of the projectile from the vertical plane in which it should move, or the errors, in excess or defect, in the extent of the range, so that the proper means may be used to obtain the requisite accuracy.

M. Piobert, in his valuable work entitled 'Traité d'Artillerie' (tom. ii. p. 270), has made many useful observations on the lateral, as well as the longitudinal, deviations of projectiles; and he has formed, from numerous experiments carried on during several years with various natures of ordnance, and both with solid and hollow shot, some interesting tables exhibiting such deviations, together with the probabilities of striking targets or other objects, of different superficial extent and at various distances. Thus, with 24, 16, and 12-pounder guns (French), at the distance of 656 yards, the charges being one-sixth of the weight of the shot, the average number of hits in 100 rounds were respectively 6.2, 4.9, and 4.7; while, with the same guns and charges equal to one-third of the weight of the shot, the number of hits per cent. in the same object and at the same distance were 8.6, 5.6, and 7.2. On these tables, in part, the author has founded his conviction that the best means of obviating both the longitudinal and lateral deviations is the employment of heavy guns of their respective natures, with full charges, at low elevations, the shot being solid and accurately formed, and the windage as small as possible.

140. Of the two kinds of error, the lateral deviation is by far the most pernicious in naval gunnery; for, in this respect, beyond certain limits the shot would be wholly wasted; while, with respect to the error in extent of range, there is a considerable probability that it may be redeemed by the production of some secondary effect.

The probability of striking an object fired at depends on its superficial magnitude (in a vertical plane perpendicular to the plane of fire). With like guns the probability of striking, at different distances, diminishes rapidly as the distance increases; but against bodies of various magnitudes, at the same distance, the probability increases with the surface when the latter is small (not exceeding 3 or 4 feet square), while it increases in a much higher ratio than the surface when this is great. There is, moreover, a magnitude (the length of a side of a ship, for example) which will exceed by two or three times the extent of any error arising from the lateral deviation at the given distance, and then such an object cannot be missed, provided the error in the length of range should not cause the trajectory to intersect too high or too low, a vertical line passing through the object.

141. When an object moves with great velocity in a trajectory having small elevation above the horizontal plane (the level of the sea, for example), it is evident that, whether the shot fall short of or go over the point aimed at, great errors in the extent of range will correspond to very small errors in a vertical direction at the place of the object; and that the latter errors are so much less as the elevation of the gun is less, or as the trajectory is less incurvated. Hence there may be considerable differences in the length of the range, and yet a great probability that the shot will be intercepted by some part of the body or rigging of the ship, or other object fired at.

If the first graze of the shot falls short of the object, the angle between the horizontal plane and the descending branch of a trajectory having small elevation, is more favourable to the ricochet than the greater angle formed by a more elevated trajectory would be; and it is manifest that a shot, moving in a trajectory of the first kind, might take effect on the hull or rigging of a ship which in the other it might entirely miss. Again, if the first graze should fall beyond the object, the shot whose path is least elevated, if it pass over the hull of a vessel, will scarcely fail to strike some part of the rigging; while one whose trajectory is higher would pass above the whole. The like observation will hold good with the equal ranges obtained from a long and a short gun; the latter, which has greater elevation than the former, describing a higher curve. These two cases suppose the actual elevation not to be disturbed by the floating motion; but it is evident that an error of this nature must, in general, be to the disadvantage of the shorter gun.

142. Ricochet firing, at elevations under 3 degrees or 3½ degrees, with shot from guns near the level of the water, may take place at distances not exceeding 600 yards with considerable effect. But in this practice it is essential that the angles of graze should be as small as possible; therefore great charges should be used, and the elevation of the gun should not exceed 2 degrees. The penetrating power of shot fired à ricochet is, however, much inferior to that of shot fired directly; and therefore in this respect, as well as for correctness of fire, the direct practice is, to a certain extent, the most advantageous.

In firing to windward, the steep sides of the waves are unfavourable to practice; for shot striking those sides do not rise, or they soon lose their velocities; also ricochet firing against boats will be found most effective when the water is smooth.

Table VIII., Appendix B., exhibits the results of the ricochet practice with solid and hollow shot from on board the "Excellent," in 1838. The extents of the ranges were such as were made before much deflection took place.

143. It has long been imagined by many practical artillerists that the ranges of shot, when fired over a broad valley or over water, are less in extent than when fired over a level or a gently undulating ground, the charge and nature of the ordnance being alike in both cases; and M. Piobert, in his 'Traité d'Artillerie,' has given a table of the comparative ranges of shot in such circumstances, which appear to confirm the opinion. This officer, in endeavouring to explain the cause of the difference in the ranges, suggests that when a shot is fired point-blank, or at a low elevation, over ground which is either level or which rises in the direction of the line of fire, the air driven off in every direction about the ball in its flight must be condensed between its path and the ground; and this condensed air reacting against the ball may prevent it from descending so rapidly as it descends when the repelled air is enabled to escape freely: thus it may be that the ranges are longer when the fire is made over a level plain or gentle eminences than when it is directed across a deep valley, which affords room for a greater diffusion of the air.

When shot is fired over the sea, the convex surface of the water, which is depressed in every direction about the gun, and the absence of such inequalities of surface as exist on land, readily permit the escape of the air under the trajectory. Hence there is little or no reaction from below against the shot; and to this circumstance M. Piobert ascribes the supposed inferiority of the ranges over sea compared with those over land.

But from experiments made at Gavre in France, in 1843, it was found that, *cæteris paribus*, the ranges at sea are very nearly equal to those obtained on land. The general opinion of the inferiority of the former appears therefore to be unfounded; and it is observed, by the writers of the 'Report' on those experiments, that the ranges stated in the work of M. Piobert, which are in favour of that opinion, have been taken from an old work on gunnery, and are not the results of any known experiments.

144. The ordnance employed at Gavre to determine the extent of ranges over sea and land, and also to ascertain the amount of the longitudinal and lateral deviations of projectiles in naval gunnery, were a long 30-pounder gun, weighing 61 cwt. 1 qr. 4 lbs., the diameter of the bore being 6.484 inches, and the windage .1772 inch, and a canon-obusier of 80 (*liv.*), weighing 72 cwt. 3 qrs. 16 lbs., the diameter of its bore being 8.799 inches, and the windage .0945 inch. Solid shot only were projected from the former, and hollow shot with wooden bottoms from the latter. The ordnance was placed in a barge (*ponton*) above 60 feet long and 24 feet wide, which was moored at convenient stations, and, in each day's practice, twenty rounds were fired. The lines of fire were directed from west to east, and allowance was made for the oscillations of the vessel. With the 30-pounder solid shot, charge 11 lbs. .5 oz., and elevations varying from 3° 5′ 48″ to 6° 50′ 2″, the ranges over the sea varied from 1453 yards to 2229 yards, and over land from 1355 yards to 2247 yards. With the canon-obusier, No. 1, hollow shot, and charge 7 lbs. 11.6 oz., and elevations varying from 4° 46′ 17″ to 10°.4′ 50″, the ranges over the sea varied from 1369 yards to 2470 yards, and over land from 1361 yards to 2208 yards. The mean of the longitudinal deviations of the 30-pounder shot was 132 yards, and the greatest 176 yards of

the canon-obusier; the mean deviation was 87 yards, and the greatest 323 yards. The mean lateral deviation of the 30-pounder from a vertical plane passing through the axis of the gun was 37.5 feet, and the greatest 49.8 feet; of the canon-obusier the mean deviation was 48.6 feet, and the greatest 73.8 feet. In these experiments the lateral deviations were also referred to a line of mean direction so situated that the sum of all the deviations to the right of it was equal to the sum of all the deviations to the left of it; when it was found that the greatest deviation of the 30-pounder shot from this imaginary line was 31.8 feet, and the least 18.7 feet; the greatest deviation of the hollow shot was 66.2 feet, and the least 16.4 feet. The extreme lateral deviations appear to be, in some cases, more than twice as great as the mean deviations; and this may be accounted for partly by the windage of the ordnance, and partly by the wind acting at times across the line of fire.

145. The near agreement in most of the ranges over land and sea, in these experiments, appears to be at variance with the results of experiments made on land and at sea with the artillery employed in the British service. On comparing the ranges over the land, from the experiments at Deal in 1839, with those over water, from the experiments on board the "Excellent" in 1838, the nature of the ordnance, the charges, &c., being alike, there were found to be only three in which the ranges over the sea exceeded those over land. In all the others, the ranges over land were the greatest. In many of them the difference was as much as one-tenth, and in some it amounted to one-sixth of the whole range. This is in some measure due to the height of the guns above the ground, in the Deal experiments, being greater than that of the guns of the "Excellent" above the water; but the cause of the discrepancy, whatever it may be, requires to be investigated by experiments purposely conducted, with precisely the like natures or ordnance and with equal charges, in order, should the variations be found to be only such as may be ascribed to accidental circumstances, that the same tables of artillery practice may with confidence be used in both services.

146. In estimating the probabilities of correct firing, all the sources of error should be anticipated and allowed for; and

it may be observed here, that it is near the further extremity of the range that the velocity of the lighter and smaller kind of projectile is most diminished, consequently, that, in this part of the trajectory, the causes of the two kinds of deviation are most effective in producing them. Hence it follows that the two kinds of deviation may be much diminished by the employment of those guns which, with the least elevation, have the power of throwing solid shot, with their momenta nearly unimpaired, to the greatest distance; and this fact is what it was intended in the present article to establish. Force may not always be deficient when missiles are projected from the shorter and lighter nature of gun, yet the probabilities of striking objects at considerable distances are much higher when ordnance of a contrary description is used.

This subject will be further considered in treating of hollow shot, and of the lighter natures of ordnance employed in the British service.

147. The great disadvantages we suffered from the numerous frigates of the inferior classes which we had in our navy during the war (1793 to 1814) were severely felt. From not having had a sufficient number of frigates capable of bearing the nature of armament which was likely to be opposed to them, we were obliged, in common prudence, to employ two vessels where one of superior force might have answered better. Frigates capable of bearing the 8-feet 24-pounders, or 32-pounders of 50 cwt., are certainly vast and expensive ships; but they perform their service at a cheaper rate, and in a much more certain and creditable manner to the nation, than two vessels of very inferior rate. The full service of two ships acting against traders and privateers cannot be effected without frequently parting company; and then the honour and interest of the flag they bear are at risk, from exposure to unequal combat; whilst the enemy's force, against which these two inferior vessels may have been sent, remains always entire. Two ships, once divided, may be beaten in detail by a vessel by no means a match for both together; but the honour of the large ship is always secure, and the chance of capture remote. She *may* meet a superior; but if so, to take her would be creditable—to yield, no disgrace. A fleet of line-of-battle ships must keep together, resisting all

temptations to chase single ships; but two vessels, sent to cruise on predatory service, will only exert half their powers by keeping company; for this restrains separate exertion, halves the chance of meeting an enemy, and when one is discovered, there always ensues a chance of the two vessels parting company in the chase.

148. All the American frigates of the large class during the war with this country in 1812 and 1813 carried long guns. The "President" had, on the main-deck, 24-pounders (length 8½ feet, weight 48½ cwt.); on the quarter-deck and forecastle, 42-pounder carronades (length 4 feet 4 inches); both English calibre. The "Chesapeake" mounted on the main-deck, twenty-eight 18-pounders (length 7 feet 8 inches, weighing 39 cwt. 1 qr.), and twenty 32-pounder carronades, nearly of British pattern. The "Essex," on the contrary, was armed almost exclusively with carronades; and the effect of these we shall examine hereafter.

149. Much of the reasoning contained in the preceding articles attaches to carronades. At close quarters, they are a formidable species of ordnance; but at long ranges, on account of the inferiority of their charges, they are no match for long guns, even of smaller calibre (compare the ranges of shot from carronades with those obtained from other ordnance in Tables V. and VI., Appendix B); and any vessel fitted exclusively with carronades might, undoubtedly, be destroyed or captured by a vessel of very inferior rate mounting long guns, if her commander knew how to avail himself of the great superiority of his weapons.

150. The very mortifying situation in which the gallant Sir James Yeo found himself, in September, 1813, on Lake Ontario, shows the danger of the carronade system of armament. Sir James states, in his letter of the 12th September, "the enemy's fleet of eleven sail, having a partial wind, succeeded in getting within range of their long 24 and 32-pounders; and, having obtained the wind of us, I found it impossible to bring them to close action. *We remained in this mortifying situation five hours,* having only *six guns in the fleet that would reach the enemy.* Not a *carronade was fired.* At sun-set a breeze sprung up from the

westward, when I manœuvred to oblige the enemy to meet us on equal terms. This, however, he carefully avoided."

In Sir James Yoe's despatch of the 15th November, he complains in strong terms of the want of long guns in the Lake Erie squadron.

Captain Barclay states, in his letter of the 12th September, 1813:—"The other brig of the enemy, supported in like manner by two schooners, and apparently destined to engage the 'Queen Charlotte,' kept so far to windward as to render the 'Queen Charlotte's' 24-pounder carronades useless, whilst she and the 'Lady Prevost' were exposed to a heavy and destructive fire from the 'Caledonian' and four other schooners, armed with *long* and *heavy guns.*"

The action of the "Phœbe" with the American frigate "Essex" illustrates and confirms, though happily in a reverse sense, all that has been said on the serious dangers of the carronade system of armament, opposed to a vessel, fitted with long guns, commanded and managed as the British frigate was. The "Phœbe" mounted long 18-pounders on the main-deck, and 32-pounder carronades on the quarter-deck and forecastle. The "Essex" had forty 32-pounder carronades, and only six 12-pounder guns (length 6 feet $8\frac{7}{10}$ inches). Captain Porter, of the "Essex," says—"The 'Phœbe,' by edging off, was enabled to choose the distance which best suited her long guns, and kept up a tremendous fire, which mowed down my brave companions by the dozen." Again—"The enemy, from the smoothness of the water, and the impossibility of reaching him with our carronades, was enabled to take aim at us as at a target; his shot never missed our hull, and my ship was cut up in a manner which was perhaps never before witnessed."

This action displayed all that can reflect honour on the science and admirable conduct of Captain Hillier and his crew, which, without the assistance of the "Cherub," would have insured the same termination. Captain Porter's sneer at what he calls the "respectful distance" the "Phœbe" kept, are in fact acknowledgments of the ability with which Captain Hillier availed himself of the superiority of his arms; and this brilliant affair, together with the preceding facts, cannot fail to dictate the necessity of abandoning a principle of armament exposed to such perils; and to teach the importance of adapting the tactics of an operation to the comparative natures and powers of the arms.

151. The defects of carronades, and the danger of employing this imperfect ordnance, are now generally felt and admitted; that ordnance, however, rendered important service in its time, for it taught us practically the great value of a reduced windage, the advantages of quick firing, and the powerful effects produced at close quarters by shot of considerable diameter striking a ship's side with moderate velocity. Let it be observed, also, that the carronade-armed "Glatton," under Captain Trollope,[a] proved victorious over a superior force by dint of the heavy blows inflicted at close quarters; while the defects of the same nature of ordnance, in long ranges, on the occasions mentioned in the preceding article, exposed the gallant commanders of the British ships to the severest mortifications, and the naval service of the country temporarily to reproach. The like reproach, but in a still more serious degree, will undoubtedly be incurred if that imperfect arm be still retained in the British service, and its place be not supplied, at least in large vessels, by a superior nature of ordnance. In the French navy, the carronade may be said to exist only in name; for the *carronade à tourillons* is in reality a powerful gun.

152. VI.—*On Recoil and Preponderance.*—It has been found, by suspending a gun in the same manner as the block of a ballistic pendulum is suspended, that, on attaching weights to the piece in order to diminish its recoil, the initial velocity of the shot discharged was the same as when the gun was allowed to recoil to its full extent; and even when the recoil was entirely prevented, the velocity of the shot was unaltered. It is evident, however, that some uncertainty in artillery practice must exist in consequence of the irregularity of the recoil; and it was at one time supposed that, by mounting a gun on a non-recoil principle, the shot might be projected to greater distances, but the experiments above alluded to serve to show that this is not the fact. A formula has been given (Art. 72), by

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[a] James' 'Naval History' (1847), vol. i. p. 335.

which the velocity of the recoil may be computed, and it is there shown that the motion of the shot must be very slightly affected by the recoil if the latter were steady; but it is evident that an imperfect equilibrium on the trunnions, or an accident happening to the gun or its carriage at the moment of firing, such as a bed breaking, a quoin flying out, or a truck coming off, will sensibly affect the length as well as the direction of the range.

The following table contains the results of some experiments made to determine the extent of the recoil of sea-service iron guns on ship-carriages, upon a horizontal platform.

Shot and Charges.	Elevation.	32-pr.		24-pr.		18-pr.	
		ft.	in.	ft.	in.	ft.	in.
1 shot, charge $\frac{1}{3}$	2°	11	0	11	0	10	6
2 shot, charge $\frac{1}{3}$ of a single shot	4°	19	6	18	6	18	0
2 shot, charge $\frac{1}{4}$ ditto	7°	11	6	12	0	12	0

In an experiment made in 1848 at Woolwich, on a platform inclining 2½ degrees, two hollow shot, weighing together 112 lbs., were projected with a charge of 5 lbs. of powder from an 8-inch gun, weighing, with its sea-service carriage, 78 cwt.; the initial velocity must consequently have been about 709 feet per second, and the velocity of the recoil (by the formula Art. 72) 9 feet per second. Now a 32-pounder gun, weighing with its carriage 65 cwt., projects a solid shot, the charge being 10 lbs., with an initial velocity of 1600 feet per second, and the velocity of recoil is 7 feet per second. By observation, the recoil of the 8-inch gun, on the inclining platform, was 14 feet, and that of the 32-pounder 9 feet; and these extents are, as by theory they ought to be, nearly proportional to the squares of the velocities of recoil.

153. On the discharge of a gun, the unsteadiness of the recoil and the *jump* of the piece by the striking of the breech on the quoin or on the elevating screw, are greatly affected by what is called the *preponderance*, an element which depends much on the position of the trunnions. If these are placed too far forward, the projection of the gun in a ship's port may be too small, while the breech is rendered too heavy; if too far back, the muzzle droops on firing, and violent shocks are produced

on the quoin or screw; and these effects are much aggravated when the common axis of the trunnions is below that of the bore. In order that such inconveniences may be avoided as much as possible, the pressure of the breech, when the axis of the bore is horizontal, is usually made equal to one-twentieth of the whole weight of the gun. The preponderance of a piece of ordnance is a very important feature in gunnery, on account of its effects in producing shocks, and in rendering the practice inaccurate; and the amount of it is now made a subject of a particular proof.

154. It is remarkable that, in the experiments which were carried on at Shoebury Ness, in June, 1852 (Art. 193, p. 152), the higher elevation of the ordnance always gave the greater recoils, though the charges and weight of the shot were equal and the guns the same. At an elevation of 32°, for example, the recoil was 4 feet 1 inch, which is nearly double the recoil (2 feet 2 inches) at an elevation of 28°. The circumstance is so contrary to what should take place on mechanical principles, if the platform were, in all the experiments, equally inclined, that it must be ascribed to some particular effect produced in the platform itself. May not a gun fired at a considerable elevation acquire a jumping motion up and down, thus shaking the carriage irregularly, and making it recoil on the slides more than it would at a less elevation?

With respect to the strain produced in the carriage of a gun by the discharge of shot, it may be observed that experiments made in France show that the initial velocity of the shot, and, consequently, the velocity of the recoil, increases with the elevation of the gun; and this is sufficient to account for the increase of the strain with the increase of the elevation. At 10° of elevation the strain is greater than, with double the charge, it is when the axis of the gun is horizontal. It is evident, therefore, that, in order to have the strain as little as possible, the lowest elevations should be given which will afford the required range. The strain on a gun is supposed to vary with the sine of the elevation.

155. VII.—*The Effects of Wads.*—Experience has proved that different degrees of ramming, or different dimensions of wads,

make no sensible alteration in the velocities of the ball as determined by the vibrations of the suspended gun. Stout, firm junk-wads,[a] so tight as with difficulty to be rammed into the gun, have been used: sometimes they were placed between the powder and ball, sometimes over both, but no difference was discovered in the velocity of the ball. Different degrees of ramming were also tried without wads. The charge was sometimes set home without being compressed, sometimes rammed with different numbers of strokes, or pushed up with various degrees of force: but the velocity of the ball remained the same. With great windage, the vibrations of the pendulum were much reduced, although tight wads under the shot were used; so that wads do not prevent the escape of the inflamed powder by the windage, nor under any circumstances occasion any sensible difference in the velocity of the ball.

156. It follows that tight wads should not be used in action, because they increase the difficulty of loading, without doing any good: they may be used in loading guns before an affair; but, with a view to quick firing, the wads used in action should be no tighter than is necessary to prevent the charge from shifting while the gun is run out. Occasionally the operation of ramming home a tight wad has taken up two or three minutes. This is a very serious and unnecessary waste of time. When a wad is so "high," or tight, as to require the force of a *blow*, instead of a ***push***, it spreads from the stroke, and consequently becomes harder, and more difficult to be moved. Care should therefore be taken to provide easy wads, correctly gauged, and made so as to spread under a pressure sufficient to retain the charge from shifting, upon being set up with a smart blow.

157. From experiments made in France (1842-1844) with a 30-pounder and a 12-pounder, long guns, projecting solid and hollow shot, with and without wooden bottoms, it appears that, generally, the charges being equal, the cartridge which has the

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[a] Wads are generally made of rope-yarn rolled up in a cylindrical form; they are usually placed immediately on the shot, and they fit the gun rather tightly, so that they may prevent the shot from shifting its place or rolling out. A grummet wad consists of a piece of rope formed like a ring, the external diameter being equal to the calibre of the gun.

greater diameter causes the shot to have a greater initial velocity. This, however, was not always the case; and it was found that, with the 30-pounder gun, the initial velocity was the greatest when the diameter of the powder within the cartridge was 5.95 inches (Eng.), and, with the 12-pounder gun, 4.33 inches (Eng.). In 1845 the diameters of the *mandrins* (moulds) used in making cartridges for the French canons-obusiers were regulated conformably to the above results. (See Arts. 225, 226.)

It may be observed that the velocities were greater when the hollow shot had wooden bottoms than when they had not, in the ratio of 1 to ·98 nearly.

158. From experiments made on board the "Excellent" in 1847, it was found that a grummet wad is more efficient than one of junk, in preventing the cartridge from shifting its place in the bore when the guns (a 32-pounder and a 10-inch and 8-inch shell gun) were run out with a strong jerk. From the experiments alluded to, it must be inferred that, both with junk and grummet wads, the cartridge is more liable to change its place in the guns with conical chambers than in those which have none; and the fact affords strong evidence of the disadvantages of using chambered ordnance (see Art. 126) for broadside shot-guns in quick firing, the chambered ordnance requiring the introduction of a wad over the cartridge before the shot is put in, whereas in a cylindrical bore the shot may always be set home in immediate contact with the cartridge.

Several valuable experiments have recently been made by Major Mordecai, of the United States' artillery, on the deviations of shot from the object when wads of different kinds were employed: the gun being a 14-pounder, the windage .143 inch, and the charge 6 lbs.

These deviations were found to be the greatest when junk wads were used, whether one wad was placed on the ball only, or one on the powder and another on the ball. The deviations were also considerable when hay wads were used; and they were the least when grummet wads were employed, whether one only was placed on the ball, or there was placed one on the powder and another on the ball. The deviation was rather greater when a sabot was next to the powder, and a grummet wad over the ball.

159. With respect to small arms, it is found that wads of different kinds have different effects upon the projectile by modifying the action of the charge; and from experiments which have been made in the United States with a musket-pendulum, the following results have been obtained.

With a charge equal to 77 grains, a musket-ball wrapped in cartridge-paper, and the paper crumpled into a wad, the velocity of the ball was 1342 feet; and when two felt wads, cut from a hat, were placed on the powder with one on the ball, the velocity was 1482 feet. With a charge equal to 140 grains, two felt wads being placed on the powder and one on the ball, the velocity was 1525 feet; when cartridge-paper was used, crumpled into a wad, the velocity was 1575 feet; and when one wad of pasteboard was placed over the powder with another on the ball, it was 1599 feet. These results seem to indicate that wads made of the stiffest materials are the most advantageous.

160. VIII.—*Penetrations of Shot into Materials.*—The experiments which have been made to determine the penetration of shot into different substances, have led to very various and often discordant results, arising, no doubt, from inequalities in the consistency, or in the degrees of elasticity, of the materials, but all of them tend to confirm the laws which have been stated in Art. 82. In that article there is given a formula (*c*) for computing the depth of the penetration of shot into oak timber; and Table XXI., Appendix B, contains the computed amounts of penetration, the shot being fired from different natures of French ordnance and at different distances of the gun from the object. The table is abridged from the 'Aide Mémoire Navale,' Paris, 1850; the weights and measures being expressed in English denominations. The velocities at the time of impact are computed from the formula (*c*), Art. 63; and the depths penetrated, from the formula (*c*), Art. 82.[a] M. Piobert, in his

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[a] In order to have the penetrations of shot into other media, the numbers in the table must be multiplied by 1.64 for firm earth, consisting of sand and clay in equal portions; by 1.3 for sand and gravel intermixed; by 3.21 for earth newly raised, and .41 for sound masonry. Experiments in France have shown that wood, in consequence of its elasticity, recovers nearly its original volume after being penetrated, and thus closes up the cavity formed

'Traité d'Artillerie,' has given Tables professing to contain the results of experiments made in France on the depths of the penetration of shot into masonry, wood, earth, and water, from guns of different calibres, with various charges of powder, and at different distances from the object struck.

161. In order to determine the circumstances approaching as nearly as possible to those which may occur in the naval service, many experiments were made in 1838 on board of H. M. S. "Excellent," under Captain Sir Thomas Hastings, by firing both solid and hollow shot against the "Prince George" hulk, which was moored at the distance of 1200 yards. The guns were laid at small angles of elevation, generally between 2 and 3 degrees, except when the shot was intended to strike the hull after ricocheting on the surface of the water, when the elevations were 1 degree; and the following is a brief statement of some of the most remarkable effects which were produced. It should be observed that the shots often entered the side of the hulk diagonally, and pierced or splintered parts of the structure at different places in the interior; the depth penetrated is expressed by the sum of the distances in solid wood, which the shot passed through or deeply furrowed.

Several 18-pounder shot, with charges of 6 lbs. of powder, penetrated to depths varying from 21 to 33 inches, according to the state of the wood, and there stuck. The effects produced by 32-pounder shot were much greater; with a charge of 6 lbs. one passed through the ship's side diagonally in indifferent wood (30 inches), then, continuing its course, it struck a knee on the opposite side of the ship, making one large splinter, and, after rebounding, it struck the combings on the side which it first entered. Another, with an equal charge, passed through the bow portsill, and struck upon the iron knees of the cable-bitts, which it broke in two; the standard of the bitts was also shaken to pieces. The shot itself was broken in pieces, and the fragments cut the chain-cable in two places. With charges of 8 lbs. the 32-pounder shot penetrated to depths varying from 22 to 48 inches.

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by shot on striking it. Experiments have also shown that a projectile remains embedded in oak only when it has penetrated to a depth nearly equal to its diameter.

Two 32-pounder shot fired singly with charges of 10 lbs. 11 oz., entered at the same place, so as to render it impossible to distinguish their separate effects; together, after penetrating through the ship's side in firm wood, they shattered a sound wooden knee: they then passed across the deck, cutting down a wooden stanchion 6 feet long and 8 inches square under the beam; this they shattered in pieces, causing many splinters, six of which were very large, and one of them swept the deck as far as the pumps. One of the two shot penetrated its own depth in sound wood on the opposite side of the ship, and there stuck; the other struck and splintered a port on the opposite side, after which it rebounded against the side which it first entered.

A 68-pounder shot (solid), with a charge of 10 lbs., penetrated diagonally through an oak chock of sound wood, which it shattered to pieces, flattening a large iron bolt; from thence it passed into the ship's side in good wood, making a total penetration of 46 inches.

162. Many hollow shot were fired with remarkable effects from 68-pounder guns, making penetrations which varied from 25 to 56 inches. One of these, with a charge of 8 lbs., penetrated the side of the hulk, passing through 28 inches of good wood, tore out the iron hook which holds the port-hinge, and fractured the after side of the port, driving the splinters about the deck. It rent away the end of a beam, grazed the deck, passing through two planks, and cutting down a stanchion 8 inches square, making several large splinters; it then struck against the opposite side of the ship, from whence it rebounded against that which it entered.[a]

Hollow shot from a 68-pounder carronade, with a charge of 5 lbs. 8 oz., penetrated to depths varying from 28 to 31 inches. One of these pierced through the ship's side (24 inches) just above the water-line, in fair wood, and then passed through the ceiling in the orlop (7 inches thick), consisting of very strong wood, shattering it considerably.

163. In 1848 some experiments were made to try the pene-

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[a] At 800 yards, with heavy guns, a charge of one quarter of the weight of shot may always be used; at 500 yards the charge may be reduced to one-sixth; and, within 400 yards, two shot at once may be used with advantage.

tration of shot into water, when fired with small angles of depression towards its surface. In these experiments three targets were placed vertically in the water, 8 feet asunder, the nearest being about 37 yards from the mouth of a gun, which was a 32-pounder, and charged with 10 lbs. of powder.

When the gun was depressed 7 degrees, the shot struck the first target at the water's edge, and, passing through it, rose from thence and pierced the other targets at the heights of 12 and 18 inches above the water. Again, the water having risen 2 feet, the gun, charged as before, was fired, when the shot striking the water at 8 feet short of the nearest target, rose and passed through the three targets successively: the first at 6 inches from the water, and the others successively higher. The same gun being fired with a depression of 5 degrees, the shot passed through the first target under water, grazed 4 feet, and rebounded from the second target.

The gun was fired once with a depression of 9 degrees, when the shot did not come up again. It passed through the first target at 2 feet under water, and, grazing along the mud, rebounded from the second target, having entirely lost its force. With a depression of 7 degrees, the shot being fired into the water where it was 1 foot deep, rose, after grazing about 8 feet along the mud, and at length fell at the distance of 400 yards. Being fired with the same depression into water 2 feet deep, the shot did not reach the mud, but immediately rose, and finally fell about 600 yards off.

164. In order to ascertain if shot reflected from water would damage a ship, shots from a 32-pounder gun, with a charge of 10 lbs. and a depression equal to 7 degrees, were fired from a *lump* alongside of the "Leviathan," and the following are some of the effects produced:—At the distance of 16 yards, the shot struck the water at 4 feet from the ship's side, and in one experiment it lodged in the cutwater; in another it indented the ship's side, and in both cases it struck at 18 inches below the water-line. At the distance of 36 yards, with a depression of 5 degrees, the shot struck the water at distances from the ship's side varying from 2 to 15 feet; and ricocheting, entered the ship at distances above the water-line varying from 2 inches to 3 feet.

In consequence of the loss of force which the balls, in all these experiments, sustained by striking the water, it has been inferred that, if a shot be fired with such a depression as a ship's gun will bear, it will not penetrate into water more than 2 feet; and consequently that it will be impossible to injure a ship by firing at her under water. The correctness of this inference we must however be permitted to doubt till further experiments have been made. It is highly probable that conoidal shot would penetrate to a certain depth into the water, and strike the ship below the water-line.

165. From the tables of ricochet practice made on board the "Excellent" in 1838, against the "Prince George" hulk at the distance of 1200 yards, the following particulars are extracted:—A shot fired from a 32-pounder at an elevation of half a degree, with a charge of 10 lbs. 11 oz., penetrated, after one graze from the water, the after port-timber of one of the ports, to the depth of 28 inches in very good wood, shattered the head of the rider, started the plank between the ports, and passed over to the opposite side, where it penetrated to the depth of 10 inches. This shot also broke the beam-clamp, a piece of good wood 6 inches thick.

A 68-pounder hollow shot, with a charge of 12 lbs. and an elevation of half a degree, after five grazes struck a chock of solid wood 4 feet 8 inches thick under the fender, and shattered it in pieces. It struck also a large iron bolt, which it flattened. Another, with a charge of 10 lbs. and an elevation of 1 degree, after two grazes penetrated the ship's side diagonally (34 inches), in tolerably good wood, below the chocks, and lodged behind a cluster of iron knees on the orlop-deck, which were shaken considerably. The planking on the outside of the ship was also started. A third, after two grazes, struck a chock used for the sheers, tearing off a piece 6 feet long, 1 foot deep, and 2½ feet broad. It then penetrated 11 inches deep in the ship's side, in bad wood.

A 68-pounder shot, with a charge of 8 lbs. and an elevation of 1 degree, after two bounds, penetrated to the depth of 24 inches, close to the side of a port just above the lower port-sill, in bad wood, started the inside planking, and tore off a piece which splintered. One of the splinters, a very large one, was thrown beyond the main-hatchway to the opposite side of the deck. The shot having crossed the deck, struck a corner of the main-hatchway combings, and tore out a large piece on each side, destroying the use of the combings. It struck a winch-handle which was lying on the deck, and drove one end of it through a port-scuttle. After striking the combings, the shot grazed a beam and fell on the deck. Another shot, with a charge of 7 lbs. and an elevation of 1 degree, after three bounds, penetrated through the ship's side diagonally (29 inches), shattered the ceiling, and made several splinters.

A hollow shot from a 68-pounder carronade, with a charge of 5 lbs. 8 oz. and an elevation of 4 degrees, after one bound, struck the upper surface of a bulwark, and went overboard.

Ricochet practice is now much better understood than formerly, and is daily becoming more important in the service. When made with large ordnance it is susceptible of great accuracy on level ground, or on the surface of smooth water.

166. In 1838, experiments were made at Gavre with two solid balls fired at once against a butt of oak timber, in order to determine the different penetrations of the shot, and the distances between their centres at different distances from the piece. The diameter of each shot was 6·283 inches (English), and its weight 33 lbs. 4·6 oz. Three different natures of ordnance were used: a long 30-pounder (French) gun, a canon-obusier of 30, and a 30-pounder (French) carronade. One ball was in contact with the charge, and the other in contact with the former. In the carronade, a grummet wad was placed over the shot which was farthest from the charge, but in the other pieces a junk wad. The following tables exhibit the results:—

TABLE I.

Nature of Ordnance.	Charge.		Initial Velocity.		Velocity at Striking.		Penetration.	
			Ball nearest the Charge.	Ball farthest from the Charge.	Ball nearest the Charge.	Ball farthest from the Charge.	Ball nearest the Charge.	Ball farthest from the Charge.
	lb.	oz.	ft. per sec.	ft. per sec.	ft. per sec.	ft. per sec.	inches.	inches.
Long 30 pr...	8	4.3	938	1194	889	1129	29.61	42.12
Canon-obusier of 30 ..	4	6.4	761	958	718	905	21.06	30.51
30-pr. Carronado ..	3	8.4	727	856	689	810	19.68	20.59

TABLE II.

Distances of the Butt.	Long 30-pr. Charge 8 lbs. 4.3 oz.				Canon-obusier of 30. Charge 4 lbs. 6.4 oz.				30-pr. Carronade. Charge 3 lbs. 8.4 oz.			
	Distances between the Centres.				Distances between the Centres.				Distances between the Centres.			
	Horizontal.		Vertical.		Horizontal.		Vertical.		Horizontal.		Vertical.	
Yards.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.
55	1	0.2	0	8.3	0	8.6	0	7.9	0	5.9	1	3.7
109	1	11.2	1	7.3	2	3.5	2	0.	0	11.8	1	5.7
164	2	0.8	4	0.4	1	7.7	2	9.8	1	5.7	2	5.9
219	3	1.4	4	6.3	4	7.9	6	3.6	3	6.9	2	1.6
274	2	4.3	9	3.	4	0.	6	6.3	5	0.6	2	11.4
328	4	8.6	9	4.6	4	3.6	5	6.5	7	6.5	4	4.7
383	5	3.4	11	0.2	4	11.4	10	10.7				
437	6	8.	13	8.9	9	8.5	11	6.4				

From all these experiments, it is evident that the ball which was in contact with the charge had the least velocity and the least penetrating power (see Art. 104). It is further remarkable that, with the two first pieces at distances beyond 150 yards, the vertical dispersion greatly exceeds the horizontal dispersion.

167. In the summer of 1835 some experiments were carried on at Metz, in order to ascertain the effects of cannon-shot on plates of forged iron, carefully manufactured by rolling; and the following account of them is extracted from the 'Mémorial d'Artillerie,' No. 5, page 361. The dimensions and weights are given in English denominations:—

No. 1 plate was 48.8 inches long, 18.4 inches wide, 1.44 inches thick, and weighed 343 lbs. No. 2 plate was 40 inches long, 16 inches wide, 1.72 inches thick, and weighed 220 lbs. No. 3 plate was 62.4 inches long, 18 inches wide, 3.08 inches thick, and weighed 581 lbs. The shot were fired from 12-pounder and 24-pounder guns (French), which were placed at the distance of 66½ feet from the plates.

From the 12-pounder gun, with a charge equal to 2 oz. and a velocity equal to 340 feet per second, impressions from 0.16 inch to .2 inch were made in No. 1 and No. 2 plates. The shot was unaltered in form, and rebounded back to a distance of 117 feet. From the 24-pounder gun, charge 8.8 oz., and a velocity of 463 feet, the shot produced a crack in the rear face of No. 2 plate; with a charge of 1.1 lb., and a velocity of 633 feet, the shot completely pierced No. 1 plate, and detached a fragment.

From the 12-pounder gun, charge 1.1 lb., velocity 866 feet, the fire being directed against No. 1 plate, also with a charge equal to 2.2 lbs., and velocity 1216 feet, the fire being directed against No. 3 plate, the shot did not pass through, but produced deep impressions and cracks towards the bottom of the indentation. The shot were broken, and the plates were brought to a heat which produced a deep blue colour at the places of fracture. From the 24-pounder gun, charge 4.4 lbs., and velocity 1266 feet, the shot did not pierce No. 3 plate, but produced cracks diverging from the centre of the impression; but with a charge equal to 6.6 lbs., and velocity 1500 feet, the shot perforated No. 3 plate, carrying out a portion corresponding nearly to its own diameter. With charges above 4.4 lbs., the shot passed completely through No. 1 and No. 2 plates, and the diameters of the holes were found to approach that of the shot in proportion as the velocity of the latter was greater. In one case the hole appeared as if punched in a form very nearly circular.[a]

168. From the experiments made at Metz in 1834, it appears that masses of cast-iron above 1 yard square and 13 inches thick, do not resist the shock of balls fired against them with even moderate velocities, having been fractured not only at

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[a] This warrants the condemnation pronounced by high authority on iron steamers in France:—"De tous les navires à vapeur, les plus impropres à la guerre sont ceux en fer."—('Les Principes et l'Organisation de la Marine de Guerre,' par le Général Du Bourg, ancien officier de la Marine, p. 313, Paris, 1849.) The French were the first to propose the introduction of the use of iron in the formation of steam-vessels armed with "*la nouvelle arme*," the canon-obusier. Colonel Paixhans entertained an opinion that such vessels might thus be made shell-proof, and accordingly propounded this in his work ('Nouvelle Force Maritime,' page 7), in which it is announced that the steam-vessels so armed and fitted were to be made proof against artillery by being *cuirassés en fer!* This proposition was taken into consideration by the Comité Consultatif de la Marine, to which the whole of the project was referred, for a Report; and seriously entertained and discussed by them (see section No. 19, pp. 92 *et seq.* in the work just quoted); and this it was that led to the construction of iron steamers in our naval service. The proposition of rendering ships impenetrable to shot, in this or any other manner, was found to be impracticable by any means available in ship-building. The French soon afterwards came to the conclusion that, of all vessels that can be constructed, those made of iron are the most improper for war; and they for a time desisted from any attempts to introduce iron vessels into their naval service.

the point of contact, but also at points considerably distant from thence. It was found also that the sides of a traversing gun-carriage of iron, whose dimensions exeeeded those of any carriage which can be employed on service, were broken by an 8-pounder ball, having a velocity of 492 feet, which proves that carriages of this nature would, if struck, be rendered unserviceable; and that a collision which, with a wooden carriage, would have damaged only an accessory part, without requiring its being replaced, would, with a cast-iron carriage, have a more fatal effect. Not only is the object struck destroyed in a short time, but the fragments scattered in different directions are highly dangerous.

169. In August, 1840, some experiments were made at Woolwich, in order to determine the effects of shot upon an iron target lined with a composition of caoutchouc and cork, the invention of Lieut. Walker of the Royal Marines. The thickness of the iron was ⅝ of an inch, and of the composition 9 inches. The gun was a 32-pounder, and was placed at the distance of 40 yards from the target.

With a charge equal to ¼ lb. of powder the shot rebounded, making only a small indentation; but with a charge equal to ½ lb. the shot penetrated the iron and lodged in the composition: had the shot been heated, the composition would have been set on fire, when by no immediate possibility could the shot have been taken out, so that the consequences might have been fatal. With a charge of 1 lb. the shot passed through both the iron and the composition, producing a clean, round hole, the disk which was struck out being nearly a circle; and with a charge of 10 lbs. there was formed a clean hole, but the fragments struck out were very numerous, small, and jagged.

The target was then turned so as to present to the gun the face armed with the composition; when, with a charge of 1 lb., there was formed an irregular fracture 13 inches long; and, with a charge of 10 lbs., the target was pierced and greatly torn, the mean diameter of the perforation being 18 or 19 inches. It does not appear, therefore, than any advantage would be gained by thus lining or covering the sides of an iron vessel.

170. In 1840 a series of experiments were also carried on at Gavre, in France, with grape-shot, consisting of 10 balls of 4 lbs. each, disposed in two layers between two plates of wrought iron, through which passed a central stem; the balls were confined laterally by three iron hoops, one above another, and the upper plate was kept close over the balls by means of a screw. The grape, which was fired from a canon-obusier of 80, with and without a wooden bottom, weighed in the former case 72 lbs. 12 oz., and in the latter 67 lbs. 12 oz. And the following is a table exhibiting the dispersions of the balls at different distances from the gun:—

Distance in Yards.	Grape with Wooden Bottoms.			Grape without Wooden Bottoms.		
	Dispersion in Feet and Inches.			Dispersion in Feet and Inches.		
	Horizontal.	Vertical.	Mean.	Horizontal.	Vertical.	Mean.
	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.
109	3 2	9 7	6 4.5	6 4	7 7	6 11.5
164	11 9	13 6	12 7.5	12 7	11 7	12 1.
219	15 1	15 4	15 2.5	16 0	18 1	17 0.5
274	18 0	18 6	18 3.	19 7	21 4	20 5.5
328	22 11	28 6	25 8.5	26 7	29 3	27 11.

From the experiments alluded to, it may be deduced that the mean deviation, at the distance of 1 yard from the gun, is—

For grape-shot with wooden bottoms	0.96 inches.
For ditto without ditto	1.04 „

From experiments made on grape-shot, the balls being contained in a canvass bag as usual, when fired from the same nature of ordnance, the mean dispersion, at 1 yard from the gun, was found to be .94 inch. An iron plate in front of the ball causes, therefore, the dispersion to be greater than it would be without such plate. A wooden bottom causes a diminution of the dispersion: but such bottoms are very liable to be broken to pieces in the gun, by which the dispersion of the balls is rendered irregular. The dispersion of grape-shot is found to increase when the number of ball is increased.

On the whole, however, grape-shot confined between iron plates appears to offer no advantages over that which is in canvas, and at sea the hoops would soon be corroded by rust.

In 1837 a number of experiments were made at Gavre, with different natures of ordnance, on the penetration into oak of balls constituting grape or case-shot, the guns being at 54½ yards from the butt; and the following is a table of the results:—

Nature of Ordnance.	Nature of Shot.	Charge.	Initial Velocity.	Velocity at the instant of Impact.	Mean Penetration.
		lbs. oz.	Feet.	Feet.	Inches.
Canon-obusier of 30	15 balls, 2.1 inch diam.	4 6.4	764	715	7.56
	120 balls, 1.05 ditto ..	4 6.4	758	666	3.35
Canon-obusier of 80	48 balls, 1.85 ditto ..	8 13.	924	854	8.5
Long 30-pr. (Fr.) ..	15 balls, 2.1 ditto ..	8 1.5	886	830	9.61
Canon-obusier of 80	10 balls (4 liv.), 3199 do.	8 13.	924	882	14.8
Long 30-pr. (Fr.) ..	120 balls, 1.05 ditto ..	8 1.5	945	830	4.76

171. When a cluster of grape and one round-shot are fired at the same time from one piece of ordnance, it is found that if the grape is placed in contact with the charge, the ball being beyond it, the plate of the grape is oftened fractured, and when not broken in pieces, it takes a figure decidedly curved with the convexity towards the round shot; the balls of grape are frequently broken by their mutual percussions, and the stem is either broken or forced out of its place. The like effects are produced, but in a much less degree, when the shot is placed in contact with the charge, the grape being beyond. It was ascertained, from experiments made at Gavre in 1838, that, when the grape was in contact with the charge, the dispersion of the balls was twice as great as when the round-shot was in such contact. It follows that the dispersion of grape-shot is diminished by augmenting the thickness of the plate; and it is found that with the same piece of ordnance the dispersion of grape-shot is nearly proportional to the number of balls which compose the cluster. Also, the dispersion is smaller in proportion as the piece of ordnance is longer.

172. The effect produced by shot when fired against iron steamers was remarkably exemplified on the "Lizard" during the operations which took place in the Paraná in 1846, when

it was found that, on being struck, the plates of the ship bulged, and the perforations were so irregular and jagged that, for the purpose of stopping them, the common plugs were quite useless. This circumstance suggested the expedient of employing what has been called a *parasol plug*, which consists of an iron bolt furnished with arms of the same metal and covered with thick canvass well tarred. On being thrust through the shot-hole, and then forcibly drawn back, the head expanded, and thus, the aperture being covered, the leak was closed. In consequence also of the ship being struck, the splinters and rivets detached by the shot flew about like grape, and nearly all the men killed and wounded suffered from this cause. Grape-shot fired at a distance of 200 yards pierced the side; and persons present, who were highly capable of judging, concurred in opinion that a 32-pounder shot would have gone through the sides of three or four iron steamers, doing damage which would be successively greater in those more remote from the ship first struck, till the force were spent. A remarkable circumstance is said to have happened to the "Alecto" at the same time. An infantry soldier fired his ramrod at her, when, like a dart, it went point foremost quite through the nearest side of the funnel, but being prevented by the button from passing through the other side, it fell down in the interior.

173. In the years 1849-51 some experiments, of which notice is given below, were carried on at Portsmouth under the direction of Captain, now Rear-Admiral, Chads, C. B., in order to try the effects of shot in and upon iron ships; and a distinct knowledge of all the facts established by these trials is a matter of such immense importance, that the author thinks it necessary to present to the reader a summary of all the experiments that have been made, to ascertain exactly the effects of shot of various descriptions on plates or ribs of iron.

The first experiment, made on the 6th of November, 1849, was for the purpose of testing the resistance of iron plates against musketry, canister, and grape shot. Oak planking was also fired at, to make a comparison between the two materials. A marine's percussion musket was used: charge, 4½ drs.; distance, 40 yards. The results were as follow:—

Iron plates, $\frac{1}{8}$ Oak plank, 1-inch	All passed through.
Iron plates, $\frac{2}{8}$ Oak plank, 2-inch	4 in 6 passed through.
Iron plates, $\frac{3}{8}$ Oak plank, 3-inch	Both musket proof.

Canister, 100 yards : 6 lbs. charge.

Iron plates, $\frac{3}{8}$ Oak plank, 3-inch	Passed through.
Iron plates, $\frac{4}{8}$ Oak plank, 4-inch	Canister proof.

Grape, 200 yards : 6 lbs. charge.

Iron plates, $\frac{4}{8}$ „ $\frac{5}{8}$ „ $\frac{6}{8}$	All passed through.
Oak plank, 4-inch „ 5-inch	All passed through.
„ 6-inch	Generally passed through.

Experiments were made in June, 1850, against two sections of the "Simoom,"[a] $\frac{5}{8}$-inch thick, placed 35 feet apart: the guns and charges were those used in all steam-vessels.

The result was, that two or three shot, or sometimes even a single one striking near the water-line of an iron vessel, must endanger the ship.

Another most serious evil is, that the shot breaks, on striking, into innumerable pieces, which pass into the ship with such force as to range afterwards to a distance of 400 or 500 yards; hence the effect on men at their quarters would be more destructive than canister shot, supposing them to pass through a ship's side, as when the plates are only $\frac{3}{8}$-inch thick.

Rear-Admiral Chads stated, in a letter to the author, that out of seventeen 32-pounder shot which struck the iron butts at the distance of 450 yards, with charges varying from $2\frac{1}{2}$ to 10 lbs., sixteen were shivered to pieces on passing through the first side, and became a cloud of langrage too numerous to be counted.

Experiments were further made on the 11th of July, 1850, against an iron section similar to the "Simoom;" it was filled in and made solid, with $5\frac{1}{2}$-inch oak timber between the iron ribs, and $4\frac{1}{2}$-inch oak planking above the waterways, which were

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[a] This ship is clinker-built; and its sides are thicker than those of any other iron vessel in the navy.

1 foot thick, and with 3-inch fir above the port sills: these were strongly secured to the iron plates by bolts.

The results were as follow:—

The holes made by the shot were not so irregular as on the former occasion, but as clear and open. All parts of the shot passed right through the iron and timber, and then split and spread abroad with considerable velocity; parts of the iron plates, and a few very small pieces of shot, were sometimes retained in the timber.

With low charges the shot did not split into so many pieces as before.

With high charges the splinters from the shot were as numerous and as severe as before, with the addition, in this and the former case, of the evil to which other vessels are subject—that of the splinters torn from the timbers.

On the 13th of August, 1850, an iron section similar to the "Simoom" was prepared with a covering of fir plank on the outside, of the thickness of 2, 3, and 4 inches in different parts.

The result of this experiment was similar to the last, when the wood was on the inside, with the exception of the splinters from the wood.

The holes made by the shot were regular, of the full size of the shot, and open.

Every shot split on passing through; those between the ribs into a few pieces only; those that struck on the ribs into a great number; in both cases, when combined with the splinters of the iron side, the effect must prove highly destructive.

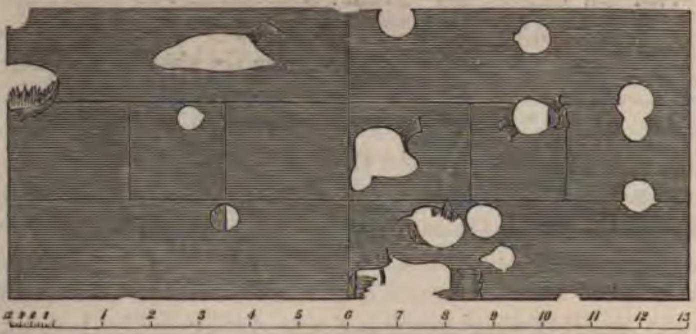
A comparison as to the effect of shot on iron and timber was made by firing 8-inch hollow shot, and 32-lb. solid shot, at a butt built for experimental shell-firing, with timber having 6-inch plank on the outside, and 4-inch within; the result was, that the splinters from the wood were trifling when compared with those from the iron.

Again, experiments were made on the 10th October, 1850, against an iron section similar to the "Simoom," lined on the inside with a composition called by Mr. Walters, the inventor, "kamptulicon;" the result was the same as the former trials when lined with wood. It neither prevented the shot from breaking into numerous small pieces, nor did the hole close up, as was anticipated, after the shot had passed through.

174. Experiments were made, July 5th, 1851, at a butt constructed with oak and fir uprights, to represent the timbers of a ship; one half covered with $\frac{3}{8}$, and the other half with $\frac{4}{8}$ sheet-iron.

The first practice was with the iron outside (fig. 3): 32-lb. solid shot, and 8-inch hollow shot, with distant charges, passed through the $\frac{3}{8}$ iron without splitting.

Fig. 3.



It has not been thought necessary to describe, in detail, the fractures and ravages made by the shot. The delineations, faithfully reported, *sautent aux yeux*, and carry conviction to the mind.

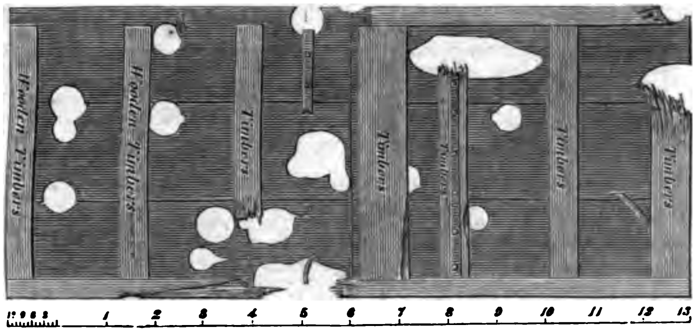
In firing against the $\frac{4}{8}$ iron plates, two of the shot, on striking a double part where there was a joint, split into four or five pieces, but not in so destructive a manner as on the former occasion against the $\frac{5}{8}$ plates.

Some shot that passed through this part were picked up and found to be starred or cracked, showing that $\frac{4}{8}$ is the extreme thickness of iron which should be employed in constructing iron vessels, in order to prevent the breaking of the shot.

The shot on passing through the $\frac{4}{8}$ iron plate made clear, clean holes, of their own diameters, without rending the iron further, but the disc struck out was invariably broken into numerous pieces. Fig. 4 represents the reverse of the target, and exhibits the effects on the timbers.

The butt was subsequently turned, so as to represent the off-side (fig. 4, opposite), where the shot would strike the timbers before passing through the iron: reduced charges were used to diminish the velocity of the shot to what it would be after having passed through the front side.

Fig 4.



A 32-pounder shot passed through an oak timber, carrying away the iron at the back in a fearful manner, laying open a space of 19 inches by 12, and curling the iron up so as to preclude the possibility of stopping it if under water.

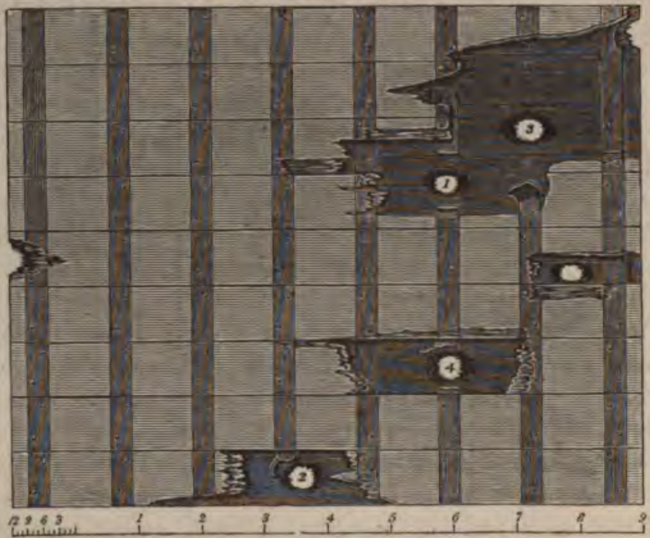
An 8-inch shot also struck a fir timber, with almost a similar result; the hole was 2 feet 6 inches by 10 inches.

On the 11th and 12th of August, 1851, experiments were made, the particular objects of which were to endeavour to diminish or obviate the destructive effects produced as above on iron plates by the impacts of shot, and to prevent the shot from splitting into pieces. For these purposes a butt was constructed to represent a section of the "Simoom," formed of iron ribs of $\frac{5}{8}$-inch iron, $4\frac{1}{2}$ inches wide, and $11\frac{1}{2}$ inches apart, instead of iron plates: these were covered with 5-inch teak planking on the outside and 2-inch on the inside (fig. 5, overleaf). The breadth of the 5-inch planking was $10\frac{1}{2}$ inches, and of the 2-inch, $9\frac{3}{8}$ inches.

This butt, 10 feet long by 8 in depth, was fixed between piles firmly driven at the distance of 450 yards from the guns, and with the outside face towards them.

No. 1. Solid shot, 32-pounder, 56 cwt. gun, 10 pounds charge. —Hit direct about 3 feet from the centre of the butt, making an open hole (1, fig. 5, overleaf) the size of the shot with a jagged edge through the 5-inch teak; it then cut directly through an iron rib, carrying away 7 inches of it; the shot then, with the pieces of the rib, passed through the 2-inch teak close to the edge of a plank, carrying away an extent of 3 feet in length by 1½ in height.

Fig. 5.



A large number of splinters both of wood and iron were found; the iron ones ranging from 200 to 400 yards: the shot passed on to 1300 or 1400 yards.

No. 2. Solid shot, 32-pounder, 56 cwt. gun, 10 pounds charge. —Hit direct 9 inches from the bottom (fig. 5), and about the middle part of the butt, making an open hole the size of the shot with a jagged edge through the 5-inch teak; it then cut through the back of an iron rib, carrying away 10 inches of the lower part of it; the shot then, with the pieces of the rib, passed through the 2-inch teak in the centre of a plank, carrying away an extent of 3 feet in length by 1 in height, which probably would have been greater but that the shot struck so near the bottom of the butt and centre of a plank.

A large number of splinters both of wood and iron were produced; the iron ones ranging from 200 to 400 yards: the shot passed on to 1500 or 1600 yards.

No. 3. Hollow shot, 56 lbs., 8-inch, 65 cwt. gun, 10 pounds charge.—Hit from ricochet 25 yards short, about 2 feet from the side and 3 from the top of the butt, making an open hole the size of the shot with a jagged edge through the 5-inch teak; it then cut directly through an iron rib, carrying away 26 inches of it; the shot then with the pieces of the rib passed through the 2-inch teak at the edge of a plank, carrying away an extent of 3 feet in length by about 2 feet in height.

A large number of splinters both of wood and iron; the iron ones ranging from 200 to 400 yards; the shot passed on to 1300 or 1400 yards.

No. 4. Hollow shot, 56 lbs., 8-inch 65 cwt. gun, 10 pounds charge.—Hit direct, about 3 feet from the centre of the butt, making an open hole the size of the shot with a jagged edge through the 5-inch teak; it then cut directly through an iron rib, carrying away 8 inches of it; the shot then with the pieces of the rib passed through the 2-inch teak, in the centre of a plank, carrying away an extent of 3 feet in length by 1 in height.

A large number of splinters both of wood and iron; the iron ones ranging from 200 to 400 yards; the shot passed on to 1400 or 1500 yards.

175. A butt of the same description reversed was then used, to try the effect of shot passing off the opposite side of a ship fitted in this manner.

For this purpose 5 lbs. charges were used with the 8-inch, and 4 lbs. with the 32-pounder gun, to allow for the decreased velocity of the shot after having passed through the first side with a 10-pounds charge.

With solid shot, 32-pounder, 56 cwt., 4 pounds charge.—Hit direct 2 feet from the bottom and about the middle part of the butt, making an open hole the size of the shot with a jagged edge through the 2-inch teak; it then cut directly through an iron rib, carrying away about 7 inches of it; the shot then with the pieces of the rib passed through the 5-inch teak near the edge of a plank, making an open hole 12 inches in length by 6 in height, but the wood much splintered to 3 feet in length by 14 inches in height.

Thus, it appears that the destructive effects of the impacts of shot on iron ships cannot be prevented. If the iron sides are of the thickness required to give adequate strength to the ship ($\frac{5}{8}$, or at least $\frac{4}{8}$ of an inch), the shot will be broken by the impact; if the iron plates be thin enough to let the shot pass into the ship without breaking, the vessel will be deficient in strength; the shot will do its work, particularly in oblique or raking fire, more effectively than its splinters, and in passing out, make apertures more difficult to plug or stop than in passing in. When a clean hole is made by a shot penetrating an iron plate, the whole of the disc struck out by the shot is broken into numerous small pieces, which are driven into the ship with very destructive effects; and if the plate be so thick (viz. upwards of $\frac{4}{8}$ of an inch) as to cause the shot to break on striking, the fragments will nevertheless pass into the ship as in the case of a concussion or percussion horizontal shell (Arts. 265, Note[a], and 269), and so produce a terrific compound effect by the fragments of both. The expedient of combining wood and iron, either by substituting timber for the iron ribs, or the reverse—outside planking for the iron plates—makes the matter worse. The pieces of ribs struck off, sometimes of great length, pass on with the shot, to produce more extensive ravages elsewhere.[a]

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[a] Descriptions of some of the splinters of Iron Plates, Rivets, and Shot, picked up in the space between the Targets set up to represent a section of an iron vessel. The splinters were taken promiscuously from innumerable fragments found there when the firing ceased.

Description.	Greatest Dimension.	Least Dimension.	Weight.
	Inches.	Inches.	Ounces.
Splinter of a plate, extremely jagged and pointed	$1\frac{1}{2}$	$\frac{3}{8}$	$\frac{1}{4}$
Splinter of a plate near a rivet, bent, jagged, and pointed.	2	$\frac{3}{8}$	1
Splinter of a plate near a rivet	$1\frac{6}{8}$	$\frac{3}{8}$	$1\frac{1}{4}$
Piece of a rivet, a good deal flattened, bent, and jagged.	$1\frac{2}{8}$	$\frac{3}{8}$	$1\frac{3}{4}$
Splinter of a shot much jagged	$1\frac{1}{2}$	$\frac{1}{2}$	$2\frac{1}{4}$
Splinter of a plate extremely jagged and pointed	2	$\frac{5}{8}$	$2\frac{3}{4}$
Splinter of a plate, with part of a rivet attached, of very irregular shape, pointed and jagged in all parts.	$2\frac{1}{4}$	Too irregular to be defined.	$3\frac{1}{4}$
Splinter of a shot, very jagged, and two of the edges sharp.	$1\frac{3}{4}$	Ditto.	$3\frac{1}{2}$
The larger specimens varied from $3\frac{1}{2}$, $4\frac{1}{2}$, and 6 ounces, to nearly as many pounds; all of them were extremely jagged, pointed, and, in some cases, sharp at the edges.			

176. It is generally believed that iron vessels, however convenient and advantageous in other respects, are utterly unfit for purposes of war. This opinion has been confirmed by the decision of a mixed committee of officers of the naval artillery and engineers. This committee was appointed under the authority of the Admiralty and Board of Ordnance, in order to consider how far it might be possible to carry into effect a plan for arming the Contract Mail Packet Steamers, and to report whether or not the terms of their contract have been observed by the several companies as regards the adaptation of their vessels for war-purposes. From this category the committee entirely and unanimously reject iron vessels. Exclusive of these they found that of the fifty-three vessels belonging to the Peninsular and Oriental and the West India Mail Companies, eight only (of wood) were capable of being effectually fitted to receive an armament especially directed to the object of defence; though some of the others might be fitted to serve as armed packets or armed troop-ships. In almost every case it was considered impracticable to have a pivot-gun either forward or abaft, on account of the sharp form of the bow and the great rake of the stern. To put a vessel in a condition to carry and fire the guns assigned to it, it was estimated that the expense of alterations, and the fittings of ports with a magazine and shell-room, would vary from 600*l.* to 800*l.*

177. It becomes now a question of serious import to decide whether iron steamers which have been condemned as ships of war, on account of the extensive ravages produced by the impacts and penetrations of shot upon and in vessels formed of that material, are fit to be employed as transports for the conveyance of troops and stores in the event of war.

In vessels made of iron the weight of the whole material is considerably less than that of vessels of the same dimensions but made of timber. With equal displacement (the weight of water displaced) therefore, the former can carry a greater weight of cargo, their capacity for stowage being greater on account of the thinness of their shell. But when an iron vessel is bilged and becomes filled with water, the superior weight of the material of which she is formed is a momentous consideration. Timber, when immersed in water, loses as much of its weight as is equal to that of the water displaced by it, and it floats. A cubic foot of oak timber has a buoyancy, when immersed in salt water, of 76 oz., and a cubic foot of fir, a buoyancy of 450 oz.; but the excess of the weight of a cubic foot of iron over an equal volume of salt water, is 6180 oz., and, with this force, the iron sinks. When, therefore, an iron ship is bilged, having lost its power of floating, the weight of the iron tends to break and destroy it, unless it be stranded on a smooth and shelving bank or beach. This was the case with the "Great Britain," which rested, throughout her length, upon the beach on which she grounded; but when an iron vessel strikes upon, and is perforated by a rock, (as in the case of the "Birkenhead," which was wrecked near the Cape of Good Hope), she becomes bilged, and there she remains with deep water at her extremities; she then becomes filled, either wholly or partially, and the iron, deprived of buoyancy, exerts a prodigious force to break the vessel's back and sink the portions which are not in contact with the rock. Even if the portion which is not in such contact should be furnished with compartments which may not permit the water to enter, the difference between the power of floatation in that water-borne portion, which acts in a contrary direction to the weight of the iron, will constitute a strain which no iron vessel can resist, tending to fracture it at the section which divides the filled from the unfilled portion. Should there be no water-tight compartments, or should these not effectually act, then an iron vessel, perforated near the midship's section, with deep water under her extremities, will infallibly be destroyed by the weight of the iron at both ends, acting upon the fulcrum on which the vessel rests.

What has been said is applicable to the most melancholy case of the "Royal Charter," an iron screw steamer from Melbourne, which was wrecked on our own coast, near Liverpool, during the fearful storm in October, 1859, when the vessel broke transversely in two places, and above 400 persons perished.

When an iron vessel parts, all the fragments of the material of which she is composed sink, and nothing floats to save life but a few loose spars: whereas the fragments of a timber ship float, and many, perhaps most of the crew, may thus be saved. In the fearful wreck of a transport, in which the author once was, the whole of the quarter-deck, from the mainmast to the stern, with the top-sides to which it was attached, came on shore like a raft, when the vessel broke up. What had been our fate if that transport had been formed of iron?

Applying these observations to the case of the "Birkenhead," and on a full consideration of the facts as taken from the report of the proceedings of the court martial on the surviving officers and crew of that ship, there cannot be the least doubt that, had she been a wooden vessel, she would have held together long enough in a sea so smooth as to permit all her hands to be saved. To this conclusion it may be objected, by persons who have not duly considered the difference of circumstances, that the "Avenger," though constructed of timber, went to pieces even more quickly than the "Birkenhead," when, going at full speed, she struck upon a reef of rocks; and, with the exception of a small boat's crew, all hands perished; but, on that occasion, the sea broke over the reef with such violence as to render it impossible that any vessel could resist it, or that any of the crew could be saved by clinging to the fragments into which it was broken.

178. Having several of these vessels on hand, the Admiralty have acted wisely in employing them as troop-ships at present. Some have accordingly been appointed to, and fitted for, that important service. The armaments have been removed from the main-decks, and a few light guns placed on the upper-decks, where timber is substituted for iron in the formation of their bulwarks; this removes some of the objections to iron sides, inasmuch as the men fighting the guns on those decks would not be liable to suffer more from an enemy's shot than in a wooden ship.

There can be no doubt of the advantages and expediency of employing those vessels as troop-ships in time of peace. Their safety from conflagration; their speed with steam power; the advantages of the screw, which admits of such vessels having great sailing power, and, on the whole, their great capacities and capabilities of voyaging, which have been so well exemplified in their performances, prove that the best possible use is being made of those vessels by so employing them during peace. But, in war, it is not enough that the people on the upper decks will not be exposed to the destructive effects produced by shot on iron, by the substitution of timber for that material, in the upper works; for the main-decks appropriated to the troops will still be liable to the terrific effects described and delineated as above: and although, by the happy expedient of water-tight compartments, the vessel, however desperately damaged, may be prevented from sinking and the troops from being drowned, the latter cannot be protected from being killed and wounded in great numbers, or captured, in the event of falling in with, and being attacked by, any enemy's vessel armed with even a very few heavy guns.

How far iron ships are fit and safe as packets, in times of war, is another question, which will have to be well considered. The Government packets are, by their contracts, to be so built and fitted, that they may, in the event of hostilities, be converted into vessels of war: if so, it is clearly demonstrated by the facts established in these most important proofs, that vessels subject to these stipulations must not be made of iron: for of this we are sure, that iron vessels are, and will be found, unfit for all purposes of war. Whilst, therefore, the best and the most is being made of our existing iron ships, employed as they now are, we should be prepared with other means to carry on that most important service in war. We have noble ships, which have whole decks available for the reception of troops, great space for the stowage of stores—vast steam-ships, possessing full steam, full sailing, and full gunnery powers, admirably adapted to these services, highly capable of executing them quickly, safely, and easily; prepared for any contingency, whether to fight or run, and therefore best suited to carry out that grand maxim—that promptitude, celerity, strength, and certainty in the modes and means of communication, either to succour and support our remote possessions, or to defend the centre of the empire, is, in fact, a practical multiplication of the forces of the state.

179. IX.—*On Cylindro-conoidal and Excentric-spherical Projectiles.*—Sir Isaac Newton has given in the 'Principia' (lib. ii., schol. to prop. 34) an indication of the form of a solid body which, in passing through a fluid, would experience less resist-

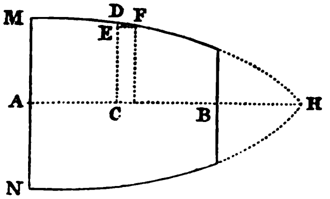
ance than a body of equal magnitude and of any other form. He imagined that this might be of use in ship-building, and it is evident that the principle is equally applicable in the theory of projectiles. Investigations of the differential equations of the curve may be seen in Vince's 'Fluxions,' in Airy's 'Tracts' (p. 237), and in the writings of other mathematicians. The body is a solid of revolution, and the differential equation is—

$$y = C \frac{d z^4}{d y^3 d x}$$

in which C is a constant.

The form of a section through the axis of the solid is given in the annexed diagram. A B is the axis, and in the direction of that line the solid is to move; y is any ordinate, as D C; and dx, dy, dz, are elementary portions, E F, E D, D F respectively. The end B, as well as A, of the solid is a plane surface; for the numerator of the fraction in the above equation will, evidently, be always greater than the denominator, and therefore y, the ordinate to the curve, can never be zero.

Fig. 6.



180. It is plain, however, that the minimum of resistance would not be obtained with a shot of an elongated form, when discharged from a musket or piece of ordnance, unless the axis A B can be kept in the direction of the trajectory. This may be accomplished if the shot be caused to have a rotatory motion on that axis by being discharged from a rifled bore; and without such rotation, not only will the axis perpetually deviate from the direction of the path, but the projectile will even turn over.

181. The advantages of this form of shot are, that when rotating on their longitudinal axes, and moving with their smaller extremities in front, they experience less resistance from the air than spherical projectiles of the same diameter. To this form alone are to be referred the long range with the great momentum and penetrating power of the projectiles for rifle-

muskets (see Part VI.), which have recently been introduced in the British and foreign military services.

182. Hollow cylindro-spherical projectiles, filled with powder and furnished with percussion caps at their points, were proposed some years ago for rifled muskets, by Captain Norton, for the purpose of penetrating into and exploding the ammunition packed in tumbrils and limber-boxes, and the experiments made with them met with some success; but, on account of the great difficulty of insuring the ignition of the charge on the shot striking, these missiles were found so uncertain that they have not been adopted.

183. The desire of obtaining the advantages which are stated in Art. 103 to be possessed by oblong shot, in combination with those alluded to in Art. 181, probably led to the formation, for heavy ordnance, of shot uniting the cylindrical with the conical or conoidal figures. Cylindro-conical and cylindro-ogivale (cylindro-conoidal) shot and shells, fired from rifled cannon, have recently attracted so much of the attention of professional and other persons, that perhaps some account of these projectiles may be looked for in a treatise which, though dedicated more particularly to the service of naval artillery, is intended to explain generally the theory and practice of military projectiles.

Iron rifled guns for the purpose of discharging such projectiles were, in 1846, invented by Major Cavalli, of the Sardinian artillery, and by Baron Wahrendorff, a Swedish noble. These are loaded at the breech, and experiments for the purpose of testing the merits of their shot have been carried on both at Aker in Sweden and at Shoebury Ness in this country.

The projectiles alluded to are represented in the subjacent figures 7 and 8; the first is designated cylindro-conical, and the other cylindro-conoidal; their entire lengths are about 16¾ and 14¾ inches, respectively, and their greatest diameter 6½ inches: each has two projections, *a b*, directly opposite to one another, and ¼ inch deep, which enter the grooves in the rifled bore. (These projections make an angle of 7° 8′ with the axis of the shot.) Each shot, if hollow, weighs about 69 lbs.; and if solid, about 101½ lbs. The hollow projectiles of M. Cavalli are each furnished with a double percussion agent; one part is the ordinary percussion cap, and the other consists of four small capsules of glass containing sulphuric acid, placed about the neck of the shot, the intervals being filled with chlorate of potash, while the upper part of the neck is filled with common

Fig. 7.

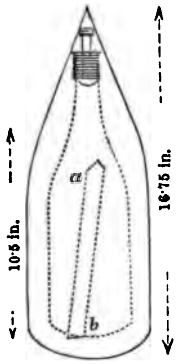
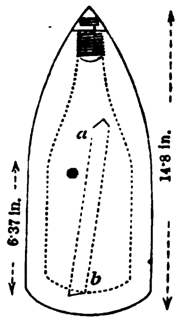


Fig. 8.



gunpowder, and stopped with wax.[a] It is said that the shock produced by one of these projectiles, when let fall on a pavement from a height of several metres, is not sufficient to cause explosion, and that this will not take place when the shot fired with a small charge strikes earth; it being only when fired with a service charge sufficient to break the glass globes by the shock that explosion takes place. M. Cavalli admits, however, that inconvenience and uncertainty exist in using such means, from the difficulty of combining the chemical ingredients so that the shell may resist the shock produced by the explosion of a service charge of powder, and yet be acted on by the shock of impact, which, in general, is much less than that of the explosion. This difficulty attaches to all such modes of procuring the explosion of shells on striking a resisting body, and, in point of fact, has hitherto stood in the way of the production of a good concussion-fuze or an efficient percussion-shell.

184. Dr. Hutton recognised, from his experiments in 1796, that there was a certain position of a projectile in which its deviations were less than in other positions, but no development

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[a] The projectiles are fully described in a pamphlet by M. Cavalli, entitled 'Mémoire sur les Canons se chargeant par la Culasse,' &c., Paris, 1847, p. 28. The glass globes are not shown in the above figures.

of the discovery appears to have taken place till M. Clement, in 1808, remarked, not only that the irregularities in the lengths of the ranges depended on the same cause as the lateral deviations, but also that the *obus* (a shell whose exterior and interior surfaces are not concentric) occasionally afforded ranges longer and more correct in proportion as the distance of its centre of gravity from the centre of the figure was greater. At length, between 1835 and 1840, a series of experiments were carried on in Belgium with great care, and with ordnance of different calibres, from which it was ascertained that when the centre of gravity was above that of the figure, the range was greater than when it was below, in the ratio of 2467 to 1315; and that when the centre of gravity was to the right or left, the deviation of the shot was in like manner towards the right or left.

185. These results were confirmed by experiments which M. Paixhans carried on at Metz in 1841.[a] This officer caused to be projected from a 12-pounder (Fr.) field-gun, a homogeneous spherical shot with the usual *sabot* at an elevation of 4°; and afterwards, with an equal charge and elevation and a like sabot, a ball having in it a cavity which caused the centre of gravity to be at a certain distance from the centre of the figure, and diminished the weight of the shot from 13.24 lbs. to 11 lbs. The following were the effects observed:—

When the centre of gravity was above the centre of the figure the ranges were the longest, and, when below, the shortest; when to the right or left hand, the deviations were also to the right or left. The mean range which, with the usual shot, was 1640 yards, was, with the shot whose centres of gravity and of figure were not coincident, the centre of gravity being upwards, equal to 2140 yards, being an increase of 500 yards. The mean of the lateral deviations, which with common shot was $\frac{13}{100}$ of the range, with the last mentioned shot was only $\frac{8}{100}$. Similar results were obtained at the same time with shells .15 metres (5.9 inches) diameter, both with high and low charges, the elevation being 4°. M. Paixhans

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[a] See 'Constitution Militaire de la France,' note D, p. 243. Paris, 1849.

remarks, however, as an anomaly, that the lengths of the ranges were more nearly equal when the ordinary, than when the excentric kind of shell was used.

In 1842, M. Paixhans made experiments with his canon-obusier of 80 livres, from which he found that, with a charge of 13.24 lbs. of powder and an elevation of 10°, the usual shell had a range equal to 2560 yards, while the non-concentric shell, its centre of gravity being placed upwards, had a range equal to 3198 yards: with a charge of 17.6 lbs, the range of the latter shell was 3540 yards.[a]

186. M. Paixhans infers from these experiments that if this method of placing shot, in which the centres of gravity and of figure are not coincident, should be employed with projectiles which are not spherical (as the cylindro-conoidal shot), the advantages above mentioned will be obtained in a much higher degree; and he adds that experiments with such shot would cast light upon a part of the theory of projectiles which is at present involved in considerable obscurity. At the same time there are artillerists who go so far as to say that the influence of excentricity in the projectile, on the form of the trajectory it describes, is such as to permit what has hitherto been considered an imperfection, and a cause of error, to be made the means of regulating and compensating the deviation to which all shot are subject, and thus to render the practice with excentric shot more precise than that of concentric spherical balls, whether solid or hollow.

This assertion, if true, would entirely overthrow what has ever been stated as an essential condition of accuracy in the flight of projectiles, and would impugn what has been inculcated in this work (Art. 89, with the Note, and Art. 119), on the importance of making spherical projectiles as perfect in form and homogeneity as possible, and of preserving them, with the most scrupulous care, free from rust, perfectly clean, and well lacquered.

No doubt the form of the trajectory of an excentric spherical projectile will be very much influenced by the position which its centre of gravity occupies when placed in the gun; and to

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[a] 'Constitution Militaire de la France,' note D, p. 246. Paris, 1849.

M. Paixhans is due the credit of showing that the deviations may thus be made to take place either in vertical or lateral directions with tolerable certainty; and if the amount of the deviations were in every case constant, the practical value of such projectiles would be most important.

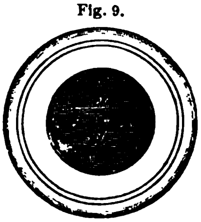
It will be shown hereafter that the experiments which have been made in this country with excentric spherical projectiles, far from overthrowing, confirm, in a remarkable degree, the soundness of the theory, and the truth of the maxim, that, of all spherical projectiles, those are the most accurate in their flight which are most perfect in sphericity and homogeneity; and it will be seen that the only practical advantage resulting from the employment of excentric shot and shells, is the increase of range which takes place when the centre of gravity is placed upwards; it must be remembered, however, that this increase is variable in amount, and that it can only be of use in firing at great distances, as against arsenals, roadsteads, or fortresses, so large and crowded that the objects can scarcely be missed.

When the centre of gravity is not coincident with that of figure, the projectile is made to revolve *ab initio* on the former centre; thus occasioning a compound motion in the flight of the projectile. Now, the shot being placed in, and fired from the gun, with the line joining the centres of gravity and figure in a vertical plane, and perpendicular to the axis of the gun; if the centre of gravity be above that of figure, the shot on leaving the gun must continue, as when passing along the bore, to turn over on a horizontal axis perpendicular to the plane of projection, the resultant of the projectile forces in the powder causing the front to turn in a direction from below upwards: hence the resistance engendered at the anterior surface of the projectile, by the rotation, conformably to the theory of M. Magnus (Art. 89), gives rise to a force of reaction which produces a motion of the shot upwards. The resistance engendered at the posterior surface of the projectile, by the same rotation, gives rise to a force which produces a motion of the shot downwards; but, as the density of the air is greater in front of, than behind the ball, on the whole the motion is upwards, and this increases the extent of the range.

If the ball moves in a direct line, and its axis remains always in the direction of that line, the air will be compressed in front of, and rarified behind the projectile, but will remain symmetrical with respect to density on the sides around the axis of rotation; and no deviation, or error of *derivation*, as M. Tamisier names it (because it is derived from the rotation of the projectile), will be engendered.

When the centre of gravity is below the axis of the bore, the resultant of the projectile forces will cause the front of the shot to turn from above downwards, and, a rotation in this direction continuing, the range will be diminished. In like manner, when the centre of gravity is placed on the right or left hand of the axis of the bore, the shot will turn on a vertical axis, and produce deviations to the right or left hand respectively. The cut represents a front view of the muzzle of a gun, with the projectile in it. The points *a*, *b*, *c*, *d*, show the different positions of the centre of gravity in a vertical section through the geometrical centre of the shot.

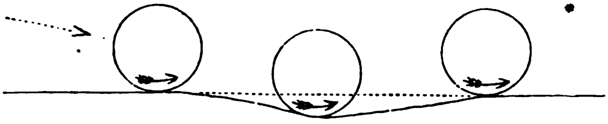
Fig. 9.



187. With respect to the ricochet of excentric spherical projectiles, there can be no doubt that the rotation which causes deflection in the flight must act in a similar manner to impede a straightforward graze. When an ordinary well-formed homogeneous spherical projectile, upon which probably very little rotation is impressed, makes a graze, the bottom of the vertical diameter first touches the plane and, immediately, the projectile acquires, by the reaction, a rotation upon its horizontal axis, by which the shot rolls onwards throughout the graze, favourably for a straightforward second flight.

But in the case of an excentric spherical projectile, placed with its centre of gravity to the right or to the left, its rotation upon its vertical axis during the graze must occasion a fresh deflection in its second flight; and it is only when the centre of gravity is placed in a vertical plane passing through the axis of the gun, that the rotation occasioned by touching the ground will not disturb the direction of the graze, though the extent of range to the first graze will be affected more or less, accordingly as the centre of gravity of the projectile may have been placed upwards or downwards. In the former case the rotation of the projectile conforms with that produced by the graze, and will not therefore retard the motion so much as when the centre of gravity is placed below. In the latter case, the projectile turning in the reverse direction tends to increase the resistance of the plane to the progress of the shot during the graze. In neither of these cases is there any tendency to produce deflection if the medium struck be uniform.

Fig. 10.



Fired with the Centre of Gravity upwards.

188. Although convinced of the soundness of the theory respecting the homogeneity of spherical projectiles and the truth of the practical maxims founded thereon, as well aware of the deviations occasioned by excentricity, the author deemed the subject one of so much importance as to require the fullest experimental investigation; and he addressed accordingly to the Lords Commissioners of the Admiralty, and to the Master-General of the Ordnance,[a] an earnest recommendation that courses of experiments should be instituted on board Her Majesty's ship "Excellent," and at Shoebury Ness, to ascertain the amount of the deviations, vertical and horizontal, in the flight of excentric spherical projectiles when placed in the gun with the centres of gravity and figure in different positions with respect to the axis of the bore, and to compare the flight of such projectiles with that of projectiles formed with the utmost possible attention to homogeneity and sphericity. The object in having such experiments made was to ascertain whether the deviations of the former were so regular as to admit of being allowed for in pointing the gun; and whether any result might appear to disprove the maxim that spherical and homogeneous projectiles are the truest in their flight. The recommendation was, with the utmost promptitude and liberality, carried into

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[a] July 9, 1850.

effect; and courses of experiments were instituted both at Portsmouth and Shoebury Ness.

The following are the results of the experiments made on board the "Excellent" at Portsmouth.

The positions of the centre of gravity are stated with respect to the geometrical centre of the shot; and the ranges with the deflections, which are expressed in yards, are the means of those obtained from the different rounds fired in the like circumstances.

July 18, 1850. With a 32-pounder gun of 56 cwt., the quantity of metal removed from one side of the shot being 1 lb.:—

	Charge 8 lbs., Elevation 2° 7½′.		Charge 10 lbs., Elevation 3° 30′.	
Position of the Centre of Gravity with respect to the Centre of the Shot.	Range.	Deflection.	Range.	Deflection.
On the Right ..	1032	6 right.	1474	20 right.
On the Left ..	1163	7 left.	1479	24⅔ left.
Upwards	1433	7 right, 3½ left.	1991	20 right, 6 left.
Downwards ..	980	5 right, 3 left.	1499	2 right, 6½ left.
Inwards	1150	4⅓ right.	1608	5½ right.
Outwards	1097	4⅔ right.	1428	9 right.
Concentric ..	1160	4 right, 3 left.	1624	1 right.

July 26, 1850. With an 8-inch gun, 9 feet long, of 65 cwt., the quantity of metal removed from one side of the shot = 5 lbs. 5 oz.:—

	Charge 10 lbs., Elevation 5°.		Charge 10 lbs., Elevation 2° 30′.	
Position of the Centre of Gravity.	Range.	Deflection.	Range.	Deflection.
Right..	1617	14⅔ right.	1040	5 right, 1 left.
Left	1684	17 right.	1028	2 right, 4½ left.
Upwards	1940		1146	4⅓ left.
Downwards ..	1562		957	3 right, 3½ left.
Inwards	1740	8⅔ left.	1126⅔	1½ right, 1 left.
Outwards	..		1080	8½ left.
Concentric ..	1702	3⅓ right.	1033	2¾ right, 2 left.

August 7th, 1850. A 32-pounder gun of 56 cwt., 9 ft. 6 in. long. Quantity of metal removed from one side of the shot = 1 lb.:—

Charge 8 lbs., Elevation 12°.

Position of the Centre of Gravity.	Range.	Deflection.
Upwards	3614	Variable.
Downwards	2676	Variable.
Coincident	3058	16½ right, 29 left.

An 8-inch gun of 65 cwt., 9 ft. 6 in. long. Quantity of metal removed from one side of the shot = 3 lbs.:—

Charge 10 lbs., Elevation 10°.

Position of the Centre of Gravity.	Range.	Deflection.
Upwards	3612	Variable.
Downwards	2480	Variable.
Coincident	2765	13 right, 13½ left.

189. The experiments were carried on under the direction of Captain (now Rear-Admiral) Chads, C.B. The shot were rendered excentric by a hole drilled in each of them on one side, and afterwards filled up with a wooden plug, or covered with a brass plate.

From the preceding abstract it is evident that the vertical deviations arising from the centre of gravity being placed upwards produced considerable augmentations of range, and, though these were variable in amount, yet, since they might become of great practical utility for particular purposes, it was desirable to ascertain whether a like increase of range might not be obtained when excentric shells are projected at great elevations from the most powerful guns.

190. The author, in consequence, addressed to the Master-General of the Ordnance (Memorandum of Sept. 5, 1850) a recommendation that experiments should be made at Shoebury Ness with a 32-pounder gun, with solid shot carefully selected, and with shot made excentric by removing some of the metal, as in the previous experiments, and likewise with excentric 68-pounder shot and excentric 8-inch shells at moderate and at great ranges. He also recommended that experiments

should be made in order to ascertain how much an excentric projectile revolving (as when the centre of gravity is placed sideways in the gun) upon its vertical axis would be deflected from its original course on grazing the ground.

Experiments with these particular objects in view being immediately ordered to be made, they accordingly took place at Shoebury Ness, under the direction of Captain Walker, R.A., and the three following tables contain an abstract of the results.[a] The first column shows the position of the centre of gravity with respect to the geometrical centre of the shot. The distances are in yards.

Sept. 19th and 20th, 1850. With a 32-pounder gun of 60 cwt.

	Charge 8 lbs., Elevation 2° 30′.		Charge 10 lbs., Elevation 2° 30′.	
Position of the Centre of Gravity.	Mean Ranges.	Mean Deflections.	Mean Ranges.	Mean Deflections.
Below	1137	6⅓ right, 4 left.	1287	10 left.
Above	1570	6⅔ right, 20⅔ left.	1633	9⅚ right, 21 left.
Right	1395	9⅔ right.	1346	13⅓ right.
Left	1252	17⅓ left.	1364	19⅔ left.
Inwards	1355	6⅔ left.	1393	4 left.
Outwards	1322	13⅓ left.	1386	2⅙ right, 3⅓ left.

October 3rd and 9th. With a 32-pounder gun of 56 cwt.

	Charge 10 lbs., Elevation 12°.		Charge 10 lbs., Elevation 2° 30′.	
Position of the Centre of Gravity.	Mean Ranges.	Mean Deflections.	Mean Ranges.	Mean Deflections.
Accidental	3006	59 right, 80 left.	1401	7⅓ right, 2 left.
In the axis of the bore	3114	72 right, 54 left.	1397	4⅙ right, 6 left.
Right	..	.. ..	1257	16 right, 6⅔ left.
Left	..	.. ..	1244	8⅔ left.
Upwards	3498	185 right.	1594	22⅔ right.
Downwards	2598	24½ right, 178 left.	1180	4⅓ right, 2 left.

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[a] In the preceding and following tables the means of the deflections towards the right and left hand are given separately. This method has been preferred because it exhibits the mean ratio of the deflections in opposite directions. The usual process is to add together (algebraically) all the deflections, considering those on the right and left to have contrary signs, positive and negative, and to divide the sum by the whole number of rounds; but this process exhibits an appearance of accuracy which does not always exist. Some artillerists have preferred taking the arithmetical mean of the deflections to the right and left without distinction of direction.

October 10th and 12th. With an 8-inch gun, 65 cwt., and the weight of the solid shot = 68 lbs., from which 4 lbs. of metal were removed in order to render the shot excentric.

	Charge 10 lbs., Elevation 5°.		Charge 10 lbs., Elevation 10°.	
Position of the Centre of Gravity.	Mean Ranges.	Mean Deflections.	Mean Ranges.	Mean Deflections.
Accidental	1820	16⅓ right, 18⅓ left.	2616	4⅔ right, 23½ left.
In the axis of the bore	1762	15⅔ right.	2702	80⅓ right, 32 left.
Right..	1726	53⅓ right.	2558	181 right.
Left	1608	15 right.	2332	57 left.
Upwards	2207	26⅔ right, 4⅔ left.	3339	141 left.
Downwards	1462	20 right.	2051	66 right.

191. The method adopted in making experiments with excentric shot was, first to ascertain the position of the centre of gravity, by floating the projectile in mercury, and marking its culminating point or vertex; then a mark upon the shot diametrically opposite to that point, gave the direction of the axis in which the two centres lay; thus the shot, when fixed to a wooden bottom, could be placed in the gun with the centre of gravity in the several positions, upwards or downwards, right or left, inwards or outwards, in which the flight was to be tried.

On making these experiments, it appeared that not above one iron shot in a hundred, when floated in mercury, was indifferent as to the position in which it was so floated, but turned immediately until the centre of gravity arrived at the lowest point, and consequently that not one shot in a hundred was perfect in sphericity and homogeneity. This defect commands the most serious consideration. It has been remedied, as we have seen (Art.. 89, Note), in the fabrication of leaden bullets, and there can be no doubt that, if duly notified to the contractors for the supply of iron shot, mechanical skill and ingenuity would discover some mode, by the employment of wrought iron,[a] of providing more

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[a] A proposition, emanating from an officer of the Royal Engineers (Captain Symmons), of great acquirements and intelligence, and much experience in the manufacture of wrought-iron girders and other heavy articles, has recently been made for fabricating guns of wrought iron, which, with equal powers of resistance to guns of cast iron, may be much lighter, and more capable of resisting the explosion of the charge. The reader will perceive (Art. 219, Note),

perfect shot, as well in figure as in density. The process by which this may be effected will no doubt render the shot much more costly, and, if it were necessary for general service, the expense would prove a fatal objection to the suggestion, but this is not required. Ordinary shot, however imperfect in these respects, are sufficient at distances and under circumstances which do not require a high degree of perfectibility. But when a successful result may depend upon the effect of one or two rounds—suppose from the pivot-gun of a large steamer, which may have just attained a favourable position, not likely soon to be regained, if the effect of its shot should fail—economy in expense becomes the worst of prodigality. It is now proved, beyond all doubt, that perfect concentricity is indispensable to accuracy in the flight of spherical projectiles; and no expense, therefore, should be spared in providing at least a few correct shot for such occasions.

192. On analyzing the experiments both at Portsmouth and Shoebury Ness, it appears that the flight of the ordinary solid shot was the most true, the lateral deflections being frequently but one-half, sometimes one-third or one-fourth only, of the

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that Mr. Daniel Treadwell, of the United States, constructed a 32-pounder sea-service gun, in great part of pieces of wrought iron welded together, and compressed by a hydrostatic machine of great power, the whole mass formed into a gun by turning and boring—therefore this is not a new proposition, so far as material is concerned; but it is anticipated that the means recently discovered for welding and consolidating bars of wrought iron into uniform masses will allow of a gun being produced of that material, sufficiently sound and tenacious to withstand the action of repeated discharges of shot by the agency of gunpowder,

With respect to shot, it may be stated that a manufacturer of great experience is now prepared to make shot of wrought iron for experiment. These will not be so apt to split or break as shot of cast iron; they may also be made more spherical, and perfectly homogeneous: it is, therefore, extremely desirable that experiments should be instituted to try that important proposition. Wrought-iron shot may be more liable to rust and corrode than cast-iron; but by proper precautions this may be prevented. If heated to a certain temperature, and then plunged into a vessel containing pitch, a very enduring lacker will be formed.

In a letter from Messrs. Fox, Henderson, and Co., addressed to Captain Symmons, it is stated that a wrought-iron shot 6.2 inches diameter would weigh 34.24 lbs., and one 6.3 inches diameter would weigh 35.92 lbs. Cast-iron shot of those diameters weigh, respectively, 31.89 lbs. and 33.46 lbs. Also that the price of 200 wrought-iron shot weighing 35 lbs. each (in all 3.12 tons) would be (5*s.* 5½*d.* each) 54*l.* 12*s.* If the shot were galvanized, the additional cost would be (1*s.* 3½*d.* each) 13*l.* 2*s.* Hence the total cost of 200 wrought-iron shot 6.2 in. diameter, galvanized, would be 67*l.* 14*s.*

deflections of the excentric shot; that these last deflections were always in the direction in which the centres of gravity of the shot were placed in the gun;[a] and that the increases or diminutions of range caused by the vertical deviations were produced, respectively, as the centres of gravity of the shot were placed upwards or downwards. It appears also that the lateral deviations, though, in general, constant in direction, were very variable in amount. In the experiments carried on at Shoebury Ness, on the 9th of October, 1850, the vertical deviation of a 32-pounder shot, with a charge of 10 lbs. and an elevation of 2½°, produced an increase of range equal to above 400 yards. And, on the following day, the vertical deviation of a 68-pounder shot from an 8-inch gun of 65 cwt., with a charge of 10 lbs. and an elevation of 5°, produced an increase of range nearly equal to 750 yards. There can be no doubt, therefore, that from a 68-pounder gun of 95 cwt., with a full service charge, and an elevation of 15° or 20°, a range may be obtained, which, under certain circumstances, may be of very great importance to the naval service of the country.

193. In October, 1850, Capt. (now Rear-Admiral) Chads made, on board the "Excellent," some important experiments with 10-inch shells, which he rendered excentric by boring two holes in each, diametrically opposite to one another, stopping up one with lead, and the other with wood. Shells thus prepared, and also common shells, were fired at elevations of 15° with 12 lbs. of powder; and, while the mean range of the latter was 3073 yards, the others, when the centre of gravity was upwards, ranged from 3200 to 3550 yards. These important results were produced by an excentricity which amounted only to .15 inch —a circumstance which will no doubt be noticed, and lead to the trial of a greater excentricity, in future experiments.

In compliance with the recommendation of the author, as above stated (Art. 190), four guns of 112 cwt., mounted on carriages which admit of elevating the gun up to 32° inclusive, were prepared as proposed by Captain (now Rear-Admiral) Chads, and the experiments were resumed at Shoebury Ness in July, 1851.

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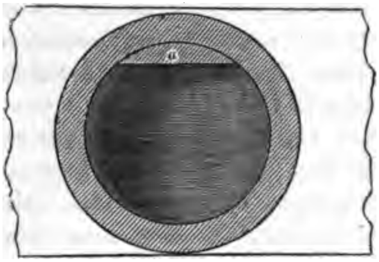
[a] There is one exceptional case only in the whole of the trials.

The shells were made excentric by being cast with a solid segment, *a*, weighing 4 lbs., of the interior sphere, left in the shell (fig. 11), by which the weight of the shell was increased to 91 lbs. The figure shows the position of the excentric shell as placed in the gun with the centre of gravity upwards, for the purpose of determining the longitudinal deflection, or increase of range, thence arising.

Fig. 11.



RESULT of COMPARATIVE TRIALS from 10-inch Guns of 112 cwt., $10\frac{1}{2}$ feet in length, with Excentric and Concentric Hollow Shot of 91 lbs. and 87 lbs. respectively, and 15 lbs. Charges of Powder, taken at Shoebury Ness, in the year 1851.

Elevation.	Nature of Projectile.	Ranges.	Increase of Range obtained with Concentric Shell.	Deflections		Times of Flight.
				to Right.	to Left.	
°		Yards.	Yards.	Yards.	Yards.	
2	Excentric	1192	.. ..	$1\frac{2}{3}$	$3\frac{2}{3}$	$3\frac{24}{40}$
	Concentric			Not taken.		
4	Excentric	1830	145	$9\frac{2}{3}$	$9\frac{1}{3}$	$6\frac{10}{40}$
	Concentric	1695		9	$10\frac{2}{3}$	$5\frac{27}{40}$
8	Excentric	3024	559	$48\frac{2}{3}$	61	$12\frac{10}{40}$
	Concentric	2465		$25\frac{1}{3}$	13	$9\frac{17}{40}$
12	Excentric	3805	621	37	116	$16\frac{8}{40}$
	Concentric	3184		$72\frac{1}{3}$	54	$13\frac{18}{40}$
20	Excentric	5076	939	$87\frac{1}{2}$	$105\frac{1}{2}$	$25\frac{24}{40}$
	Concentric	4137		157	109	$19\frac{18}{40}$
24	Excentric	5311	706	162	255	$28\frac{13}{40}$
	Concentric	4605		45	280	$24\frac{3}{40}$
28	Excentric	5566	916	185	221	$32\frac{26}{40}$
	Concentric	4650		89	198	$24\frac{27}{40}$
32	Excentric	5536	670	361	139	$34\frac{35}{40}$
	Concentric	4866		321	298	$28\frac{12}{40}$

It appears from the preceding table, that the excentric shell reached its greatest power of range at 28°, whilst that of the concentric shell continued to gain up to 32°; it remains to be seen whether at higher elevations the concentric shell would gain upon or overtake the other.

The deflections with both projectiles at these high elevations were very great, but those of the excentric cannot be said to have been in every case greater than those with the concentric shell; seeing that at 12° and 20° it was the reverse, and at 32°, whilst the deflection to the right was nearly equal, that to the left was more than twice as much with the concentric as with the excentric projectile.

In these experiments both the excentric shells and hollow shot were occasionally found to be cracked when recovered after firing. In prosecuting these experiments it may therefore be necessary to increase the thickness of metal in both these projectiles. The increase of weight thus rendered necessary, the charge remaining the same, will reduce somewhat the initial velocity: in some cases it may increase, in others diminish the range (Arts. 246, 251); but the projectile will be enabled the better to overcome the resistance of the air, and though the striking velocity may be less, the momentum, and consequently the penetrating power, which varies with the density of the projectile (Art. 82), will be greater than that of the lighter shell.

It must be remarked, that firing at these high elevations partakes so much of the conditions of vertical shell firing as to be liable to all the uncertainties of that practice with ordinary projectiles (Art. 268), and is such that there would be little probability of hitting a ship or battery; but in shelling fortresses, arsenals, crowded roadsteads, or any extensive space, these extreme ranges might be very serviceable.

In June, 1852, experiments were resumed at Shoebury Ness with a 10-inch gun, of 116 cwt., carrying an excentric shell of 100 lbs., and the following is an abstract of the results:—

Charge 16 lbs., Elevation 28°.		Charge 16 lbs., Elevation 32°.	
	Yards.		Yards.
Mean range in 10 rounds ..	5342	Mean range in 23 rounds ..	5675
Greatest range	5473	Greatest range	5860
Mean deflection, right	334	Mean deflection, right ..	107
,, left	380	,, left	284

It is deserving of remark that, after the greatest range (5860 yards) had been obtained, at the next discharge the gun burst. This was at the 54th round.

All the results above stated prove decisively the correctness of the deductions from theory, and of the practical maxim that errors in sphericity and homogeneity in a shot are causes of its deviation from a correct path; and it follows that spherical and homogeneous projectiles, being the most simple, and quite indifferent to the position in which they are placed in the gun and rolled home, as well as to that in which they pass through the atmosphere, are decidedly to be preferred to the others.

In ricochet firing, whether the rebounds take place from water, as in the experiments made on board the "Excellent," or on land, as in those carried on at Shoebury Ness, the shot when revolving on a vertical axis, instead of making a straightforward graze, suffered deflections which were invariably towards the same side of the line of fire as the centre of gravity; and at every graze up to the fourth a new deflection took place. (See Art. 188.)

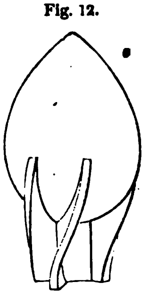
194. The results of these very curious and instructive experiments fully explain the extraordinary anomalies, as they have heretofore been considered, in length of range and in the lateral deviations: these have been attributed to changes in the state of the air, or the direction of the wind, to differences in the strength of the gunpowder, and to inequalities in the degrees of windage. All these causes are, no doubt, productive of errors in practice, but it is now clear that those errors are chiefly occasioned by the excentricity and non-homogeneity of the shot and the accidental positions of the centre of gravity of the projectile with respect to the axis of the bore. The whole of these experiments furnish decisive proof of the necessity of paying the most scrupulous attention to the figure and homogeneity of solid shot, and the concentricity of shells; and they exhibit the remarkable fact that a very considerable increase of range may be obtained without an increase in the charge, or elevation of the gun.

The abstract given in Art. 190 of the Shoebury Ness experiments is formed from the Report made to the Master-General of the Ordnance by the Select Committee to whom the consideration of those experiments had been referred; and, in concluding the subject, the author has great satisfaction in stating that the Report alluded to is perfectly in accordance with the views which induced him to recommend that those experiments should be instituted. The Report states that, though no useful application of the excentric principle can be made in general service, and that its use is limited to cases in which a more extended range may be required than is practicable under ordinary circumstances, yet the Committee expresses a decided opinion that the very interesting experiments which have been made, agreeably to the author's suggestions, must be considered as highly instructive, since they prove that the most influential among the various causes of the deflection of shot, in their flight, is the want of perfect homogeneity in their material.[a]

195. In December, 1848, and again in January, 1849, some experiments were made at Woolwich, in the presence of Colonels Dundas and Chalmer, with a shell weighing 57½ lbs., of a conoidal figure, having curvilinear grooves on its convex surface, the invention of a Captain Thistle, of the United States' army; but the ranges, and the accuracy of the practice, were found to be inferior to those of spherical shot from the same ordnance.

196. In March, 1849, Dr. Minesinger, an American, exhibited at Woolwich a spherical ball (23 to the lb.), having attached to it a four-grooved tail resembling the first screw-propellers with four leaves. The ball was fired from a gun 5 feet 7 inches long, with a percussion-lock. The gun contained at the breech a space for a chamber (an old construction), and five of these chambers, each 3 inches long, being previously loaded, might be successively introduced in the barrel, no ramrod being necessary. Each chamber has a projecting nipple, on which is a percussion-cap. The grooved tail of the ball is placed next to the charge, and 20 rounds may be fired in a minute.

Fig. 12.



Dr. Minesinger exhibited also an oblong shot or shell (fig. 12) for a 32-pounder gun, with a four-grooved tail similar to that of the musket bullet; it weighed

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[a] The Report was communicated to the author by order of the Master-General of the Ordnance, Jan. 11th, 1851.

46 lbs.; when used as a shell it is cast hollow, and has a copper cap placed on the end. Neither of these projectiles was found to answer the proposed purpose. Dr. M.'s shot were fired from a British 32-pounder of 56 cwt., with a charge of 10 lbs., and were found to be *decidedly inferior* to the service balls used with that nature of ordnance.

197. A very ingenious invention was, a few years since, patented by Mr. Lancaster, for causing a shot to rotate on its axis throughout the range, by firing it from a carbine or a piece of heavy ordnance, having an elliptical bore of small excentricity. The helix, which has a turn of about one-fourth of the periphery in its length, is not uniform, being nearly rectilinear to a certain distance from the bottom of the bore, and increasing gradually but rapidly in curvature from thence to the muzzle. In August, 1851, some experiments were carried on at Shoebury Ness, with an 8-inch cast-iron gun of this nature, 10 feet long and weighing 96 cwt. The ellipticity of the bore, or the difference between the axis, was .27 inch: the shot, of which a section perpendicular to the axis was elliptical, was hollow, its form cylindro-conoidal, and it weighed 75 lbs. An elliptical piece of felt, rather larger than the base of the projectile, was fixed to that base, with a plate of iron of the like form, but smaller, below it. This felt performed the office of the patch in the ordinary rifle, and it had the effect of taking away the windage without creating much friction.[a]

Seven rounds were fired, and in all, except one, the shells broke in, or on leaving, the gun; they were blown to atoms, as if they had been large iron canisters for holding powder, instead of being designed for projectiles.

In December, 1852, some further experiments were carried on at the same place, with a 68-pounder gun of 92 cwt., formed as above described, and carrying a spheroidal shell. With charges of 10 lbs., and elevations from 2° to 17°, the ranges to the first graze were from 1340 yards to 5600 yards. At the eighth round the shell stuck in the gun.

Two 8-inch round shot fired from the same gun, with charges

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[a] It will be seen in Art. 212 that, in the United States, shot have been enveloped in felt in order to prevent the abrasion of the bores of the guns.

[illegible] and at elevations of 15°, ranged, one of them to the distance of [illegible] yards, with a deflection to the right of 50 yards, and the other [illegible] yards, with a deflection of only 2 yards, to the right.

188. The author has ever entertained an opinion that the elliptically bored gun was a dangerous piece of ordnance, and he felt confident that if, with the maximum charge and an elevation of 18° as proposed, there were propelled solid shot or shells so strong as not to break, a great risk of the gun bursting would be incurred. This opinion was verified by the results of the experimental trials carried on at Shoebury Ness in 1854, when one of Mr. Lancaster's 68-pounder guns, which was formed of wrought iron, burst, though a reduced charge of 12 lbs., instead of 16 lbs. of powder (the maximum charge), was employed. The fragments were thrown to a considerable distance, but happily no one was injured, the firing party having, from some distrust of the gun's strength, been placed under cover: had it been otherwise, a fatal catastrophe must have ensued, as in the bursting of the guns at Malta and Gibraltar. It was observed that the vent had become much enlarged; but this circumstance, as well as the reduced charge employed, must be considered as having diminished the danger of the gun bursting. This accident, together with those which have since occurred on service, can be ascribed only to the peculiar formation of the bore, which causes the shot, in forcing its way through, to exert a great strain on the gun. In a former experiment a shell stuck in the bore while the gun was being loaded; and it is easy to conceive, therefore, that a shell might stick in going out; in which case, if the shell should not break, the gun must inevitably burst.

It is moreover a matter of no small difficulty to make a wrought-iron elongated elliptical shell. The body, without the bottom, is easily forged and formed; but to complete the shell, by welding the bottom firmly to the body, is not easily executed, and it appears that this is the main cause of failure. The cost of manufacturing one of these shells is at present something enormous. The formation of the elliptical bore is likewise a nice and costly operation, which enhances considerably the price of the gun over that of a 68-pounder. Wrought-iron shells do not, like those of cast iron, break into many pieces by the explosion of their bursting charge, but they are apt to open at their weakest parts. Also, the percussion-fuze, being at the apex of the shell, would, it appears, act before the body of the shell is imbedded in the material which it is intended to injure or destroy; and, when a wrought-iron shell is fired against a hard body, as granite, the point yields to the blow, and is blunted or doubled back, by which the impact of the shell is deadened, and the penetrating power is diminished.

To the vast force with which the projectile rubs and strikes against the surface of the bore, while following the spiral turn, and thus acquiring the properties of a rifle-shot, may be attributed the frequent breaking of the projectile, even when made of wrought iron. It requires much habitual skill, or knack, in serving the gun, to introduce and set the shell home, through the turning of the bore; and it is not unlikely that, in some instances, the bursting of the Lancaster guns may be occasioned by the oval ball leaving a space between it and the gunpowder, or by getting fixed in the gun by change of position whilst it is being propelled through the oval bore. Without the utmost care in loading, these guns must be liable to burst at every round, and the firing must be very slow. The strongest gun bursts readily if the ball be obstructed in its progress when near the muzzle, which, no doubt, was the cause of the bursting of one of the Lancaster guns near the muzzle at Sevastopol. With respect to leaden shots fired from the Lancaster elliptically-bored muskets, no such accident can happen with them; but they often *strip*, or pass straight out of the barrel, which must happen when, being heated in the flame, they change their form and do not follow the windings of the spiral bore. Iron shots are incapable of changing their form, and must, therefore, either follow the spiral bore, or cause the gun to burst. The withdrawal of the Lancaster elliptically-bored guns from the "Pelter" gun-boat at Portsmouth, and from the despatch-gun-boats "Arrow" and "Beagle" at Sevastopol, and the judicious order to arm all the new gun-boats with the 68-pounder guns of 95 cwt., were necessary consequences of the very unfavourable reports which were made of those guns at Bomarsund, as being deficient in precision, and not to be depended on, corroborated, as these reports were from very high authority on the spot, of the very bad practice made by the Lancaster guns at 1300 yards at Sevastopol in the land-batteries, and the fact that two of them burst! In firing into the town they were said to have done great damage to the place, when loaded with their own peculiar shells; but few of these having been supplied, the oval guns were chiefly used in firing round projectiles, shot and shells, grape and canister shot, all of which would have been more efficiently and appropriately used from 68-pounder guns. So confident were the expectations entertained of the alleged powers and the assumed precision of the Lancaster guns to destroy any works at a distance of 5000 or 6000 yards, that it was actually intended to rebore 68-pounders and 8-inch shell guns into the elliptical spiral form! This transformation would have weakened them so much, that the danger of bursting, to which elliptically-bored guns are already so liable, would be greatly increased:—it will undoubtedly spoil a capital 8-inch gun, and make a very bad and dangerous elliptical howitzer; because, being chambered, it is incapable of receiving the large charges requisite to produce the long range, in which, together with their alleged superior precision in distant firing, the peculiar merits of the Lancaster guns were supposed to consist; these were, in fact, the sole reasons for which they were introduced into the naval service. Though executed at enormous cost, and equipped with their peculiar shells (each wrought-iron shell is said to have cost twenty pounds), they have failed to accomplish on service the special purposes for which they were designed. They cannot, as has been shown, resist a charge of 16 lbs.; they are also proved to be defective in precision in distant firing, and even at short ranges. It must nevertheless be observed that the Lancaster guns may be useful for particular services. In the attack of Sveaborg (1854) Captain Hewlett commanded two gun-boats which were armed with them. Their fire was directed against a Russian three-decker which was moored across the harbour, and which their shells twice set on fire, besides causing the enemy a great loss of life by the explosions. It may be added that shot of 68 lbs. fired from these guns have as great a range as if fired from an ordinary gun of 95 cwt. The flight of the oblong projectile is certainly very erratic, but they may be used with advantage against large objects. Let it be observed that the bombardment of towns can be more effectually accomplished by mortars of equal weight,[a] projecting much heavier shells with equal bursting-charges, and producing nearly equal ranges.

199. The bombardment of a fortified place is more destructive to the non-combating inhabitants, generally very numerous, than to the defenders of the works, who, when not on duty, are lodged in shell-proof barracks, and produces less effect upon the military works than upon the dwellings of the citizens. In fact, the object of the bombardment is to compel the garrison to surrender, not by the injury which it may sustain, but by the slaughter and misery inflicted on the unoffending inhabitants; and no retrospect can be more afflicting than that which intrudes on the mind of one who, like the author, has witnessed the horrors of a bombardment.

When the very existence of a nation is menaced, when, consequently, self-defence, active as well as passive, is a paramount consideration, the infliction of the greatest possible injury on the aggressor, by any means whatever, becomes justifiable; but, in a war of policy, which should be directed rather against the chief of a state and his forces than against his subjects, a measure, the dreadful consequences of which fall upon these alone, must inevitably engender among them feelings of bitter animosity against the nation by which they have been so cruelly outraged.

200. But, if it be determined that a place, whether it be an inland fortress or a naval arsenal, shall be bombarded, the ordnance used should be of large calibre, and mortars should be

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[a] It was stated, some time since, that a certain number of mortar-ships were about to be constructed, and that they were to be armed with 13-inch mortars slung by the trunnions upon iron rods moving upon an iron shaft of 9 inches in diamèter, in such manner that by their pendūlous weight they may remain undisturbed by the motion of the vessel, and be fired with certainty, at any elevation, whatever be the pitching or rolling motion of the ship! We old artillerists of the war between 1793 and 1814 remember Congreve's suspended mortar, or howitzer, for it was either, accordingly as it might be placed in the slings; all such contrivances failed, and the author cannot help expressing his apprehension that such will be the result with respect to these suspended mortars. Twenty mortar-ships should have been sent with our fleets to the Baltic and the Black Seas during the war in 1854.

service, are not sufficiently cogent to warrant the disuse of such ordnance in naval expeditions. It appears to the author that a large fleet fitted out specially for the purpose of bombardment, should be provided with a certain number of bomb-ships. These are very inexpensively furnished, draw little water, and may be towed to their fighting positions by small steam-tugs: an officer and a few marine artillerymen suffice for the service of the mortars: they are also small objects for the enemy to fire at; and, if destroyed, there is comparatively little loss in value, and small risk of life. Seven bomb-ships were attached to the Baltic fleet in 1801, and, from these, at the time of forcing the passage of the Sound, shells were thrown into Cronenberg with considerable effect, while the fleet sustained no injury whatever from the enemy's guns. Admiral Nelson made use of those bomb-ships at the battle of Copenhagen; and to this bombarding power was greatly indebted in bringing those very critical operations to a successful termination. In the British naval service, though bomb-ships no longer exist, 13-inch and 10-inch sea-service mortars are retained: from this it appears that horizontal or howitzer shells, fired from the pivot-guns of steam-frigates, are supposed to be efficient substitutes for mortars in bombardments of fortresses and naval arsenals: but this is not so; and therefore to employ large and costly steam-ships in this way, is to incur a risk of very great loss in property and life, without the power of accomplishing the peculiar conditions required in bombardments, and which mortar-shells can so much more effectually fulfil. (See the preceding article.)

The bombardments by the French of St. Juan d'Ulloa, in 1838, and of Vera Cruz, in 1839, prove sufficiently that our neighbours have not abandoned the use of sea-service mortars; and, from the 'Aide Mémoire Navale,' we learn that such mortars are considered indispensable for bombardments. The French possess several mortar-ships (*bombardes*), as "La Dore," "L'Acheron," "Le Vesuve," "Le Cyclope," &c., each carrying two mortars and complements of 500 shells.

The following table gives the ranges, deflections, &c., of a 12-inch French sea-service mortar; and to these are added the number of shells in every hundred fired, which, in experiments with different mortars, fell within rectangular areas of various magnitudes.

employed rather than howitzers. When the object is to crush buildings or destroy shipping, bomb-shells, fired at considerable angles of elevation, should be used, in order that the momentum acquired in their descent may be sufficient to penetrate magazines or casemates down to the foundations, and, there exploding, set fire to the buildings, and create havoc and disorder among the troops; or, should they fall on ships, either pierce through and sink them, or, by exploding, blow them up. Neither percussion nor concussion shells, fired at comparatively small elevations, will serve this purpose; and it may be doubted whether any time-fuzes can withstand the shock of the charge which must be used in firing excentric shells (Art. 192) from a 68-pounder gun, or a 10-inch shell-gun, to obtain a range of 5000 or 6000 yards. But it is known that the fuze of a 13-inch shell will resist the shock produced by the explosion of 20 lbs. of powder in a sea-service mortar, and the fuze of a 10-inch shell will resist the shock produced by 10 lbs. of powder. The effect of the recoil of a 10-inch shell-gun downwards on the deck of a steamer, severely damages the vessel by straining it in every joint; but no distress is caused by the discharge of a 13-inch shell in a mortar-ship, in which the ordnance is placed on a solid mass of material resting on the bottom of the vessel.[a]

201. For the bombardment of a naval arsenal, the 13-inch mortar is a most valuable piece of ordnance; and, as its transport by sea is neither so difficult nor so costly as by land, the considerations which prevent, or impede to a great extent, the employment of these, and of 10-inch mortars, in the land-

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[a] The ranges of the 13-inch and 10-inch sea-service mortars differ very little from each other, the former being 4200 yards, and the latter 4000 yards, the elevations in both cases being 45°. (Tables II. and III., Appendix B.) The weight of a 13-inch mortar is 101 cwt., that of a 10-inch gun 86 cwt., and of a 68-pr. gun 95 cwt. The weight of a 13-inch shell, empty, is 190 lbs., and that of its bursting powder 6 lbs. 12 oz.; the weight of a 10-inch shell, empty, is 85 lbs., and that of its bursting powder 2 lbs. 12 oz. Lastly, the weight of an 8-inch shell, empty, is 41 lbs., and that of its bursting powder 1 lb. 14 oz. ('Artillerist's Manual'). The practice of these large shells, from their comparatively small initial velocities, with respect to range, time of flight, and velocity in the curve, may be determined with tolerable precision from the parabolic theory. (See Art. 49, Note.) A range of 4000 yards, or about 2⅓ miles, is quite adequate to the bombardment of any arsenal, with its magazines, barracks, dock-yards, and basins: these could scarcely be missed at every discharge, and a few 13-inch shells would suffice to crush the buildings and destroy the shipping.

service, are not sufficiently cogent to warrant the disuse of such ordnance in naval expeditions. It appears to the author that a large fleet fitted out specially for the purpose of bombardment, should be provided with a certain number of bomb-ships. These are very inexpensively furnished, draw little water, and may be towed to their fighting positions by small steam-tugs: an officer and a few marine artillerymen suffice for the service of the mortars: they are also small objects for the enemy to fire at; and, if destroyed, there is comparatively little loss in value, and small risk of life. Seven bomb-ships were attached to the Baltic fleet in 1801, and, from these, at the time of forcing the passage of the Sound, shells were thrown into Cronenberg with considerable effect, while the fleet sustained no injury whatever from the enemy's guns. Admiral Nelson made use of those bomb-ships at the battle of Copenhagen; and to this bombarding power was greatly indebted in bringing those very critical operations to a successful termination. In the British naval service, though bomb-ships no longer exist, 13-inch and 10-inch sea-service mortars are retained: from this it appears that horizontal or howitzer shells, fired from the pivot-guns of steam-frigates, are supposed to be efficient substitutes for mortars in bombardments of fortresses and naval arsenals: but this is not so; and therefore to employ large and costly steam-ships in this way, is to incur a risk of very great loss in property and life, without the power of accomplishing the peculiar conditions required in bombardments, and which mortar-shells can so much more effectually fulfil. (See the preceding article.)

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TABLE of PRACTICE with a French Mortar of 32 Cent. (12¼ inch), 1840.
Elevation 42°.

Charges.		Ranges.	Time of Flight.	Mean Deviation.				Charges.		Ranges.	Mean Deviation.			
				Longitudinal.		Lateral.					Longitudinal.		Lateral.	
lbs.	oz.	Yards.	″	Yds.	ft.	Yds.	ft.	lbs.	oz.	Yards.	Yds.	ft.	Yds.	ft.
1	1.6	279	7.33	5	1	8	2	1	15.7	545	9	2	15	1
2	3.2	601	10.6	10	3	16	1	2	5.8	654	12	0	17	1
3	4.8	984	13.5	16	1	24	0	2	10.7	763	13	0	19	2
4	6.4	1333	15.8	21	2	32	2	2	15.4	872	15	1	22	0
5	8.	1651	17.85	27	1	40	1	3	5.	981	16	1	24	0
6	9.6	1924	19.53	32	2	50	0	3	9.6	1090	18	2	27	1
7	11.2	2191	20.65	38	0	59	0	4	0.	1199	19	2	29	1
8	12.8	2458	22.55	43	2	67	2	4	5.1	1308	20	2	31	2
9	14.4	2694	23.6	49	0	75	1	4	11.2	1417	21	2	35	0
11	0.	2909	24.4	54	1	84	0	5	1.1	1526	24	0	38	0
12	1.8	3113	25.1	58	2	91	2	5	7.2	1635	26	0	41	1
13	4.	3271	25.6	62	0	99	0	5	14.2	1744	28	1	44	2
11	5.3	3405	26.15	65	1	105	2	6	5.3	1853	30	2	48	0
15	7.	3497	26.6	68	2	111	0	6	12.3	1962	32	2	51	1
16	8.6	3589	27.03	73	0	116	2	7	3.4	2071	35	0	54	2
17	10.4	3671	27.47	74	0	120	0	7	10.4	2180	37	0	57	2
18	12.	3744	27.85	75	1	124	1	8	1.9	2289	40	1	62	0
19	13.6	3817	28.22	76	1	127	1	8	9.	2398	42	1	65	1
20	15.4	3889	28.6	77	1	129	2	9	1.	2507	44	2	68	2
22	1.	3961	28.92	78	1	132	0	9	8.8	2616	47	0	73	0
23	2.6	4026	29.23	79	2	134	0	10	1.2	2725	50	0	76	1
24	4.2	4091	29.53	80	2	136	1	10	10.	2834	52	1	79	2
25	5.9	4151	29.8	81	2	137	1	11	8.4	2943	54	1	85	0
26	7.6	4211	30.05	83	0	139	1	11	12.	3052	56	2	89	1
27	9.2	4267	30.3	84	0	140	2	12	5·1	3161	59	0	93	2
28	10.7	4316	30.5	85	0	141	2	13	3.8	3270	62	0	99	1
29	12.4	4349	30.65	86	0	142	2	14	2.9	3379	64	1	103	2
30	14.1	4360	30.75	87	1	144	0	15	3.9	3488	67	2	111	0
								16	10.5	3597	71	0	116	2
								18	3.2	3706	74	0	122	0
								19	13.6	3815	76	1	127	2
								21	7.2	3924	78	1	131	0
								23	4.3	4033	79	2	134	0
								25	13.	4142	81	2	137	1
								27	3.9	4251	84	0	140	2
								30	14.	4360	87	1	144	0

The arrangement of this Table is the same as in the 'Aide Mémoire d'Artillerie Navale,' from which it was taken; the intention being that the Charges, Ranges, &c., for which the time of Flight is given, may be easily distinguished from the others.

Table of Practice with a Mortar, &c.—*continued.*

Number per Cent. of Shells which struck the Ground within—

	1. A Rectangle of indefinite length in the direction of the Line of Fire, and whose Breadth was, in Yards,								
	2	5½	11	22	33	44	54	65	87
Mortar of 32 c. (12½ in.) pointed at an object distant 654 yards ..	24.	35.5	53.5	74.	86.5	93.	96.	98.	99.5
Mortar of 32 c. and 27 c. at 654 yards (12½ in. and 10½ in.)	17.5	26.	40.	60.	72.5	84.5	91.5	96.	99.
Mortar of 27 c. (8½ in.) at 654 yards	13.	20.	30.5	48.	62.	75.	84.5	91.4	96.5
Mortar of 15 c. (6 in.) at 327 yards	11.	27.	50.	80.5	95.	99.	100.	100.	100.
Ditto ditto at 654 yards ..	..	..	..	..	..	..	..	..	..

	2. A Square whose Side was, in Yards,									
	2	3½	11	22	33	44	54	65	87	109
Mortar of 32 c. (12½ in.) pointed at an object distant 654 yards ..	.72	1.95	5.78	15.8	27.1	39.5	50.4	60.3	72.6	80.
Mortar of 32 c. and 27 c. at 654 yards (12½ in. and 10½ in.) ..	.53	1.43	4.32	12.8	22.7	35.9	48.1	59.0	72 3	80.
Mortar of 27 c. (8½ in.) at 654 yards	.33	.9	2.53	7.7	15.1	24.4	34.2	44.3	59.8	71.5
Mortar of 15 c. (6 in.) at 327 yards	..	..	..	..	..	..	..	..	..	..
Ditto ditto at 654 yards ..	.11	.68	2.56	10.3	21.4	34.9	48.	62.8	85.3	100.

202. Numerous gun-boats were sent to act with the naval force in the Baltic sea, in 1854, and no expedition intended to act in shallow waters was ever undertaken without being accompanied by such craft. Numerous gun-boats, each armed with a powerful gun, formed part of the equipment for the naval force sent to Walcheren in 1809, and were found extremely useful, on all occasions, in shallow inland waters. The day after the landing of the troops, a gallant and efficient attack was made by those boats on the fort of Ter Veer, then invested on the land side, which ended in the place being taken.

After the action at Copenhagen, in 1807, the Danes lost nearly all their line-of-battle ships and frigates, but they still possessed some stout brigs of war, and a great number of well-armed gun-boats; and during the calms which frequently prevail in the Danish waters, the latter were particularly destructive to the British cruisers and convoys.

On the 4th of June, 1808, during a calm in the Great Belt, the "Tickler" gun-brig, commanded by Lieutenant Skinner, was attacked by 4 Danish gun-boats, and after a conflict of four hours, in which the commander was killed, she was obliged to surrender. A few days afterwards, the bomb-vessel "Thunderer," Captain Caulfield, and the gun-brig "Turbulent," Lieutenant Wood, with a convoy of 70 vessels, were attacked by 25 Danish gun-boats, when the "Turbulent" was captured, with 10 or 12 of the merchant-ships: and on the 2nd of August, the gun-brig "Tigress," Lieutenant Greenswood, was taken by 16 Danish gun-vessels. On the 25th of October, in the same year, the British 64-gun ship "Africa," with a homeward-bound convoy of 137 sail, was attacked by a Danish flotilla, consisting of 25 large gun and mortar boats, and 7 armed launches; nearly all the convoy escaped, but the "Africa" was severely damaged; and, had the daylight continued two hours longer, she must have surrendered or sunk.[a]

On the 7th of July, 1809, a British squadron of 4 ships, under Captain Thomas Byam Martin, while cruising off the coast of Finland, discovered a Russian flotilla of 8 gun-boats, and a fleet of merchant-vessels, at anchor under Porcoln Point. The position which these had taken was one of extraordinary strength, being between two rocks, which served as covers to their wings, and from whence a destructive fire of grape could be poured upon any boats that should approach them. Notwithstanding this, the boats of the ships, 17 in number, advanced close up to the gun-vessels without firing a musket, and, boarding them, carried all before them: 6 of the vessels were taken, 1 sunk, and 1 escaped; 12 merchant-vessels also, laden with powder and provisions for the Russian army, were taken. On the 25th of the same month, 17 boats from a British squadron, under Captain Dudley Pater, attacked 4 Russian gun-boats, and, after a sanguinary contest, succeeded in capturing 3 of them.[b]

The Russians have now in the Baltic numerous gun-boats, which, keeping in comparatively shallow water, among the islands, where no large ship can approach them, are ready at every moment to issue forth and seriously annoy the most formidable fleet of line-of-battle ships on the coast.

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[a] James' 'Naval History,' vol. v. pp. 74-76.

[b] *Ibid.*, pp. 180-182.

PART III.

ON ORDNANCE RE-BORED, AND NEWLY CONSTRUCTED, FOR THE BRITISH AND FOREIGN NAVIES.

SECTION I.—ON BORED-UP GUNS.

203. THE practice of *reaming-out* guns, or boring them up, first took place in the British service in the year 1830, when about 800 guns, 24-pounders, 7 feet 6 inches long, which had been made according to the construction recommended by Sir William Congreve, and about as many more guns, also 24-pounders, of Sir Thomas Blomefield's construction, were bored up to 32-pounders for the navy. The practice was afterwards extended to iron guns of all natures, from the 9-pounder to the 32-pounder inclusive, by enlarging the bore of each to the next, and, in some cases, to the second higher calibre, and leaving reduced windages.[a] This may be considered as a temporary expedient to increase the weight of metal projected from such guns as were then on hand in this country, at a time when the advantages of large calibred ordnance were not absolutely decided on, and when the Government was not prepared to sanction the expense of casting new guns for projecting the heavier natures of shot or shells. But now that the vast advantages of heavy shot are well understood, and that France, the United States, and other countries have determined on arming their ships with new, long and powerful ordnance, the time is come in which the half measure, as it may be called, should be abandoned; that the bored-up guns in the service, with such exceptions as will be mentioned presently, should be superseded, and that good and efficient guns should be

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[a] The French, on the recommendation of General Paixhans, had previously decided to bore up their long guns to the next greatest calibre: but all guns so treated have been superseded in their naval service by new guns and canons-obusiers.

provided of calibres equal to those to which the bored-up guns were enlarged. By such a measure only can it be expected that in a future war our ships should be able to contend successfully with those of nations which have adopted in their navies the most approved natures of ordnance.

204. The great advantage arising from the reduction in the windage, together with the increase in the weight of metal projected, procured immediately for the bored-up guns a certain degree of consideration, which, it is to be apprehended, has caused the imperfections arising from the diminution of the quantity of metal in the gun itself to be overlooked. The reduced windage indeed permits, in some respects, equal effects to be produced with lower charges of powder than were used with the original gun. For instance: the old 24-pounder gun, whose windage was .211, when bored-up to a 32-pounder, with a windage equal to .123, and charged with 7⅓ lbs. of powder, would, with rather higher elevations, propel its shot as far as the gun in its original state with its usual charge of 8 lbs. The initial velocities would be the same (about 1600 feet per second), and the force with which the shot would penetrate into any material would be, at all practicable distances, in favour of the bored-up gun. Again, if the latter were charged with 6½ lbs. of powder, by which an initial velocity equal to 1490 feet per second would be produced, it would be found that the force of penetration is at first greatest in the original 24-pounder gun, with the charge of 8 lbs.; at the distance of about 400 yards from the object the penetrating forces become equal; and at all greater distances, the penetrating force of the larger shot of the bored-up gun is the greatest.[a]

205. It is not, however, from a comparison of the effects

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[a] It is to be regretted that, when the old guns were bored up to a higher calibre, measures were not taken to introduce uniformity in the quantity of windage, and that great anomalies in this respect were allowed to subsist. Thus the diameter of the bore of the old 32-pounder weighing 56 cwt., and of those weighing from 48 to 50 cwt., is 6.41 inches, while Congreve's and Blomefield's 24-pounders of 39, 40, and 41 cwt., were bored up (as 32-pounders) to 6.35 inches; and again, Blomefield's 24-pounder of 32 cwt. and his 18-pounder of 25 cwt. were bored up, as 32-pounders, to 6.3 inches. The calibre of Mr. Monk's gun (A) is 6.375 inches. Thus there have been introduced in the service four different diameters of bores for 32-pounder guns, consequently four different windages for shot of equal diameters.

produced by the bored-up guns with those produced by the gun in its original state, that the relative values of the former, and of a gun equal in calibre but of more perfect construction, are to be determined. The advantages with respect to the power of penetration, which appear to be so much in favour of the bored-up gun, are perhaps more than counterbalanced by the defect arising from the diminution of the weight of metal in the gun, by which its recoil is rendered considerably greater than that of a gun of equal calibre and of the original formation. This circumstance, besides producing greater strain on the carriage, renders the gun more unsteady, and the practice, in consequence, more uncertain. If, in order to diminish the recoil, smaller charges of powder be employed, the penetrating power of the shot will be diminished in a corresponding degree.

206. Captain Simmons, in his 'Discussion on the Present Armament of the Navy,' has calculated a table (page 18), in which are shown the relative penetrating powers of a 24-pounder gun, and the same gun reamed out to a 32-pounder, the charge of the latter being diminished so far that the initial velocities are proportional to the weights of the guns with their carriages; when, consequently, the recoils or strains are rendered equal to one another. In this state the penetrating force of the bored-up gun falls even below that of the original 24-pounder, till the distance of the shot from the gun is about 3000 yards; but at such a distance as this, the elevation of the gun being necessarily high, the practice must be extremely uncertain. It is thus of the utmost importance, as well with respect to the extent and accuracy of the range as to the penetrating power of the shot, that a gun should contain a certain mass of metal with relation to the weight of the projectile; a deficiency in that mass causing the advantages of a diminished windage to be in a great measure lost; the shaking of the piece before the projectile quits it, particularly when high charges of powder are used, unavoidably producing irregularity in the initial direction of the shot. The perfection of a gun consists in an union of both qualities, steadiness and the least possible windage; for only by these combined can it be rendered capable of throwing shot to the greatest distance within battle range, with

the least elevation, and, consequently, with the greatest amount of useful effect.

207. Since the country now possesses a considerable number of new guns of large calibre and improved constructions, no reason exists for retaining bored-up guns as part of the armament of the British navy, except, perhaps, for brigs and other small vessels, or for private ships hired into the service. The French have no bored-up guns on the broadsides of their ships of the line or frigates;[a] nor are there any bored-up guns in the United States' navy, except the 8-inch guns, which were bored-up from 42-pounders. All the guns retained in that service are either the most efficient of the old ordnance, or certain others whose use has not yet been discontinued.[b] A great prejudice exists in the United States against the practice of boring-up,

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[a] The French ships are armed, or are appointed to be armed, with the following natures of gun, exclusive of canons-obusiers (the weights and dimensions are expressed in English denominations):—36-pounders (Fr.), length 9ft. 7 in., and weight 69 cwt., the weight of the shot being 43.21 lbs.; 30-pounders (Fr.), No. 1, length 9 ft. 8 in., and weight 59 cwt.; 30-pounders (Fr.), No. 2, length 8 ft. 6 in., and weight 49 cwt., the weight of the shot for both being 34 lbs.; and 24 pounders (Fr.), length 9 ft. 4 in., and weight 41¼ cwt., the weight of the shot being 26 lbs. 10 oz.. The decree of the 27th of July, 1849, by which the 50-pounder gun, 10 ft. 2 in. long, and weighing 84 cwt., had been ordered to be introduced into the French naval service, was rescinded by the commission which drew up the 'Enquête Parlementaire' (see tom. ii. p. 405 of that work), and 30-pounder guns were ordered to be substituted for them: this was done on the ground that, as the weight of the 50-pounder is far greater than that of a 30-pounder, by the substitution of the lighter but very efficient gun, vessels may be armed with a greater number of pieces; and, from the circumstance, it is evident that the commission attached more importance to the fire of the smaller ordnance than to that of the heavier nature, which would, necessarily, be fewer in number. It appears by the proceedings of the commission of Gavre, 1848, that three other new pieces of ordnance have been adopted in the French naval service. 1st. A canon-obusier (No. 3) of 80 (*livres*); its charge for hollow shot being 2.5 kil. = 5 lbs. 8 oz., and for solid shot 2.6 kil. = 5 lbs. 12 oz.: these are somewhat shorter than the pieces of the same nature already established. 2nd. A new 30-pounder (Fr.) gun (No. 3), its charge, with solid shot, being 3 kil. = 6 lbs. 10 oz. (reduced charge 2.5 kil. = 5 lbs. 8 oz.), and for hollow shot, 2 kil. = 4 lbs. 6 oz. The commission ascertained the ranges of a new 60-pounder gun, with solid shot and charges of one-third of the shot's weight: they also compared together the effects produced by this gun, the new 50-pounder and the new 30-pounder guns, with respect to range, and to the ravages made by their shot in targets representing the sides of ships.

[b] These are long 24-pounders, length 9 ft. 4½ in., and weight 50 cwt., and 18-pounders, length 8 ft. and weight 38 cwt., on board of the "Constellation," "Macedonian," and other ships.—*Ward*, p. 36. It is perhaps to be regretted that the long 24-pounder (length 9 ft. 6 in., and weight 50 cwt.) should have been discarded from the British navy.

since a 42-pounder bored-up to a 64-pounder, the diameter being enlarged from 7 to 8 inches, with a charge of 14 lbs., burst on board the "Fulton;" the service-charge was 8 lbs.

The long 42-pounder so reamed out, and carrying a ball of 64 lbs., is said to afford, with a charge of 12 lbs., a better range at the second graze than the gun in its original state (*Ward*, 'United States' Navy,' p. 105); but at the first graze, and at elevations not exceeding 3 degrees, the long 42-pounder with a charge of 12 lbs., which the reamed-out gun could not sustain, is greatly superior to the other.

Since the publication of Lieutenant Ward's Treatise there have been introduced, in 1851, a new shell-gun 8 feet 10 inches long, and weighing 63 cwt., and another 8 feet 4 inches long, weighing 55 cwt. Besides these, in 1850, a new 64-pounder unchambered gun 10 feet 8 inches long, and weighing 105 cwt., was adopted as a pivot-gun for vessels of all descriptions. Thus has been realized Lieutenant Ward's announcement that a gun possessing, in the highest degree, extent of range, accuracy of fire and power of penetration, was being prepared for purposes which essentially require those important faculties.

208. The defects of bored-up guns were sensibly experienced on board the "Sesostris" steam-ship, Captain Ormsby, commander. This vessel was armed with 32-pounder guns, which had been bored-up from 24-pounders; and it was found that, after a few hours' firing, the breechings were destroyed and the bolts drawn, so that her ordnance became unserviceable, even with greatly reduced charges.

209. Bored-up guns, besides being subject to the defect just mentioned, are found to be not altogether safe when fired with two shot; there are even some of them for which double-shotting was always prohibited; and, where the practice was allowed, very reduced charges were considered indispensable. The following table shows the charges with single shot for bored-up guns. No charges for double shot are now officially given.[a]

All the bored-up guns, with single shot, have been proved

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[a] It is no longer contemplated to use double shot with any nature of bored-up guns.

Nature of Gun.		Proof Charge in Pounds, single Shot.	Service Charge in Pounds, single Shot.	Shot.	Wad.
	cwt. cwt.				
32-pounder ..	39 and 40	12	6	1	1
	32	10	5	1	1
	25	9	4	1	1
18-pounder	22	7	3	1	1
	20	7	3	1	1
	15	5	2	1	1

with charges equal to about one-third of the shot's weight; but it has been found that, after being bored-up, many of the old 24-pounders with two shot, when fired with a charge of 11 lbs. of powder, burst, after having stood, with a single shot, a charge of 18 lbs. In order that such guns may be considered safe when double-shotted, it is evident that they should be tried, so shotted, with quantities of powder considerably greater than the reduced charges stated in the table. This uncertainty respecting the safety of the bored-up guns is surely a strong argument against them; and, though it would be much better if all were discarded, it is satisfactory to find that the only bored-up guns which are now to be retained in the Royal Navy are the 32-pounders of 41 cwt., 40 cwt., and 39 cwt., which have been so converted from Blomefield's and Congreve's 24-pounders; and 18-pounders, which have been bored-up from 9 and 12-pounders for the armament of small vessels. The 32-pounders just mentioned are ultimately to be replaced by the 32-pounder new gun, 8 feet long, and weighing 42 cwt.

SECTION II.—ON MONSTER GUNS.

210. In 1810, the French having caused some large pieces of ordnance to be cast at Seville, formed with them batteries at the Trocadero Point, from whence they threw shells into Cadiz, a distance of more than 5000 yards. (Art. 102, Note.) In order to obtain this range, it was necessary to use enormous charges, and to nearly fill the shells with lead. These pieces of ordnance were the invention of Colonel Villantroy, of the French artillery. They were a sort of long howitzer, with trunnions, and were capable of being fired at great elevations with high

charges; they also possessed great powers of range, even at low angles, with hollow shot; and it has been said that the construction of these howitzers suggested to Colonel Paixhans the principle on which he afterwards formed his canons-obusiers. It is, however, a remarkable circumstance that the Emperor Napoleon I. was, in fact, the originator of both natures of ordnance; since, in addressing the Ministre de la Marine, Décrès (1807), he writes to the following effect:—"I desire that you will cause to be cast for trial, in the foundry at Douay, a gun which may project shells of 8 inches diameter. Provide also some solid shot of 78 lbs. to be used with those pieces, and try the ranges and effects which may be obtained. Cause also to be cast shells and hollow shot of 48 lbs., and let them be tried. Such projectiles, fired from batteries of twenty pieces of the above description, should produce great effects."[a]

At the siege of the citadel of Antwerp, in 1832, the French used a mortar whose calibre was 24 inches, and weight nearly 7 tons, and it projected a shell which, with its bursting-charge (= 99 lbs.), weighed 1015 lbs. The effect, however, was not so great as was anticipated, and the mortar afterwards burst while being fired.

211. In the years 1842 and 1843 there were cast in England, for the Pacha of Egypt, three large pieces of ordnance, of which one was a simple gun, without chamber, 12 feet long, having a calibre of 10 inches (windage .16 inch), and weighing 11 tons; this was intended to project solid shot, each weighing 128 lbs., or shells, each weighing 82 lbs. The second was a howitzer-gun 13 feet long, having a calibre of 15.3 inches (windage .2 inch), with a chamber on Paixhans' principle, and weighing 18 tons; it threw solid shot, each weighing 460 lbs., or shells, each weighing 326 lbs. The third was a mortar, having a calibre of 20 inches (windage .2 inch), and weighing 13 tons; its chamber was conical, and similar to those of the British sea-service mortars; it threw a solid shot weighing 1030 lbs., or a shell weighing 658 lbs.

The Pacha's 130-pounder gun was fired at Deal, in July, 1842, from a carriage similar to those which are used on board

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[a] Thiers' 'History of the Consulate and the Empire.'

the British steam-vessels, with charges equal to 26 lbs. (considered as the established charge), 29 lbs., and 32 lbs. of powder; but as very little additional extent of range was obtained when the higher charges were employed, those only which resulted from the charge of 26 lbs. are given in the subjoined table. The other ranges in the table are results of computation, with the charges there stated, which are such as are supposed to be employed on service. In all the ranges the height of the gun above the plane on which the shot is supposed to fall is 16 feet:—

Description of Ordnance.	Weight of Shot or Shell in Pounds.	Charge in Pounds.	Elevations.				
			Point-blank.	5°	10°	15°	20°
			Ranges in Yards.				
Pacha's 130-pounder	Shot, 128	26	558	2151	3253	4040	4669
	Shell, 82	16	420	1767	2532	3130	3440
Pacha's 15-inch gun	Shot, 460	45	333	1235	2130	2810	3370
	Shell, 326	45	367	1553	2534	3110	3500
Pacha's 20-inch mortar	Shot, 1030	45	..	700	1035	1693	1970
	Shell, 658	45	..	907	1716	2078	2479
United States' gun	Shot, 213	30	360	1617	2600	3267	3730
	Shell, 152	30	400	1853	2759	3370	3924
French mortar ..	Shell, 1015	30	..	400	834	1033	1317

On comparing the above ranges with those which were obtained in the practice on board the "Excellent," (Table V., Appendix D.), it will readily be seen that little or no advantage would be gained, in this respect, by the employment of such unwieldy pieces over the more manageable ordnance in use in the British service.

212. In the year 1845 there was forged at Liverpool, for the United States' steam frigate "Princeton," a gun, having a bore 13 feet long, with 12 inches calibre (windage .25 inch); the gun weighed about 7½ tons, and it was intended to project from it solid shot weighing 213 lbs., or shells weighing 152 lbs. The gun is without a chamber; and a remarkable circumstance is, that the shot is to be enveloped in felt, in order to prevent the abrasion of the bore; this expedient appears to have been advantageously adopted with other guns of considerable magnitude in the service of the United States, windage being allowed

accordingly. It is said that this gun was intended to replace that which, some time before, had burst on board the same vessel; by which accident several persons, among others the Secretary of State, lost their lives. The last mentioned is said to have been made of wrought iron, not forged in the solid and then bored, but formed by welding together bars of wrought iron and fortifying them with strong hoops of that material.

213. In 1856 a gun of wrought iron 15 feet 10 inches long, and 13.05 inches in diameter of bore, was executed by the Mersey Iron Company, and submitted to the Government for the purpose of having a trial made of its powers. Its form is nearly that of a frustum of a cone, and it is strongly reinforced; the diameter at the base ring being 3 feet 7½ inches, at the trunnions 3 feet 3¾ inches, and at the muzzle 2 feet 3½ inches. It is intended to fire a solid spherical shot weighing 280 lbs., and the windage is .2 inch. The weight of the gun is 21 tons 17½ cwt., and of the carriage 7 tons 1½ cwt.

In November, the same year, this gun was experimented on, in presence of H.R.H. the Duke of Cambridge and a select committee of the Ordnance, who were appointed to witness and make a report of the results. On this occasion ten rounds were fired in each of the different positions of the gun, with charges of 50 lbs. of powder; and the following table contains the means of the several ranges obtained, with those of the deflections at each angle of elevation :—

Elevation.	Range in Yards.		Deflection in Yards.	
	First Graze.	Extreme.	First Graze.	Extreme.
°				
0 or P. B.	599	5316	2	37
1	1023	4540	2½	33
3	1800	3957	6	25
5	2433	3592	7	19½
7	2988	3418	10	11
10	3523	3523	31½	31½
12	3883	3883	34	34
15	4497	4497	69	69
18	4996	4996	98	98

The vent having become enlarged, the gun was bouched after the 70th round; and on comparing the ranges of the shot with those obtained from a 68-pounder gun (95 cwt.), smooth bore, and with a Lancaster's 68-pounder (95 cwt.), it appeared that they were always greater than the ranges given by the first of these two kinds of gun, and greater than those obtained from the other, up to 5 degrees of elevation; beyond this the Lancaster gun ranged farthest; and at 18°, the range of this last was 5300 yards.

When the new gun was received from the Company it was found that there had existed in it two flaws near the bottom of the bore; one of these had been bored out, and the cavity filled with a plug of iron 8 inches diameter and 4 inches deep; the other, which was 2½ inches long and ⅓ inch deep, remained. After the termination of the firing the flaws appeared to have undergone no change; but there was found to be a crack in the bore extending from the plug to a distance of about 3 inches.

The author cannot help expressing his conviction that such immense pieces of ordnance are quite inapplicable either for sea or land service. Could a gun capable of discharging shot of 68 lbs. be reduced in weight from 95 cwt. to about 60 cwt., it would be of great practical utility.[a]

214. The enormous engine intended for destruction, which was lately executed by Mr. Mallet, under the patronage of Lord Palmerston, is a vast mortar, consisting at the lower end of a solid cast-iron breech, abutting on which is a series of wrought iron hoops following each other in succession up to the muzzle; these are inserted into each other by rebates, and are firmly secured by six iron staves, at equal intervals about its surface, extending longitudinally the whole length of the mortar. The lower extremities of these enter into the base-ring, and the upper extremities pass through openings in the muzzle-ring, beyond which they terminate in large rivet-wads. The rings are firmly bound together by means of wedges, which are driven through the lower ends of the staves, beneath the projections of the cast-iron breech, and serve to tighten, when required, the whole system of rings or hoops. The total weight of the mortar is

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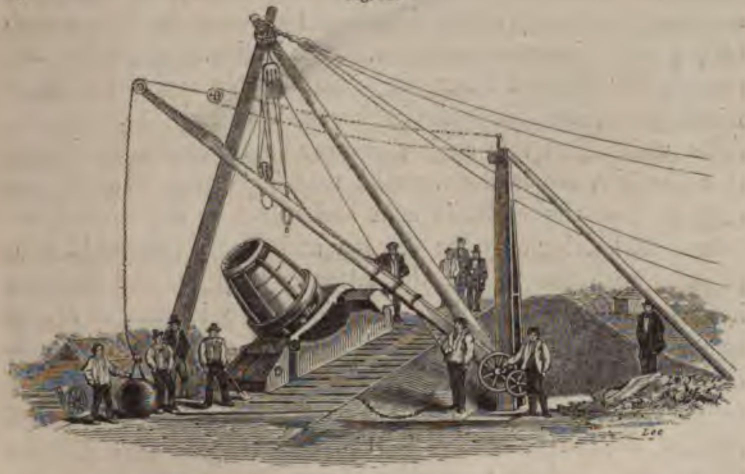
[a] This was written before the invention of the Armstrong gun.

50 tons 13½ cwt.; the diameter of the shell which it is to discharge is 3 feet, and its weight, when unfilled, is 26½ cwt. The diagram below represents the mortar, on its cast-iron bed, resting on an inclined plane of timber. The shell is raised up to the muzzle of the mortar, and lowered down to the chamber (of the Gomer pattern), by a strong tackle which is suspended from sheers; and the same apparatus is employed to give the mortar the required elevation.

Fig. 13.



Experiments which have been made with the mortar at Woolwich show that there is a tendency to separation between the trunnions and the cascable; the expansive force of the powder, acting on the breech, causes the latter to yield and press upon the part behind the trunnions; the staves are then strained, and, after a few firings, become elongated; then openings between the hoops take place, and it becomes necessary to suspend the firing in order to avoid the dangerous consequences which would ensue. The mortar is said to have cost 8000*l.*, and the results of the experiments are such as to leave no reason to think that it can ever be employed on service.

215. As there is now some probability that wrought iron will hereafter be much used in the manufacture of artillery, it may be of some importance here to notice the manner in which it is

produced from the ore, with the latest improvements which have been adopted for purifying it.

It is well known that wrought iron of the purest quality is imported largely into Great Britain from Russia and Sweden; and in those countries charcoal from wood is employed in smelting and working the iron. This material is too scarce to be used here, and in the British manufactories coke is used for those purposes. But coke contains many extraneous substances which become absorbed in the molten iron, and thus make it necessary to employ artificial means to render the iron sufficiently pure to become malleable. It is in the latter part of the process that Messrs. Nasmyth of Manchester, and Bessemer of Birmingham, have made the improvements alluded to.

To understand this subject it may be necessary to observe that the iron ore is first *roasted*, that is, burned in mass with coal, so that the carbonic acid and water of the mineral are driven off, leaving only the oxygen and earthy matters in combination with the metal; the latter is then *reduced* by being heated with coke and lime, by which these impurities are in some measure removed, and the melted metal is afterwards drawn off into moulds. This is the pig iron, or the cast iron, of commerce: it is far from being pure, containing at least 5 per cent. of foreign substances,—as carbon, phosphorus, sulphur, silicon, &c.; and the conversion of cast iron into malleable iron is effected by the further removal of these impurities.

This is done, usually, by exposing the melted iron, in contact with the atmosphere, to a strong heat, by which a large portion of the carbon is carried off, while the silicon combines with the oxide of the iron, and constitutes the *slag;* the metal next undergoes the laborious process of being *puddled*, which consists in fusing it on the bed of a furnace and stirring it about with an iron bar, so as to expose every part of it to the action of the air, by which the oxygen is absorbed, and the carbonic oxide escapes in bubbles. The slag is at first incorporated with the metal, and contributes to the removal of the impurities; after which it is separated from the iron by powerful compression and kneading between rollers. It is in this removal of the oxygen and the carbonic oxide that the improvements of Messrs. Nasmyth and

Bessemer consist. The former causes to be passed through the molten mass blasts of highly-heated, or dry steam, and the latter gains the end by passing strong blasts of air, which blow the metal into the state of a sponge, and thus permit the impurities to be carried off. In both processes a great part of the manual labour hitherto employed in the operation of puddling is dispensed with.

The malleable iron thus obtained is fit for all the purposes required in the arts: iron perfectly pure is never seen except in the laboratory of a chemist. Steel is iron combined with a small proportion of carbon; and that of the East has always been highly valued for the manufacture of cutlery and weapons of war—a circumstance due to the purity of the iron-ore in those regions, and to the use of charcoal in converting it into metal.

SECTION III.—NEW GUNS FOR SOLID SHOT.

216. It has been observed (Art. 135), that Sir William Congreve was the first who proposed to diminish the quantity of metal in the chase of a gun and increase the quantity about the seat of the charge, in order to gain a greater degree of strength without increasing the weight of the gun. The pieces of ordnance constructed by that officer were 24-pounders, 7½ feet long, and weighing from 40 to 42 cwt.; and a certain number of these constituted the armament of the "Eurotas" frigate at the time she engaged the French frigate "Clorinde," which was equipped with long 18-pounders.[a] These experimental guns certainly did not do so much execution in proportion to the duration of the action (nearly two hours) as had been done on many other occasions by an equal number of long 18-pounders, or in proportion to what she, the "Eurotas," suffered from the fire of the "Clorinde." This, perhaps, was owing in part to deficiency in the gunnery of the British frigate, but the main defect was in the short 24-pounder guns, which, however they may have succeeded in the experiments at Sheerness (when they *bounded* but a little more than the long 24-pounder against which they were tried), acted most violently on their carriages when heated with continued firing in that protracted action. This is ascribed

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[a] James' 'Naval History,' vol. vi. pp. 272, 273.

partly to the greatness of the windage, partly to the charge (one-third of the weight of the shot) being too high, and again, to the diminution of the preponderance of the breech by the trunnions being placed so far back.

217. General Sir Thomas Blomefield, about the same time, procured to be executed a considerable number of 24-pounder guns on nearly the same principle; but as neither of these kinds of ordnance were considered as having succeeded, others were cast upon a principle which was brought forward by Mr. Monk in 1838. That principle consists in maintaining the proportion which the weight of metal in a gun should bear to that of the shot[a] (about $1\frac{3}{4}$ cwt. in the gun to each pound in the weight of the shot); at the same time increasing the thickness of metal round the cylinder of the charge, and diminishing it in the chase.

Mr. Monk's proposition having been approved, he first applied his method in the construction of a 56-pounder, 11 feet long, and weighing 97 cwt. (Table VI., Appendix B.); and in this he so far reduced the thickness of metal in the chase, that he was able to appropriate an additional quantity, amounting to about 10 cwt., in the part immediately surrounding the cylinder of charge; thus he considerably increased the thickness of the gun to a certain distance in front of the load, and formed a piece of ordnance much stronger in the part where strength is most required, and yet lighter than any other iron gun of the same calibre before made. The windage in this gun was reduced from .235 inch, or about $\frac{1}{33}$ of the diameter, to .175 inch, or about $\frac{1}{44}$ of the diameter.

At that time, 1838, the heaviest solid-shot gun in the naval service was the 32-pounder, 9 feet 6 inches long, and weighing 56 cwt., the 42-pounder having been discarded, and not yet replaced by one of improved construction (see Art. 222); but shell-guns of large calibre for hollow shot and shells, had then recently been introduced for the armament of steamers.[b] Whether Mr. Monk designed his 56-pounder gun as a rival to the 8-inch shell-gun or not, does not appear; but that his guns,

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[a] As in the 32-pounder gun for general service.

[b] In 1824 the 10-inch gun; in 1825 the 8-inch gun, weighing 50 cwt.; and in 1838 the 8-inch gun of 65 cwt.

and some others of large calibre (the 68-pounder of 95 cwt.), do enter into very favourable competition with the shell-guns, and prove themselves to be more efficient in distant firing, and therefore preferable for the bow guns of steamers, is a truth which forces itself upon our serious consideration, and to this subject we shall accordingly apply ourselves hereafter. His immediate object in bringing forward his 56-pounder of 97 cwt. was to obtain by it more efficient and accurate practice at great ranges for general service, but more particularly for coast defences, in which artillery having the greatest powers of range seaward is of the utmost importance. But it appears by Table VI. that the 56-pounders of 87 cwt. and 97 cwt. have now become obsolete in the naval service, and the 68-pounders of 95 cwt. generally adopted as pivot guns.

218. From experiments made with the 56-pounder gun at Deal, in 1839, with charges of 16 lbs. and 17 lbs. of powder, at different elevations, it was proved that at an elevation of 32 degrees, with a charge of 16 lbs., its shot ranged to the distance of 5720 yards; exceeding the range of a 32-pounder, with a charge of 12 lbs., at nearly the same elevation, by 860 yards. Experience showed that the 16 lb. charges gave ranges, with solid shot, as long as, if not longer than charges of 17 lbs.; and 16 lbs. of powder were consequently adopted as the maximum charge for such guns.

A heavy 42-pounder, whose weight (80¾ cwt.) was 216 times the weight of its shot, was compared with the 56-pounder, whose weight (90½ cwt.) was 236 times that of its shot, at an elevation of 15 degrees, the greatest which could be given to the 42-pounder; and likewise with the 10-inch gun of 85 cwt., with hollow shot, when the following ranges were obtained:—

The 56-pounder	4087 yards.
The 42-pounder	3732 „
The 10-inch gun	3546 „

The trials between the 56 and 32 pounders were continued up to an elevation of 33 degrees, when, at the sixtieth round, the 32-pounder burst.

A 68-pounder of 110 cwt. was then prepared, and afterwards one of 112 cwt. The former was tried with a charge of 18 lbs. ($\frac{1}{3.77}$ of the weight of the shot), and the latter with one of 20 lbs. ($\frac{1}{3.4}$ of the weight of the shot), both of them with solid shot: but their ranges were not superior, if equal, to those of the 56-pounder, with a charge of 16 lbs., or $\frac{1}{3.3}$ of the weight of the shot. One of the most valuable guns in the service is the 68-pounder which has been constructed by Colonel Dundas: its length is 10 feet, and it weighs 95 cwt. Its greatest service-charge is 16 lbs., and its proof charge 25 lbs. (See fig. 12, plate II.)

219. It had been intended to bore-up all the 6-feet and 9-feet 24-pounders to 32-pounders, but, in the trials made with several, they failed, partly through a diminution of the windage from .21 inch to .15 inch, and partly from the increase in the weight of the shot; on which accounts, though the diminution of the weight of metal was inconsiderable in itself, the strength of the guns was so much reduced that they could not resist the charges; it therefore became necessary to provide new 32-pounders, medium guns, as they were called, in order to complete the gradation to the old standard, the 32-pounder of 56 cwt., and 9 feet 6 inches long.

Mr. Monk accordingly applied his method in the construction of the new 32-pounder of 50 cwt., 9 feet long; and he produced the excellent gun marked A (Table V., Appendix B., see fig. 13, plate II.); though no heavier than the old 24-pounder, 9 feet 6 inches long, it is thicker in the cylinder of charge than the 32-pounder, weighing 56 cwt., and its shot ranges very nearly as far with 8 lbs. of powder as the shot from the old long 32-pounder ranges with its charge of 10 lbs., though the gun is shorter by 6 inches. This very efficient gun has now generally superseded the old 24-pounders of 50 and 48 cwt., in the naval service.

Mr. Monk next applied his method, with some modifications, to the construction of the 32-pounders, 8 feet 6 inches and 8 feet long, marked B and C (Table V., Appendix B.). Of these, with the guns marked A, no less than 4279 have been proved without a single failure, although the proofs to which they were subjected were more severe than those applied to the old guns, from the windage being less, and the charges more by 2 lbs. than double the full service-charge. All these guns now enter largely into the armament of the British navy, and, though not superior in range either to the 18 or 24 pounders (old guns) of equal weight and with equal charges, they have great advantages over these from the superior magnitude and momentum of their shot.

In Table V., Appendix B., will be found the ranges obtained from the new 32-pounder guns A, B, and C. The windage of these guns is .175 inch; but, on introducing them into the Navy, that of the 9 feet gun was increased to .2 inch, and of the 8 feet gun to .198 inch.[a]

220. Table XIV., Appendix B., exhibits a comparative view of the ranges of French guns of 30 (livres), long and short, with those of English 32-pounder guns. The ranges of the French guns are obtained by interpolations from the general table founded on the experiments made at Gavre, between 1830 and 1840; while those of the English guns are obtained from the tables of experiments carried on in the year 1838 on board the "Excellent;" and, from the comparison, the following important circumstances are deduced.

With charges of 10 lbs., and elevations not exceeding 8 degrees, the ranges of the English gun are superior to those of the French gun, though the windage of the former is rather greater than that of the latter; but the differences are the greatest between the elevation of 1° and 6°. With charges of 7 lbs. and 6 lbs., the English gun maintained its superiority, in

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[a] Mr. Daniel Treadwell, of the United States, executed, for experiment merely, in 1844, four 32-pounder sea-service guns on a new construction: they consist of a number of rings or hollow cylinders one within another; the interior part of each ring, equal to about one-third of the thickness of the ring, was of steel, and the exterior part of iron; these parts, as well as the different rings, were welded together, and compressed by a hydrostatic machine, which is said to exert a power of 1000 tons, so that the pores of the metal are closed and the metal itself condensed to a degree not to be attained by hammering; the whole was then formed into a gun by turning and boring.

The bores are 5 ft. 10 in. long, and the weight of each gun is less than 1900 lbs. One of the guns bore a succession of charges commencing with 8 lbs. of powder and one shot, and ending with 12 lbs. of powder, 5 shot, and 3 wads.

The evil attending the employment of these guns would be the greatness of the recoil. The inventor contrived a means by which he conceived it might be checked; but it is doubtful whether it would effectually serve the purpose.

respect of range, at all the elevations up to 9°; the differences being the greatest when the elevation was less than 7°. But it is a remarkable anomaly, that, when the charges were 8 lbs. and the elevations more than 4°, the ranges of the English gun were considerably less than those of the French gun. It may be remarked, in addition, that, conformably to theory, the ranges of a long gun almost always exceed those of one which is shorter.

Table XV., Appendix B., contains an abstract of some experiments made with different canons-obusiers of 80 (livres), as well as with French 36-pounder and 50-pounder guns; and, on comparing the ranges of these last guns with those of the English 32-pounders in Table V., Appendix B., it appears that the ranges of the latter, with a charge of 10 lbs., and even of 8 lbs., always exceed those of the French 36-pounder with a charge of 13 lbs.; and, up to an elevation of 4°, the English 32-pounder of 56 cwt., and a charge of 10 lbs., gives ranges exceeding those of the French 50-pounder gun, with its charge of 17 lbs. 10 oz.

221. Throughout the wars previous to that of 1854-6, the 42-pounder gun had formed the armament for the lower-decks of some of our line-of-battle ships, and the regulation to that effect continued in force till 1839, when the 32-pounder of 50 cwt. (one of Monk's guns) was substituted for it. Now, neither in the French nor the Russian navy has the 42-pounder nor the 36-pounder been discarded; and, by a decree of the French Government in May, 1838, no less than one thousand eight hundred and sixty-eight 36-pounder guns have been cast for the lower-decks of the ships of the line built previously to 1834;[a] while, in the United States' Navy, not only have the 24-pounder guns been retained, but the 42-pounders, 9 feet long, and weighing 70 cwt., are mounted on the lower-decks of ships of the line.

222. Three 42-pounders, each of 67 cwt., were constructed

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[a] The Navy of France consisted in 1852 of:—ships of the line, 27 afloat, of which 11 are now fitted with screw propellers, and 23 building; frigates, 38 afloat and 20 building; corvettes, 34 afloat and 5 building; and a vast number of smaller vessels, exclusive of an extensive force in steam-ships.—'L'Enquête Parlementaire,' vol. i. p. 415. An accurate account of the French Navy, with the armament of the ships will be given on a future occasion.

in 1846 for the naval service, and tried, first at Portsmouth to ascertain their ranges, and then at Woolwich to prove *à outrance* their strength. One of these guns was constructed by Colonel Dundas, another by Mr. Monk, and the third is intermediate between the two others.

In March, 1846, the three guns were received on board the "Excellent" for the purpose of being compared with each other, and with a 32-pounder of 56 cwt., in respect of stability, steadiness, and extent of range. After trials continued during eight days, it was found that all the 42-pounders were admirable guns, alike steady in rapid firing with the established charges (10½ lbs. with single shot, and 6 lbs. with double shot), and that they have advantages in these respects over the 32-pounder guns, whose charge is 10 lbs.; their recoil also was not so great as that of the latter gun. It was found, however, that they work heavier with 15 men than the 32-pounders with 13 men; and that, in training and elevating, the latter were rather easier. The ranges of all the guns were nearly the same, the 32-pounder alone appearing to have very slightly the advantage with double shot.

With respect to the strength of the construction of the 42-pounder gun, that which had been most often fired projected 305 shot. No. 1 gun stood 40 rounds, with two shot and two junk-wads, the charge being 10½ lbs.: it bore 10 rounds, with three shot and three junk-wads, the charge being 12 lbs.; but it burst at the fifth round, with three shot and three junk-wads, and a charge of 14 lbs. No. 3 gun stood 40 rounds with two shot and two wads, the charge being 10½ lbs.: it stood 10 rounds, with three shot and three wads, and with an equal charge; but it burst at the first round with three shot and three wads, the charge being 12 lbs. No. 2 gun stood 18 rounds, with two shot and two wads, the charge being 10½ lbs., when it burst.

Mr. Monk, the constructor of No. 2 gun, could only account for the less enduring form of his gun by ascribing it to some inferiority in the metal. The specific gravity of a small cube of metal taken from the same position in each gun was tried; and the result was as follows:—

No. 1 gun	7.2375	The sp. gr. of water being 1.
No. 2 gun	7.3112	
No. 3 gun	7.1954	

Mr. Walker, the founder, stated that the guns were cast from an exactly similar mixture, a certain portion of old gun-metal, some remelted iron pigs, and some pigs as he purchased them. Mr. Walker is satisfied there is not a shade of difference between the metal of which the three guns were cast. The carriages stood well till the guns burst, when they were destroyed by the explosion. The conclusion was, that the early bursting of No. 2 gun is attributable to an inferiority of construction. The charges of powder were taken fresh from the laboratory daily; the mean diameter of the shot was 6.775.

Gun No. 1, Colonel Dundas's construction, was recommended for adoption in the naval service on account of its greater endurance, and such were introduced accordingly as lower-deck guns in the "Blenheim" and "Ajax," steam guard-ships; but having been found too heavy, requiring crews so large as to overcrowd the fighting-decks of the small 74-gun ships of which the steam guard-ships were composed, those guns were removed and the 56 cwt. 32-pounders substituted.

SECTION IV.—NEW GUNS FOR SHELLS AND HOLLOW SHOT.

223. Large calibred guns for the projection of shells and hollow shot were introduced into the Naval Service of Great Britain subsequently to the adoption of the Paixhans guns in France in 1824, as analogous or corresponding pieces of ordnance.[a] First, in that year the 10-inch gun, 9 feet 4 inches long, and weighing 85 cwt., was formed; but, being found too heavy for ordinary ships, the 8-inch gun, 6 feet 8½ inches long

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[a] The original Paixhans *canon à bombes* is about 8 cwt. heavier than the British 8-inch shell gun (65 cwt.), while it is 4 inches longer; but, by a judicious distribution of the metal, the French gun was so much reinforced about the chamber, or place of the charge, that it could bear being fired with solid shot weighing from 86 to 88 lbs. avoirdupois and charges amounting to 10 lbs. 12 oz. It was found also, by experiments made in the Roadstead of Brest, that the same gun could bear without detriment a double loading, either two shells weighing together 133 lbs. nearly, with a charge of 10 lbs. 12 oz., or two solid shot weighing together from 164 to 176 lbs., with a charge of 21 lbs. 8 oz.

and weighing 50 cwt., was introduced. This gun was, however, deemed too light and short for the armament of great ships of war; and at length, in 1838, the 8-inch gun, 9 feet long and weighing 65 cwt. (see Fig. 14, Plate II.), was brought forward. This has now become the favourite arm in the British Naval Service and it enters largely into the armament of ships of all rates and classes, for broadside batteries as well as for the pivot-guns of steamers.

Table V., Appendix B., contains the weights, dimensions, charges, and ranges of shell-guns, obtained from experiments carried on, on board the "Excellent," in 1838. The supposed inability of shell-guns to bear the great charges necessary for propelling solid shot, which, being 10 inches and 8 inches in diameter, weigh 130 lbs. and 68 lbs. respectively, is the cause that, till recently, those natures of ordnance were restricted to the firing of hollow shot, or shells, with charges not exceeding 10 lbs.,[a] and that double-shotting was forbidden. This restriction no longer exists with respect to the 8-inch guns of 65 cwt. and 60 cwt.

224. There remains, apparently, an anomaly in the windages respecting the projectiles used in the naval and land services, with the 8-inch shell-gun weighing 65 cwt., whose diameter is 8.05 inches. The average diameter of sea-service hollow shot and shells is 7.925 inches; the windage is, consequently, .125 inch; whereas, in the land service, the 8-inch shell-gun is used with the mortar and howitzer shells, whose average dia-

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[a] See 'Experiments on board of H.M.S. "Excellent," 1832 to 1849,' page 11. With 8-inch chambered guns of 65 cwt. and a charge of 10 lbs., are used hollow shot plugged with iron weighing 56 lbs., and shells weighing 48 lbs., which, with the bursting-powder (2 lbs. 11 oz.), make up nearly 51 lbs. The common shells used with the 8-inch guns for land service weigh 46 lbs., and, when charged with the bursting-powder, 48 lbs. Hollow shot, used with the like guns, is made up as the same weight as the filled shell, viz. 48 lbs., including its iron plug. Shells are cast thinner than the projectiles which are designated hollow shot, on account of the large quantity of powder which would otherwise be required to burst them; and it may be observed here that a smaller quantity of powder sufficed to burst an 8-inch shell when the common metal fuze was screwed in, than when Freeburn's wooden fuze was applied. The diameter of the hole for the metal fuze was .86 inch, and that for the wooden fuse was 1.15 inch. It appears that shells fitted with metal fuzes burst with greater violence, and are more destructive, than those which are provided with wooden ones.

meter is 7.86 inches, and windage ·.19 inch. The difference in the windages is small, but the extent and the accuracy of the ranges are considerably affected by it; and there exists no good reason why the windages should not be equalized by the adoption of the same magnitude and weight of shot and shell for both services. Until this is done, mistakes may be made in the issues, according to the present practice, of shot and shells of different diameters and weights for the same calibre of ordnance in the land and sea services.

225. Shell-guns in the British Service are chambered in the Gomer form (see Fig. 14, Plate II.), the bore, at the extremity nearest the breech, being contracted in the form of a frustum of a cone as in the carronade mentioned in Arts. 125, 126. This form of chamber, which was originally intended for mortars, is not well adapted for howitzers or shell-guns, which are to be fired horizontally, on account of the difficulty of retaining in their proper places the reduced charges, in cartridges which do not fill the chambers, and which are liable to slide down the surface of the conic frustum on which they lie, thus causing the gun to miss fire. Such failures are reported to have occurred in the experiments made on board the "Excellent" (October 12, 1838) and other ships; they have been frequently witnessed by the author, and on one occasion this took place at Woolwich (July, 1849), when, though the tubes acted, an 8-inch gun missed fire several times, and could not be made to go off but by pouring loose powder through the vent into the chamber. The chambers of the French canons-obusiers are cylindrical, connected with the bore of the gun by an enlargement in the form of a frustum of a cone (fig. 14, p. 188). Thus the cartridge is less liable to shift its place than if the whole chamber were conical; there is however a greater difficulty in introducing it; and the French, as well as ourselves, feel all the inconvenience of chambered ordnance; but our neighbours, ever attentive to adopt processes which may tend to promote rapidity in loading and firing, have found means of overcoming this difficulty by giving to the cartridge the form of the chamber itself.[a] When diminished

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[a] For this purpose the cartridge is made on a wooden plug (mandrin) of a figure corresponding to the chamber; in one-half of its length it is cylindrical,

charges are employed, the cartridges are made smaller in diameter while their lengths are the same, and thus one extremity of the charge is always in contact with the shot.

226. Strong objections attach to guns for the naval service being chambered, particularly if they are to be employed in broadside batteries. In close action every means which can be obtained to facilitate quick firing with safety and accuracy is indispensable; but, with chambered guns, great care must be taken (see Arts. 126, 225) in loading, from the difficulty, in quick firing, of getting a small cartridge set properly home, and from the risk of its place being shifted in running the gun up; to prevent this it becomes necessary to place a grommet-wad over the cartridge.[a]

227. The necessity of forming chambers for shell-guns, as well as for carronades, arises from the weight of metal in those guns being comparatively small, considering the weights of the bodies which are projected from them; so that a much greater thickness of metal is requisite about the seat of the charge than elsewhere, in order to withstand the great expansive force of the ignited gunpowder and render the gun safe; this excess of thickness is obtained by contracting the cylindrical bore of the gun near the lower extremity, and thus forming what is called a chamber.

228. The canon-obusier originally constructed by Colonel Paixhans for the French Naval Service was 9 feet 4 inches

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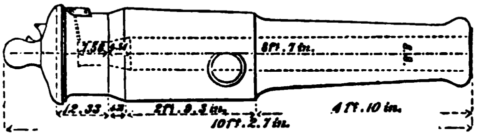
while the other half has the form of a truncated cone. The parts are of strong paper (*papier parchemin*), and the extremity, which is hemispherical, is of parchment; the latter, having been steeped in water, was stretched over the spherical part of the plug, and kept on by sail-twine; when dry it was taken off, and glued to the smaller extremity of the conical part.

The cartridge thus prepared and filled with 2 kilogrammes (4 lbs. 6.4 oz.) of powder was 23 centimetres (9.06 inches) long, from the bottom of the hemisphere to the nearest end of the cylinder. It was several times successively pressed into the howitzer without experiencing any impediment, and was afterwards withdrawn without exhibiting any appearance of the friction which the old cartridges experienced at the enlargement of the chamber. This mode of forming cartridges may appear tedious, but it is easy to see that it would in time be simplified; while, by adopting it, the process of loading the howitzer is greatly facilitated, and is besides assimilated to that of loading a gun or carronade.

[a] This practical inconvenience of chambered guns is strongly set forth in the reports of some recent trials of what the French call *la charge simultanée* (see Art. 228, note).

long, and weighed 74 cwt. nearly; and it was intended to project either solid shot weighing 80 livres (86½ lbs. English), or hollow shot weighing 56 livres (60½ lbs. English); it was subsequently designated the canon-obusier of 80, No. 1, of 1841. The charge for this gun varied from 10 lbs. 12 oz. to 18 lbs. of powder, or from ⅛ to ⅕ of the weight of the solid shot; and the diameter of the bore is 22 centimetres (8.65 inches). The diameter of the cylindrical part of the chamber was made about equal to that of the bore of a 24-pounder gun (French), consequently the contraction was considerable; and this was the cause that a difficulty was experienced in getting the cartridge into its place. Another inconvenience was that the *sight* piece on the swell of the muzzle projected too much, so that, in the recoil, it caught the upper sill of the gun-port when the gun had a small elevation. These inconveniences were remedied in the construction of a new canon-obusier (No. 1, of 1842), fig. 14, about equal in calibre to the former; the diameter of its chamber was equal to that of a 30-pounder (French), and the contraction of the bore was consequently less than in the other; this piece had also, in order to receive the *sight*, a support on the re-inforce at the commencement of the chase, whereas, previously, the sight had been fastened by bands passing round the gun.[a]

Fig. 14.
Canon-obusier of 80 (No. 1, 1842).



At a former period (1838) a different construction of the canon-obusier of 80 was tried, but the recoil of the piece in firing was found to be too great, on which account it was

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[a] On account of the great contraction at the entrance of the chamber in the gun first mentioned, it was found that the practice of ramming home the cartridge and shot at the same time, called by French writers "la charge simultanée" (which M. Charpentier acknowledges to have been first proposed by the author of this work), could not be depended on with that piece, a charge having jammed short at the second round of the trials; with the chamber enlarged as above mentioned it succeeded perfectly. It is stated, as the result of some trials made recently by the commander of the British Squadron of Exercise, that although some advantage accrues from simultaneous loading with ordinary guns, it is not desirable to attempt it with any of the new pattern chambered guns. (See the articles on Quick Loading, Part IV., Sect. iv.)

rejected. A modification of No. 1 (of 1842), designated No. 2, has been since executed for the armament of frigates of the second and third classes. Its charge is 3 kilogr. (6 lbs. 10 oz.), and it was adapted for moderate ranges, the tangent-scales being graduated only to 1200 yards. Of this description are the 18 canons-obusiers of 80, which have been mounted for experiment on the main-deck of the frigate "Psyche."

Another variety of the canons-obusiers of 80 consisted in placing the trunnions farther back, in order to give greater projection to the muzzle. This gun, which was lighter than the first, was tried on board the "Ocean" in 1843, but it has not been adopted in the service.

In 1848 a new canon-obusier (No 3) of 80 was added to the other variety of this species of ordnance for the French navy. Its charge is 2.5 kil. (5 lbs. 8 oz.) for hollow shot, and 2.6 kil. (5 lbs. 12 oz.) for solid shot. (See Art. 207, note [a].)

A canon-obusier of 150 (liv.), whose bore was 27 centimetres (10.6 inches) in diameter, was introduced, but its vast weight, as well as the weight and magnitude of the projectile, which render it difficult to be transported and to be worked on board a ship, are objections which will probably prevent its adoption. Its charge was 5 kilog. (11 lbs.)

In the French naval service there are also canons-obusiers of 30 (livres), whose charges are 2 kilog. (4 lbs. 6 oz.) and 1.5 kilog. (3 lbs. 5 oz.); the diameter of the bore being 16 centimetres, or 6.4 inches: it is regulated that they shall fire either hollow or solid shot, and they are provisioned accordingly. Besides the above *obusiers*, guns of 24, 30, 36, and 50 livres, and carronades, are specially destined, in French ships of the line, for firing live shells.

229. Extensive experiments were in 1850 made in France on the important questions as to the description of carriage and mode of installing the bow and stern guns of steam-vessels of war, with a view to decide between the traversing and pivot slide, and the ordinary carriage with trucks, which may be shifted from port to port as occasion may require. For the prosecution of these experiments several vessels have been fitted with guns mounted conformably to these two different principles. Several varieties of traversing slides are also under trial in the

French service, but they are all, more or less, analogous to those in use in the British service. The "Cuvier" and the "Cassini" are fitted with the affût à double pivot, as previously tried on board of the "Infernal;" whilst the "Caméléon" and "Pluton"[a] have been fitted with the affût *à échantignole*. The ships are armed with two canons-obusiers of 80 and two 30-pounder guns, installed in broadside ports in the ordinary way.

The great disadvantage of the pivot traversing principle, as heretofore applied, is that the bulwarks must be struck for action, when, the gun being what is called *en barbette*, the men working the piece are exposed to be swept off, if within the range of musketry, grape, or case shot; whilst the absence of all cover, however slight, is, besides the physical disadvantage, most prejudicial in its moral effect. On the other hand, as in the "Caméléon" and "Pluton," the installation of heavy guns in ports and embrasures, the sweep or open of which is limited to about 14° or 15° on each side of the directrix, renders frequent shifting of the guns from port to port necessary—an operation which must always be difficult and objectionable in action, on account of the time it requires, and which, when there is much motion, may be almost impracticable: no decision, to the author's knowledge, has yet been made on these important trials. In the British service, the two principles appear to be very happily combined by the following simple contrivance:—the slide is made to traverse on shifting centres, and to take up fighting points which are established on the deck correspondently with suitable points in the several ports which each gun thus

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[a] The total of the Steam Navy of France in February of the present year (1860) consisted of 244 ships afloat and 61 building, in the following proportions:—37 line-of-battle ships, 47 frigates, 19 corvettes, 68 gunboats, 9 floating batteries, 89 avisos, 5 iron-cased ships, and 31 transports. The total number of vessels comprising the Steam Navy of England, at the same date, was 456 ships afloat and 67 building, in the following proportions:—59 line-of-battle ships, 43 frigates, 9 iron blockships, 4 iron-cased ships, 21 corvettes, 95 sloops, 192 gunboats, 8 floating batteries, 4 screw mortar-vessels, 27 small vessels, and 61 troop-ships, tenders, yachts, &c. In addition to these will be completed within the year—10 line-of-battle ships, 12 frigates, 4 iron-cased ships, 4 corvettes, 15 sloops, and 23 gun vessels and gunboats. When we consider how much our Steam Navy must be dispersed throughout the dominions of the British Empire, and the concentration of that of France on the coasts of the country, the comparison appears very unsatisfactory.

mounted is intended to serve.[*] Thus the serious disadvantage of striking the bulwarks is avoided, and the advantages of the pivot carriage are retained.

In the first application of this principle, ports 4 feet wide, embrasured with sloping sides, were opened in the bulwarks, the height of which was 5 feet; the upper sill of the ports was made to unship when great elevations were required; whilst in close action the men were sheltered to this extent. The embrasures admitted of the guns being trained three points forward, and as many aft; but the ports are at present very much enlarged, in order to increase the sector of fire, and the height of the bulwarks is lowered: the expediency of this alteration may be doubted.

A very ingenious contrivance, invented by Colonel Colquhoun

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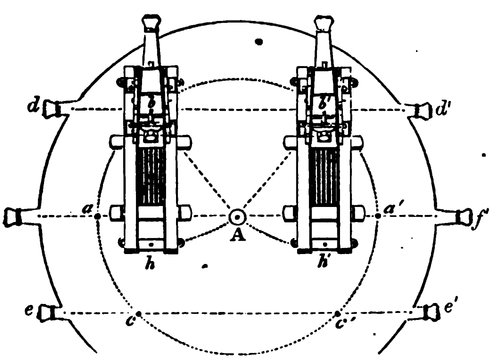
[*] This simple method of changing the centres on which traversing platforms turn, so that they may be readily shifted from the *turning* to the *fighting* point, which was applied by the late General Millar to the bow and stern guns of steam-ships, was, as the General acknowledged in a letter to the author, borrowed from his invention of that principle, in 1805, for mounting guns on round towers and circular batteries (fig. 15). A bolt passing through the hole *h* in the rear of the traversing platform, being inserted in the socket at A, the gun is turned upon that point in the direction of a radius passing through any fighting point *a*, *a'*, *c*, *c'*, &c., in the circle in which those points are established. The bolt at A being then taken out, and that of the front pivot *b* or *b'* dropped into the corresponding socket underneath the gun (which, not being seen in the figure, is indicated by a dot perpendicularly over it on the top of the gun), the platform is turned on this new centre into the position shown in the figure. The other gun is traversed in like manner, and thus the two guns may be pointed at the same object; or both to the right in the directions *d'* and *e'*, or to the left in the directions *d*, *e*, or one on each side in the directions *d'* and *e*, or *d* and *e'*.[*]

Fig. 15.



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[*] Extract of a Report of the Select Committee, dated Royal Arsenal, July 12, 1806:—"The Committee are of opinion that Major Douglas has completed very fully the object which he wished to obtain; viz., that he can traverse guns, in a circular battery, in any direction, with facility, upon different centres within a given area."

of the Carriage Department, a skilful and scientific officer, has been adopted for facilitating the operation of shifting the centres upon which the slides traverse, and for establishing, in the deck, housing points or centres upon which the guns are with great facility turned.

230. In 1842 an extensive course of experiments was carried on at Gavre with canons-obusiers of 80; and the following are the results of some of the experiments:—

With two boulets creux, having no wad between them, the projectiles always issued from the piece in a multitude of fragments.

With a hollow shot and a live shell, having a wad between them; when the shell was next to the charge, the fuze was invariably crushed or broken; when outward, the charge being high, the shell was frequently, and sometimes both the shot and shell were reduced to fragments.

Trials were likewise made with a solid shot of 88 lbs. and a hollow shot of 57 lbs.; then with a solid shot and a charge of large grape (20 balls, each of 4 lbs. weight); then with a live shell and a charge of grape: in all these cases comparatively little effect was produced; and it appeared that shells, with whatever load combined, were frequently broken in the gun.

Two solid shot were likewise fired together, but the recoil was so great, and the effect on the carriage so severe, that with the canon-obusier of 80 double shotting was peremptorily interdicted. Upon the whole it appeared that double loading could only in some cases be advantageous; and therefore, as a general rule, it was decided that such ordnance should be restricted to the discharge of single hollow shot.

231. The ravages occasioned by the bursting of guns on board the French frigates "Provence," "Vénus," "Triton," and others, the first before Algiers and the second at Brest, on which occasions great numbers of men were killed and wounded, while terror and demoralization were spread among the crews, have caused the naval authorities of France to enforce the utmost attention to the proof of the ordnance used on board ships of war. With respect to the canon-obusier of 80, on a first trial the chamber of the piece is quite filled with powder, and a cylindrical shot weighing 53 kilogrammes (116 lbs. avoirdupois)

is projected; on a second trial, an equal charge is made to propel two cylindrical shot; and on a third, three such shot, a junk wad being rammed down on them by four blows.

Cylindrical or oblong shot are reserved for this extraordinary proof of the canon-obusier; but by a regulation, dated April 1837, it is directed that no piece which has actually been subject to such proof shall be admitted into the service. It is often found that a gun, though it may have stood this severe proof apparently uninjured, is so strained as to give way on service when the ordinary charges are used; and the practice in France is to subject one gun only of each batch of metal to the extraordinary proof, all the other guns of the batch being made to undergo the ordinary proof; these are deemed capable of resisting the extreme charges, and passed accordingly.[a]

This method of proving the strength of guns rather by great loads of metal projected, than by extraordinary charges of powder, is worthy of imitation in proving naval ordnance in general. No such error can be committed, as that of putting double charges of powder—two cartridges—into a gun in action; but, after guns have been loaded with the full or distant charges and single shot, in running into action, and getting quickly within 300 or 400 yards, it may suddenly be necessary to put in a second shot, and upon such an occasion, seamen, in their ardour, may put in a third. Whatever may happen to bolts and breechings, the gun at least should stand the most severe trial; and on this account all naval guns should be proved so as to

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[a] Proof charges of the Paixhans guns are—with two shells, weighing together 132.72 lbs., 10 lbs. 12 oz. of powder; with two solid shots, weighing together 172.69 lbs., 21 lbs. 8 oz. of powder; and the maximum charge with two solid shots is 28 lbs. 1 oz. The greatest proof charge of the British 8-inch shell-gun of 65 cwt. was, previously to 1848, 20 lbs. of powder with one solid shot, and a single hollow shot only was to be fired at one time; but it has since been found that this gun is capable of resisting far greater charges of powder, and of firing two hollow shots at once. The full service-charge of the French canon-obusier of 80, No. 1, is 10 lbs. 12 oz.; that of the English 8-inch shell-gun of 65 cwt. is 10 lbs. Though, as has been just said, the Paixhans gun is restricted to the use of the hollow shot, grape and case shot in general service; this is not on account of any inability to bear firing with solid shot and efficient charges, but on account of the inconvenience and difficulty in handling and loading, in quick firing; and the great proportion of the tonnage or displacement of the ship which that great weight would absorb; using low charges, the canon-obusier of 80 is capable of discharging at once, without danger or damage to the carriage, 200 or 300 pounds' weight of case-shot (*mitraille roulante ou plongeante*).

ascertain what loads of shot they will bear, with the full service-charge of powder; and though, as in French proofs, every individual gun should not be subjected to the extraordinary proof, yet some one or two of every batch of metal, and from every contractor, should be tried *à outrance.*

232. On comparing together the ranges of the French canon-obusier of 80 (No. 1), weighing 74 cwt., with the English 8-inch shell-gun weighing 65 cwt., both of which are considered as the best of their class, the following conclusions are obtained. Using, at first, the experiments carried on at Brest in 1821 and 1824, with shells weighing 60½ lbs. and solid shot weighing 86½ lbs., the diameter of the bore being 8.95 inches, windage .09 inch, and the charge 10 lbs. 6 oz.; and the experiments made on board the "Excellent" in 1839 with hollow shot weighing 56 lbs. and solid shot weighing 68 lbs., windage .125 inch, and the charge 10 lbs.; it was found that, at an elevation of 3°, the range of the French solid shot exceeded that of the English solid shot by 651 yards, and the range of the French hollow shot exceeded that of the English hollow shot by 574 yards. At an elevation of 16°, the excesses of the French solid and hollow shot over those of the like English shot were 336 yards and 400 yards respectively. If, therefore, the Report on the French experiments above alluded to were alone considered, it would appear that the French canon-obusier is, in respect of range far superior to the English shell-gun—and an English writer of great ability has, in fact, so esteemed it; but a comparison of many ranges more recently obtained with the French and English guns has proved, beyond a doubt, that the advantages of superior range, with equal charges and elevations, are decidedly on the side of the latter.

In making this comparison, the ranges of the French canon-obusier of 80, weighing 74 cwt., were taken from a general table formed from the experiments made at Gavre between 1830 and 1840, the inclinations in that table being reduced to elevations above the horizon. The ranges were reduced to English yards, and afterwards, by interpolations, reduced to those due to the particular charges and elevations for which the ranges of the English 8-inch shell-gun of 65 cwt. are given in the tables of the experiments carried on on board the "Excellent" in 1839

(Table V., Appendix B.). The French and English shot were hollow, and the weights of the guns and shot were as above specified. The windage of the English gun was .125 inch, and that of the French gun .1378 inch.

Of fourteen ranges obtained from each gun, the charges being 10 lbs. and the elevations varying from 22′ .30″ to 13°, the mean of the ranges of the English gun exceeded that of the French gun by 114 yards; while, of seven ranges from each gun, the charges being 8 lbs. and the elevations varying from 37′ 30″ to 2° 7′ 30″, the mean of the ranges of the English gun exceeded that of the French gun by 12 yards. In three of these ranges, the elevations being the lowest, the advantage was in favour of the French gun; but in the four others, the advantage was on the side of the English gun. The ranges obtained from the 8-inch shell-gun, weighing 60 cwt., being then compared with the canon-obusier of 80, weighing as above, the charges being 8 lbs. and the elevations varying from 22′ 30″ to 10°, it was found that, in eleven ranges obtained from each, the mean range of the English gun exceeded that of the French gun by 11 yards; but, in four cases, the advantage was in favour of the latter gun, the mean of the excesses being 25 yards.

233. From experiments which have been made on board the "Excellent" with an 8-inch shell-gun weighing 65 cwt., and double shotted, it appears that such practice cannot be made with good effect beyond 200 yards.[a] In the experiments alluded to there was set up a butt of sound ship-timber, consisting of two planks crossed, each 6 inches thick, and bolted to timbers 12 inches thick; when, at the distance of 260 yards, three rounds being fired with two solid shots and a charge of 5 lbs. of powder, 5 of the shot passed through one side of the butt, striking the opposite side and indenting it one inch; at the distance of 100 yards, of two shots fired at once, one struck the bull's-eye, and the other a point about 1 foot from it. Of 30 solid shots fired two together, with a junk wad between them, 11 broke; and of 30 others so fired, with no wad, only 1 broke. In 11 rounds, a shot and a shell being fired together, with wooden bottoms, 3 of

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[a] This practice is permitted in action at or within 200 yards, and the maximum charge is 5 lbs. of powder; but double-shotting is not allowed with 8-inch guns weighing less than 60 cwt.

the shells broke; and in 3 rounds, with two shots separated from each other from 2 to 4 inches, 3 of the shots broke.

In 1849 double shot from 8-inch guns, weighing 65 and 60 cwt., were fired in a series of experiments made on board the "Excellent" against a butt representing a section of the "Princess Charlotte" at the bends and lower-deck. The shots were hollow, and weighed 56 lbs.; the charge was 5 lbs., and the distance of the butt 200 yards. At the first round both shots struck, 18 inches asunder (one in the centre of a timber), and, after passing through, ricochetted in the water at 300 yards beyond the butt.

SECTION V.—ON RIFLE GUNS LOADED AT THE BREECH.

234. The practice of loading guns at the breech is not of modern date. In a work, by an Italian named Moretti, which was printed early in the seventeenth century, it is stated that the Venetians had many guns which were so loaded, and which carried shot of 4 lbs. weight.[a] And the readers of works on Military Antiquities will find in them frequent mention of that primitive method of loading ordnance which is now reproduced.

Many curious specimens of such guns may be seen in the Royal Military Repository and in the United Service Institution. The most ancient one of this description is that which was recovered from the wreck of the "Mary Rose," sunk at Spithead in an action with the French in 1545. It is made of wrought-iron bars, secured with iron hoops and fixed in a solid bed of elm 9 ft. 8 in. long: it was loaded at the breech by a detached chamber, which was kept in its place by a chock of elm. Several ancient chambers of guns of smaller sizes, of wrought iron, of the time of Henry VII., have been found at Dover; and likewise the chase or body of a gun which was loaded in like manner. The diameter of its bore was 1½ inch. Artillery loaded at the breech with a detached chamber is still used in China; and the brass jingal, or swivel gun 1⅞ inch diameter, is of that nature; several specimens of these may be seen in the United Service Institution. A small brass 4-pounder, with a detached chamber for loading at the breech, and bearing a cypher of the Dutch East India Company, was found on an islet

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[a] This work was translated into English by Moore about 1650.

on the coast of Australia, upon which a Dutch ship, named "Zeevyk," was wrecked in 1727; and a piece of brass ordnance of Dutch make, and bearing the date 1650, has recently been brought from the Gambia by H. M. Steam-vessel "Teazer." The gun is made to load at the breech; and the charge and shot were kept in their places in the bore by a quoin or wedge in a manner nearly similar to the plan of Major Cavalli. (See the following Article.)

The method of loading at the breech does not seem to have been much in use for small arms. There is, however, in the United Service Institution, a small petronel of this description, of the time of Charles I., and two carbines of about the year 1740 or 1750.

235. It has been said, Art. 183, that, in 1846, iron rifled-cannon, capable of being loaded at the breech, were invented by Major Cavalli and Baron Wahrendorff, for the purpose of firing cylindro-conical and cylindro-conoidal shot (see figs. 7 and 8 in that Article). In these guns the mechanical contrivances for securing the breech are very superior to the rude processes of earlier times; yet it appears doubtful whether or not, even now, they are sufficiently strong to ensure safety when high charges are used in long continued firing.

236. The length of the Cavalli gun (see fig. 15, Plate II.) is 8 feet 10.3 inches; it weighs 66 cwt., and its calibre is 6½ inches. Two grooves are cut spirally along the bore, each of them making about half a turn in the length, which is 6 feet 9 inches. The chamber, which is cylindrical, is 11.8 inches long and 7.008 inches diameter. With respect to windage, it must be observed that in all rifles with *forced* leaden shot of any shape there is practically no windage and, accordingly, no waste of the charge: but it is not so with iron shot fired from rifled cannon, since the iron cannot be made to expand so as to fill the bore and enter into the grooves; there must, consequently, be some windage; and, in fact, if there were not some, or if the charge were not greatly reduced, the blowing off the breech, an accident which happened to M. Cavalli's own gun, would be of frequent occurrence.

Immediately behind the chamber there is a rectangular perforation in a horizontal direction and perpendicular to the axis of the bore; its breadth vertically is 9½ inches, while horizontally it is 5.24 inches on the left side and 3.78 inches on the right side. This perforation is to receive a wrought-iron case-hardened quoin or wedge which, when in its place, covers the extremity of the chamber which is nearest the breech. The projectile, which has been described in Art. 183, being introduced through the breech and chamber into the bore of the gun, and the cartridge placed behind it, a *culot*, or false breech of cast iron, is made to enter 2½ inches into the bottom of the chamber behind the cartridge; and a copper ring, which also enters the chamber, is placed over it. The iron wedge is then drawn towards the right hand till it completely covers the chamber. After being fired, the gun can be reloaded without entirely taking out the wedge; for the latter, which is shorter than the rectangular cavity in which it moves, can be withdrawn far enough to allow the new load to be introduced. The Cavalli gun rested on a cast-iron bed, placed on a platform constructed of strong beams of timber. It is now mounted on a non-recoil principle, which is effected by a strong iron trunnion attached to the front of the bed underneath, and working in a socket firmly fixed in front of the platform.

In the summers of 1853 and 1854, trials were made at a spot between Leiny and Cirie, in Piedmont, of a rifled Cavalli gun, made to be loaded at the breech, and with various improvements in the apparatus for loading and pointing. The gun carried cylindro-ogivale shells each weighing 30 kilogrammes (66 lbs. 3 oz. English), and provided with a metal fuze. The shells were fired with charges equal to one-tenth of the weight of the projectile, at elevations varying from 5 to 25 degrees. The firing was directed against a target about 10 feet square, and placed at the distance of 3050 yards from the gun.

In ten trials, at an elevation of 10 degrees, the mean of the ranges obtained was 3058 yards; the means of the deviations were to the right 3.4 yards, and to the left 3.39 yards. After one rebound the shot went to the distance of 4096 yards from the gun, with a deviation to the right equal to 126 yards. The mean time of flight was 11 seconds.

In fifteen trials, at an elevation of 15 degrees, the mean of the ranges was 4128 yards; the mean deviations were, to the right

11 yards, and to the left 1 foot 11 inches. The time of flight was 16 seconds.

In fifteen trials, at an elevation of 20 degrees, the mean of the ranges was 4917 yards; while the mean deviations were, to the right 6 yards 2 feet, and to the left 10 yards. The time of flight was 19 seconds.

Lastly, in ten trials, at an elevation of 25 degrees, the mean of the ranges was 5563 yards, while the deviations were, to the right 3 yards, and to the left 4 yards.

These trials were considered highly satisfactory; and no less so were some experiments also made with metal fuzes, and with a charge equal to one-thirtieth of the weight of the projectile; the first shell so fired struck against one of the beams of the target, and tore away splinters of the wood varying in length from 1 ft. 9 in. to 1 ft. 11 in. The bursting-charge appeared to be fired a little before the moment of the shell falling.

237. The rifled gun constructed by Baron Wahrendorff differs in some respects from that of Major Cavalli. (See fig. 16, Plate II.) Its whole length is 8 feet 10.9 inches, and its greatest diameter, A B, 2 feet 3.2 inches. The diameter *a b* of the bore is 6.37 inches from the muzzle to within 6 inches of the chamber, in which space, *c d e f*, it has a conical form, the diameter at *c d* being 9.65 in.; the diameter of the chamber *c d g h* is 7.5 inches. A rectangular wedge, 12.2 inches long, 8.1 inch broad, and 4.25 inches thick, is made to slide, towards the right or left hand, in a perforation, formed transversely through the breech, for the purpose of covering, after the gun is loaded, the aperture by which the charge is admitted into the bore. A notch, 7.2 inches long and .7 inch broad, is made longitudinally in the wedge, and through this passes the stem, or bar, of a cylindrical plug, by which the charge is kept in its place. This plug is 7.4 inches diameter and 4.7 inches long, and it is provided with a stem or bar, 15.75 inches long, at the extremity of which is a screw nut having two handles. The plug is introduced in a direction parallel to the axis of the gun, through an orifice in the breech; and its stem passes through a perforation made in an iron door which closes the orifice. When the gun is loaded the door is closed; the plug is pushed forward, to the rear of the charge, by means of its stem, and the wedge

is made to slide into its place: a turn of the screw nut at the end of the stem is then taken, when the whole is drawn tightly together and is ready for firing. After firing, the wedge is drawn out as far as a pin which fits into a groove in its top will permit; and this just allows the plug to be drawn back close to the door, which is hollowed, as at *k*, to receive it; the door will then open so that the plug may be withdrawn from the breech of the gun, preparatory to a re-loading being made.

238. Some important trials were, during the year 1850, made at Shoebury Ness with the Cavalli and Wahrendorff guns, in conjunction with the British 32-pounder gun weighing 56 cwt.; cylindro-conoidal shot weighing 64 lbs. being fired from the former, and round shot from the latter, and, from those trials, the relative values of the three natures of ordnance may be said to have been in a great measure determined. The foreign guns are those which were cast at Åker; and their construction has been carefully and ably described by Colonel Palisier of the Royal Artillery.

At the efficient service-elevation of 5 degrees, with charges of 8 lbs., the ranges, and also the deflections of the different projectiles were nearly equal to one another: and the like is true with charges of 10 lbs. At elevations of 10 degrees, the ranges of the foreign guns exceeded those of the English 32-pounder, with charges of 8 lbs., by 380 yards; and with charges of 10 lbs., by 690 yards; and at elevations of 15 degrees, the excess was, with charges of 8 lbs., about 790 yards; and with charges of 10 lbs., about 1100 yards. The deviations were always in the direction of the rotation of the projectiles; but they were so variable in amount that no allowance could be made for them in laying the gun with respect to the object.

It must be admitted that the Wahrendorff gun has considerable advantage, in respect of range, over the English 32-pounder at a high elevation; but it ought to be observed that the practice is, in that case, very uncertain. Such guns cannot enter into the armament of ships of war, but they may be used with advantage for flanking defences in casemates, or in coast-batteries for firing at objects at great distances.

239. With respect to ricochet firing, it is obvious that the rapid rotation of the shot upon its axis, and the projection of the

oblique wings by which the rotation is produced in the gun, must, on the shot grazing, cause a forcible action on the surface of the plane struck, whether land or water. A remarkable proof of this appeared in the recent experiments at Shoebury Ness; when, at every graze of the cylindro-conical or cylindro-conoidal shot, it took a fresh direction, deviating more and more to the right—an important circumstance, which will no doubt be found to prevail in the ricochet of all cylindro-conical rifle-shot from muskets as well as from cannon. In horizontal firing over sea, it is probable that the shot would penetrate into the water so far that the impulsive force, resolved in the vertical direction, would not be sufficient to allow it to rise from thence.

The Cavalli gun became unserviceable after having fired four rounds, by the copper ring or bush imbedded in the metal of the gun at the bottom of the bore being damaged. This rendered it necessary to remove the gun to the foundry, in order to have a new copper ring put in; for this purpose it was necessary to cut away some of the metal of the gun, in order to set in the bush afresh. But, however nicely this was done, it did not succeed, and at the next trial the whole of the breech was blown off. The Wahrendorff gun stood well, the wedge resisting more effectually the force of the discharge than that of the Cavalli gun. If the latter, when it failed, had been on board a ship, the breech would have passed through, or have made a prodigious fracture in the opposite side; and consequently, besides the physical injury, it must have produced the worst moral effect on the crew.

240. Baron Wahrendorff invented a 24-pounder gun, which is also to be loaded at the breech. It is mounted on a cast-iron traversing carriage; and, taking little room, it appears to be very fit for casemates. The upper part of the carriage has, on each side, the form of an inclined plane, which rises towards the breech, and terminates near either extremity in a curve whose concavity is upwards. Previously to the gun being fired the trunnions rest near the lower extremity; and on the discharge taking place, the gun recoils on the trunnions, along the ascending plane, when its motion is presently stopped. After the recoil, the gun descends on the plane to its former position, where it rests after a few short vibrations. The axis of the gun

constantly retains a parallel position, so that the pointing does not require readjustment after each round.

The gun was worked easily by eight men, apparently without any strain on the carriage. With a charge of 8 lbs., and with solid shot, the recoil was about 3 feet, and the trunnions did not reach the upper extremity of the inclined plane, though the surface was greased.

THE ARMSTRONG GUN.

241. In the latter part of the year 1854, Mr. William George Armstrong (now Sir William George Armstrong) submitted to the Duke of Newcastle, then Minister at War, a proposal for a rifled field-piece on a new principle, and undertook, with his Grace's authority, to construct a gun upon the plan he had suggested. This gun was completed early in the following year (1855), and became the subject of a long course of experiments which ultimately led to the general introduction of the weapon into the British service.

Sir William Armstrong's first gun, and the results obtained with it, were described by him in a letter addressed to the editor of the 'Times,' in January 1856; from which it appeared that the gun was composed internally of steel and externally of wrought iron, applied in a twisted or spiral form as in a fowling-piece. The bore was about two inches in diameter, and rifled with numerous small grooves. The projectile was a pointed cylinder 6½ inches long, and its weight was 5 lbs; it was made of cast iron coated with lead, and was fired from the gun with a charge of ten ounces of powder. It contained a small cavity in the centre, and was adapted to be used either as a shot or as a shell. When applied as a shell the cavity was filled with powder, and a detonating fuze was inserted in front so as to fire the powder on striking an object. When used as a shot the powder was omitted and a plug substituted for the fuze. The gun was constructed to load at the breech, the object being not only to obviate the disadvantage of sponging and loading from the front, but also to allow the projectile to be larger in diameter than would enter at the muzzle, and thus to ensure its taking the impress of the grooves and completely filling the bore. The piece weighed 5 cwt., and was mounted upon a carriage which bore a general resemblance to that of an ordinary 6-pounder field-gun, except that it embraced a pivot frame and recoil slide. A screw was also applied, not only for elevating and depressing the gun, but also for moving it horizontally, by which means great delicacy of aim was effected. The recoil slide had an upward inclination, which enabled the gun, after running back, to recover its position by gravity.

Prior to that time the gun had been tried under official inspection, on the sea-coast, near Newcastle-upon-Tyne. At a distance of 1500 yards, and with an elevation of 4° 26′, a target of 7½ feet high and 5 feet wide, had been struck eight times in succession; and, at the same distance, a shot had been fired quite through a timber butt 3 feet thick, and composed of six layers of rock elm so as to form a solid block.

The same gun had also been used with great success at a distance of 3000 yards, for which range an elevation of 11° was found sufficient.

The satisfactory results obtained with this small gun led to the construction of a larger one, which exhibited the advantages of the system in a much higher degree. In this second gun the steel lining was dispensed with as being difficult to manufacture and uncertain in its soundness. Instead of being internally of steel and externally of wrought iron, the gun was composed entirely of the latter material; the essential feature in its mode of manufacture being the combining, into one mass, of tubes made from iron bars twisted into a spiral form and welded by hammering.

The weight of this new gun was 12 cwt., and its projectile weighed 18 lbs. The arrangement for loading at the breech was the same as in the first gun, and may be described as follows:—A large screw was inserted in the breech, and had a hole through it forming a prolongation of the bore. Through this hollow screw the gun was sponged and loaded. In order to close the breech when the gun was loaded, a steel stopper was inserted at an opening in the upper side of the gun and was tightened by the screw against the end of the bore. The vent-hole for firing the gun was contained in this stopper. The handle or lever for working the screw was made to move freely through half a circle and at each extremity of its range to act like a hammer against a stop or clutch, so that a blow might be given in either direction to tighten or slacken the screw.

Figs. 16 and 17, below, shew the exterior of a 12-pounder Armstrong gun, such as is now used for field artillery, and fig. 18

Fig. 16.

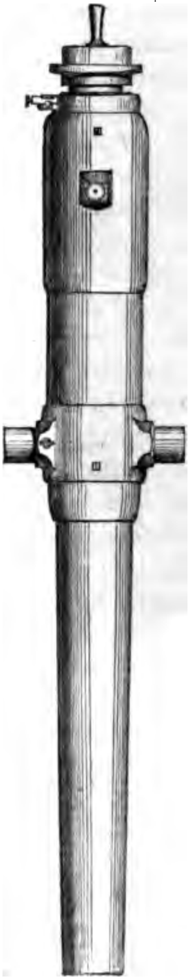


Fig. 18.

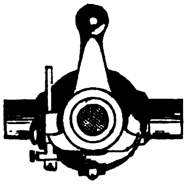
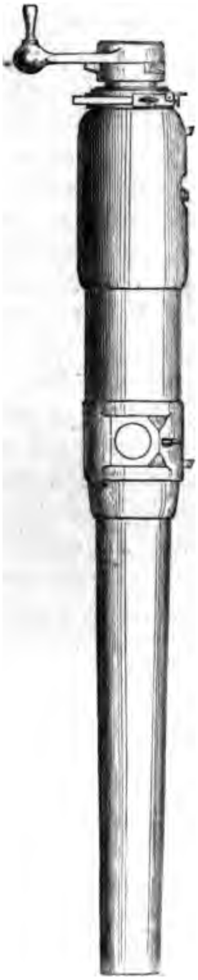


Fig. 17.



is an end view of the same, showing the hole through the breech-screw for loading and sponging the gun. These guns can be fired with careful aim twice in a minute, and fully three times per minute without aim.

The following description of the Armstrong gun, as now manufactured, was given by Sir William in the discussion which recently took place at the Civil Engineers' Institute.

"The gun is composed wholly of wrought iron, and the prominent feature in its manufacture is the application of the material in the form of long bars, which are coiled into spiral tubes, and then welded by forging. For the convenience of manufacture, these tubes are made in lengths of from 2 to 3 feet, which are united together, when necessary, by welded joints. From the muzzle to the trunnions the gun is made in one thickness, and is therefore, so far as that portion is concerned, strictly analogous to the barrel of a fowling-piece. Behind the trunnions two additional layers of material are applied. The external layer consists, like the inner tube, of spiral coils, but the intermediate layer is composed of iron slabs bent into a cylindrical form and welded at the edges. The reason for this distinction is, that the intermediate layer has chiefly to sustain the thrust on the breech, and it is therefore desirable that the fibre of the iron should be in the direction of the length, while elsewhere in the gun it is more advantageously applied in the transverse direction. The back end of the gun receives the breech-screw, which presses against a moveable plug, or stopper for closing the bore. This screw is hollow, and when the stopper is removed the passage through the screw may be regarded as a prolongation of the bore. The screw is turned by means of a handle, which is free to move through half a circle before it begins to turn the screw. It has thus a certain amount of run, which enables it to act as a hammer, both in tightening and slackening the screw. The bore is 3 inches in diameter, and is rifled with thirty-four small grooves, having the driving side rectangular and radial, and the opposite side rounded. The bore is widened at the breech end one-eighth of an inch, so that the shot may enter freely and choke at the commencement of the grooves.

"The projectile (figs. 19, 20) consists of a very thin cast-iron shell, the interior of which is composed of forty-two segment-shaped pieces of cast iron, built up in layers around a cylindrical cavity in the centre, which contains the bursting-charge and the concussion arrangement. The exterior of the shell is thinly coated with lead, which is applied by placing the shell in a mould, and pouring melted lead around it. The lead is also allowed to percolate among the segments, so as to fill up the interstices, the central cavity being kept open by the insertion of a steel core. In this state the projectile is so compact that it may be fired through six feet of hard timber without injury; while its resistance to a bursting force is so small, that less than one ounce of powder is sufficient to break it in pieces. When this projectile is to be used as a shot, it requires no preparation, but the expediency of using it in any case, otherwise than as a shell, is much to be doubted. To make it available as a shell, the bursting-tube, the concussion arrangement, and the time-fuze, are all to be inserted; the bursting-tube entering first and the time-fuze being screwed in at the apex. If then the time-fuze be correctly adjusted, the shell will burst when it reaches within a few yards of the object; or, failing that, it will burst by the concussion arrangement, when it strikes the object, or grazes the ground near it. Again, if it be required to act as "canister," upon an enemy close to the gun, the regulator of the time-fuze must be turned to zero on the scale, and the shell will then burst at the instant of quitting the gun. In every case the shell on bursting spreads into a cloud of pieces, each

Fig. 19.

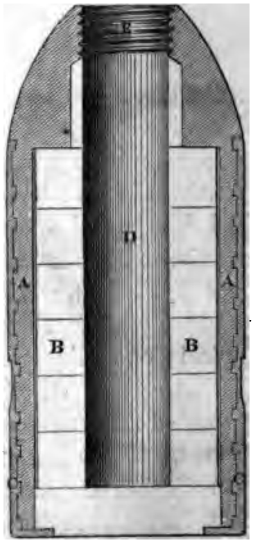
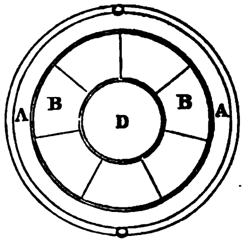


Fig. 20.



12-Pounder Segment Shell.

A A. The Cast-iron Case, or Shell.
B B. The Segment Shot in layers.
C C. The Lead Covering.
D. The Central Cavity for Bursting-Tube and Concussion-Fuze.
E. Screw for Time-Fuze.

having a forward velocity equal to that of the shell at the instant of fracture.

"The explosion of one of these shells in a closed chamber, where the pieces could be collected, resulted in the following fragments :—

Fig. 21.

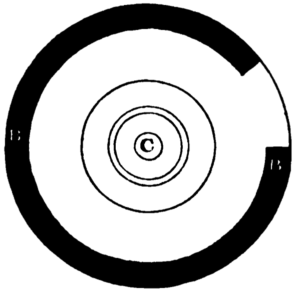
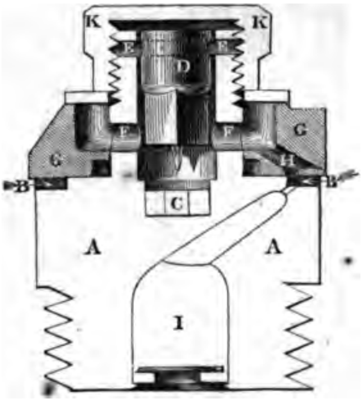


Fig. 22.



Time-Fuze.

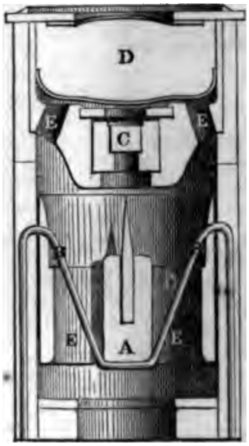
A A. The Body of the Fuze.
B B. Groove containing the Fuze-Composition.
C. The Detonator.
D. The Striker.
E E. The Holding Pin.
F F. The Flame Passage.
G G. Revolving Cover, or Regulator.
H. Igniting Aperture.
I. Chamber for Priming-Powder.
K K. Tightening Cap.

"106 pieces of cast iron, 99 pieces of lead, and 12 pieces of fuze, &c.; making in all 217 pieces.

"The construction of the time-fuze and the concussion arrangement are described as follows :—

"The body of the time-fuze (fig. 21), is made of a mixture of lead and tin, cast to the required form, in a mould. The fuze-composition is stamped into a channel forming nearly an entire circle round the body of the fuze, and is afterwards papered and varnished on the external surfaces. As the shell fits accurately into the gun, there is no passage of flame by which the fuze could be ignited. That effect is therefore produced in the following manner. A small quantity of detonating composition is deposited at the bottom of the cylindrical cavity in the centre of the fuze, and above this is placed a small weight, or striker terminating in a sharp point presented downwards. This striker is secured in its place by a pin, which, when the gun is fired, is broken by reason of the vis inertiæ of the striker. The detonator is then instantly pierced by the point, and thus fired. The flame thus produced passes into an annular space, formed within the revolving cover, which rests on the upper surface of the fuze-composition, and from this annular space, it is directed outwards, through an opening, so as to impinge on and to ignite the fuze-composition, at any required part of the circle. The fuze, thus ignited, burns in both directions, but only takes effect at one extremity, where it communicates with a small magazine of powder in the centre. The fuze is surrounded by a scale-paper, graduated to accord with the elevation of the gun, so that when the range of a distant object is found by trial, it is only necessary to turn the igniting aperture of the cover to the point on the fuze-scale corresponding with the degrees and minutes of elevation on the tangent-scale. This fuze has the advantage of being capable of adjustment and re-adjustment any number of times, before entering the gun, and the officer in command has the opportunity of seeing that it is correctly set, at the moment of being used.

Fig. 23.



Concussion-Fuze.
A. The Striker.
B B. The Holding Wire.
C. The Detonator.
D. The Chamber for Priming-Powder.
E E. Flame Passages.

"The concussion-fuze (fig. 23) is on nearly the same principle. A striker with a point, presented upwards, is secured in a tube by a wire-fastening, which is broken on the firing of the gun; the striker, being then liberated, recedes through a small space, and rests at the bottom of the tube, but as soon as the shell meets with any check in its motion, the striker runs forward and pierces the detonator in front, by which means the bursting-charge is ignited.

"The process of loading is effected by placing the projectile, with the cartridge and a greased wad, in the hollow of the breech-screw, and thrusting them either separately, or collectively, by a rammer, into the bore (fig. 24, opposite). The stopper is then dropped into its place and secured by half a turn of the screw. The gun is fired by the ordinary friction-tube, the vent being contained in the stopper. The whole operation is simple, and can be very rapidly performed.

"In the early guns it was necessary that the portion of the bore which was occupied by the shot should be perfectly clean, otherwise the shot would not always enter its place. A wet sponge had therefore to be used; but in the new guns, now issued for service, a slight alteration in the bore has enabled a greased wad to be employed with perfect effect, in substitution of the wet sponge. The gun can now be fired with great rapidity, and apparently for any length of time, without being sponged at all.

"The reason for making the vent in the stopper is, that, since the chief wear of the gun always takes place at the vent, it is better to make it in a part which can be easily replaced, than in the body of the gun itself.

"The breech-screw being internal is never exposed to injury, nor can drifting sand, or dust, ever reach the oiled surfaces, so as to impede the action of the screw by adhering to the lubrication.

"The screw is of small diameter, and the few inches of extra length in the gun, required for its reception, cannot be of any importance, considering that any further reduction of weight is prohibited by recoil.

"The stopper is secured from falling by a chain, but in practice it is preferred to leave it loose. The man who fires the gun lifts the stopper after each round, and in so doing only occupies time that would otherwise be vacant. A duplicate stopper accompanies each gun.

"The form of carriage, which was originally used, is represented in the accompanying diagram (fig. 25, overleaf). It was fitted with a recoil slide, which was

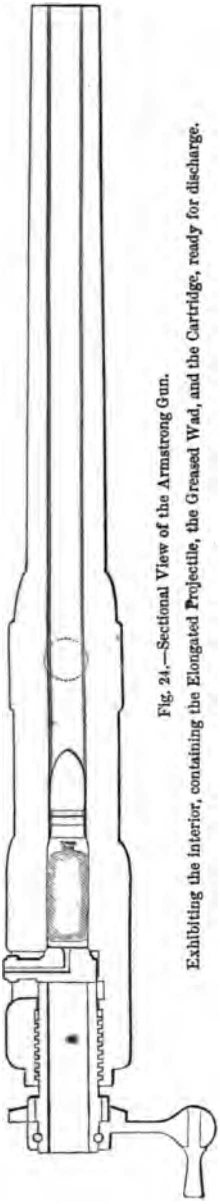
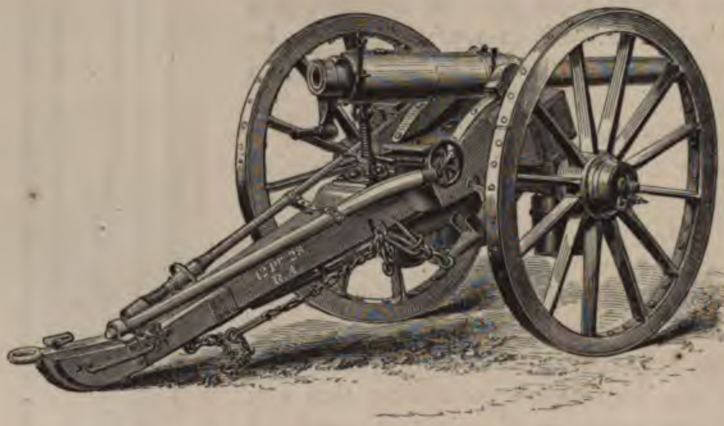


Fig. 24.—Sectional View of the Armstrong Gun.
Exhibiting the interior, containing the Elongated Projectile, the Greased Wad, and the Cartridge, ready for discharge.

afterwards abandoned for field guns; but it has been decided that the principle should be retained in ship guns (fig. 26, opposite). It is a point of great importance, that a breech-loading gun should be self-acting, in recovering its position after recoil, so as to obviate the employment of so many men to run out the gun. A traversing movement was originally applied to the field carriages, as shown in the diagram, and was found to afford great facility in laying the gun. A very neat modification of this traversing movement has recently been contrived in the Royal Carriage Department, and adopted for the field carriages."

Fig. 25.



The greatest range which has yet been attained with the Armstrong gun is 9175 yards, or nearly 5¼ miles. The conditions which are chiefly conducive to an extended range are, a small bore and a very lengthened projectile; but the more a projectile assumes the character of a bolt, the less suitable it becomes for a shell. Sir William Armstrong, therefore, deprecates any further increase of range at expense of efficiency in the shell; and, indeed, it may well be doubted whether an extension of range beyond a distance of five miles would prove of any practical utility.

The following is an example of practice with the Armstrong

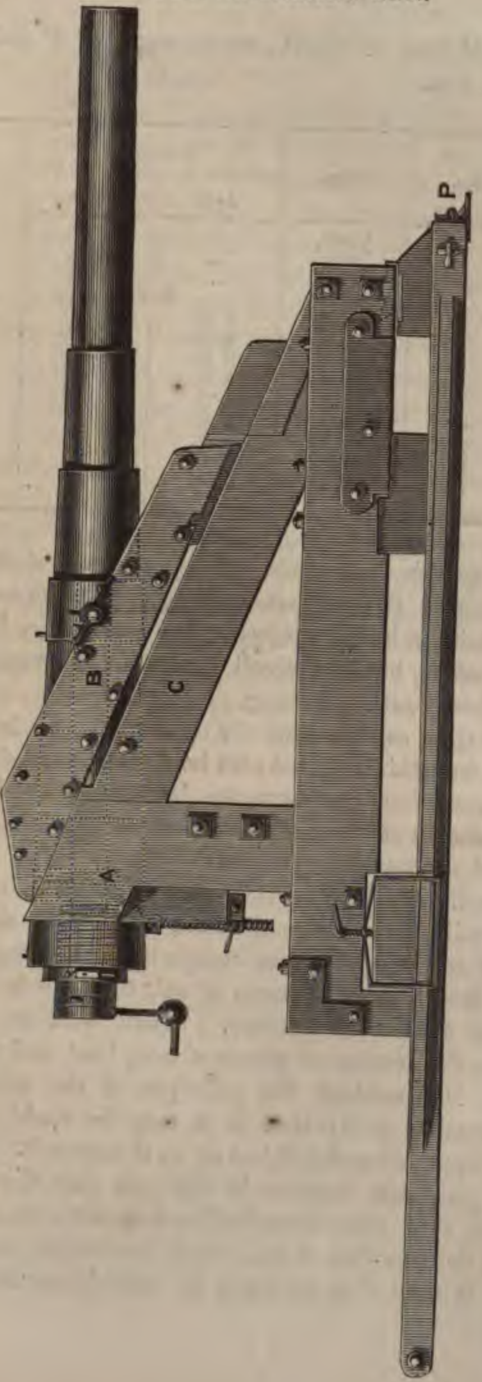


Fig. 26.—The Armstrong Gun mounted for sea-service.

A. The Breech Stopper.
B. The Upper Carriage, which recoils on the incline **C.**
P. The Pivot Bolt, which connects the Armstrong carriage with the common slide.

12-pounder field gun of 8 cwt., at an angle of 5° and with a charge of 1 lb. 8 oz.

No.	Range.	Deflection.	
		Left.	Right.
	Yards.		
1	1920	..	1 ft.
2	1910	..	1 ft.
3	1909	In line.	
4	1923	1 ft.	
5	1945	3 ft.	
6	1923	3 ft.	
7	1906	3 ft.	
8	1911	3 ft.	
9	1903	2 ft.	
10	1921	4 ft.	
11	1918	2 ft.	
12	1924	6 ft.	

The above practice was made with the ordinary shell adapted for this gun, and the minimum charge. By increasing the charge, and using a longer projectile, the same range is attained with less elevation, but the recoil becomes too severe upon the carriage for long continued firing.

The projectiles, as now used for these guns, are in all cases made of cast iron, thinly coated with lead, and, being of somewhat larger diameter than the bore, the lead is crushed into the grooves; by means of which the necessary rotation is given, while all shake and windage are prevented.

The projectile for field service admits of being used indifferently as solid shot, shrapnel shells, or canister shot. It is composed of separate pieces, so compactly bound together that it has been fired through a mass of oak timber 9 feet in thickness without sustaining fracture. When used as a shell it divides into the number of pieces of iron, lead, and fuze stated in p. 207. It combines the principle of the shrapnel and of the percussion shell: that is, it may be made to explode either as it approaches the object or as it strikes it. The shock which the projectile receives in the gun puts the percussion arrangement as it were from half-cock to full-cock, and it then becomes so delicate that it will burst by striking even a bag of shavings. It may also be made to explode at the instant of leaving the gun, in which case the pieces produce the usual effect of grape or canister.

For breaching purposes or for bursting in the side of a ship, a different construction of shell is adopted. The object in that case being to introduce the largest possible charge of powder, the projectile used is simply a hollow shot, and from its length and form is capable of containing a much larger bursting charge than is compatible with a spherical form of the same diameter.

The largest gun which has yet been completed upon Sir William Armstrong's principle is one of 65 cwt., which although only designed to throw a projectile of 80 lbs., has been frequently tried with a shot weighing upwards of 100 lbs.

Early in the course of his experiments, Sir William Armstrong's attention was directed to the improvement of the sights, as the means of aiming guns previously employed were obviously not sufficiently delicate for a gun having 57 times their accuracy. The sights which he has introduced present many peculiarities. The eye-piece of the tangent-scale is in the form of a cross slit, and has a traversing movement for correcting the effect of side wind. The vertical and lateral movements of the sight are each regulated by means of a vernier which enables the scale to be read off to one minute of a degree both for elevation and deflection.

With regard to the strength of the Armstrong guns to resist explosion, the 12-pounders have been proved by filling the chamber with powder (about 2¼ lbs.), and using a shot of double the service-weight. In the case of the 40-pounders, it is intended to apply double charges and single shot. To provide for a large charge of powder, it is only necessary to reduce the lead on the shot, so as to allow it to enter further into the bore. Sir W. Armstrong believes the strength of his guns to be enormously in excess of these charges, the object of the proof being rather to detect defects in the surface of the bore than the resistance to bursting, which he considers to be almost uniform in all guns constructed on his principle.

It is but right to state that Sir William Armstrong gratuitously ceded to the public the whole of his inventions appertaining to this subject; but, it being deemed desirable that the task of carrying them into practice should be committed to his charge, he was appointed in the first instance Engineer for Rifled Ordnance, and subsequently Superintendent of the Royal Gun Factories, in which latter capacity he now continues to act.

THE WHITWORTH GUN.

242. The method of rifling adopted by Mr. Whitworth,[a] consists in making the barrel of the gun of a hexagonal spiral form, by which rotation is impressed upon the projectile by effective rifling *surfaces*, instead of by spiral *grooves* and the non-effective "lands" of a cylindrical bore. The projectiles being of the same hexagonal form externally as the bore is internally, and no forcing process required, metals of all degrees of hardness may be employed, and slowly-igniting powder, like that of the general service, used.

This simple and very beautiful mechanical principle admits of application to firearms of every description, provided they are of sufficient strength to resist the strains put upon them by the rifling principle.

Mr. Whitworth first applied his system to rifle-muskets, and with a degree of success of which a full account will be found in Sects. 595, 596, 597.[b]

The great strain put upon a gun rifled in the ordinary manner, at the instant of discharge, is occasioned by the force exerted upon the projectile to overcome its natural vis inertiæ, together with the force required to cause the soft metal of which the projectile is formed, or with which it must be coated, to enter into the grooves of the barrel; whereas by the system of rifling by surfaces, and not by grooves, the projectile, not being forced into another form, is so easily set in motion that it may be pulled out of the gun by a slender twine.

In stating this, Mr. Whitworth appears to imagine that the recoil of a gun is produced by the reaction of the force impressed

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[a] To Mr. Lancaster is, unquestionably, due the credit of being the inventor of the new principle of rifling, which consists in renouncing the method of spiral grooves in a cylindrical gun, and substituting the rifling surfaces of a spiral bore of another geometrical figure: he chose the ellipse, but this has proved a failure, as shown in Art. 198; see also Appendix H to the 4th edition of this work. Mr. Whitworth improved this system of rifling by adopting a polygonal (hexagonal) bore.

[b] Mr. Whitworth is now preparing breech-loading rifled muskets, which there is every reason to believe will prove still more superior to other rifled muskets in accuracy, length of range, and penetrating power, than his mouth-loading rifled muskets used in the practice-ground at Hythe in 1859.

upon the projectile to drive it through the contraction of the bore. But this is an erroneous supposition (Art. 72). The recoil is not affected by any degree of resistance or impediment to the passage of the shot along the bore. Different degrees of ramming, stout, thick, and tight wads, one placed between the charge and the shot, another over the shot, rammed home with various degrees of force, make no sensible alteration in the initial velocity, as determined by the ballistic pendulum, or by the oscillating gun. The velocity of the recoil of the gun is to the initial velocity of the shot, inversely as the weight of the gun and carriage is to that of the shot, as shown by the formulæ in Art. 72. The resilition or springing back of the Whitworth gun is less than that of the lighter Armstrong gun, because the weight so driven back is greater, and therefore the velocity and length of recoil less. It remains to be seen what the recoil of Mr. Whitworth's breech-loading gun will be, compared with that of the Armstrong gun, in the forthcoming trials to test the comparative merits of the rival guns.

Mr. Whitworth entirely eschews the method of giving an increasing turn or twist to the spiral of the bore as obviously dangerous, by causing increasing strains upon the gun, in the chase and at the muzzle, just where the diminishing thickness of metal in the gun requires relief; and to which malformation of the Lancaster gun, may be attributed the frequent burstings of that gun at or near the muzzle, which occurred in numerous experimental trials, and subsequently happened on service at the attack of Sevastopol: where, on one occasion, the whole muzzle of a gun was blown off by the increasing strains thus put upon it; having got rid of which weak part, the gun continued to be used with safety and effect as a howitzer.

Mr. Whitworth predicted, truly as it has since appeared, that iron guns, cast in solid masses, would be found incapable of resisting the great strains to which rifled cannon are subject; it being well known that great inequalities in the physical structure of the metal are produced during the process of cooling; and that beyond a certain limit, little or no increase of strength is given to the gun by increasing its thickness of metal.

Notwithstanding these misgivings as to the capability of a gun, formed of cast iron in the usual manner, to bear the additional strain put upon it when converted into a rifled cannon, Mr. Whitworth was induced to apply his system to the unbored block of an ordinary 68-pounder gun of 95 cwt. for trial against the "Alfred" frigate in 1858, the sides of which were covered with plates of various descriptions of metal, and of different thicknesses (Art. 391).

The gun used in those experiments was externally of the same dimensions as the service 68-pounder, but somewhat heavier, owing to the hexagonal bore being smaller. The gun was rifled in the same manner as the Whitworth 24-pounder howitzer, but the turn of the spiral was 1 in 100 in. The diameter of the bore, measured from face to face of the hexagon, was 5 in. and from angle to angle $5\frac{1}{2}$ in.; the windage at the mouth of the gun $\frac{1}{30}$ in.; the projectiles were formed of solid cast iron—some were hardened at the point; the projectiles were from 11.7 to 12.7 in. in length, their diameter at the points 4.7 in., and at the base 5 in., their weight 80 lbs.

The result of these experiments confirmed the apprehensions entertained by Mr. Whitworth, of the inability of the gun to resist the additional strain put upon it by converting it into a rifled cannon (Art. 395); whilst, on the other hand, the results of the trials fully realized the expectations he entertained of the vast penetrating power of his flat-headed hexagonal shot (Arts. 392, 393).

The untoward results of the bursting of the gun (Art. 394), and of the jamming of the shot in the bore in the operation of loading (Art. 393, p. 400), which no doubt arose from inequalities in the metal of which it was formed, and mechanical imperfections in the conformation of the gun or shot, threw Mr. Whitworth back in the prosecution of his experiments by the necessity of preparing guns of his own manufacture, made of wrought iron, of strength sufficient to resist any strain that might be put upon them, and to prepare projectiles so mechanically exact as effectually to prevent the recurrence of any such failures. These great objects he appears to have fully accomplished by the experiments at Southport with his new breech-loading hexagonal guns which we are now to describe, viz., his 3, 12, and 80-pounders.

The length of the 3-pounder is 6 ft., its weight 208 lbs., the diameter of its bore 1½ in. The length of the 12-pounder is 7 ft. 9 in., the weight 8 cwt., the diameter of its bore 3½ in. The length of the bore of the 80-pounder is 9 ft. 10 in. The space occupied by the charge and projectile is 16 in., which reduces the length of the effective rifling surfaces to 8 ft. 6 in. The weight of the 80-pounder is 4 tons, and the diameter of the bore 5 in.

The breech is closed when the gun is loaded, by a cap (fig. 27, below), which works in an iron hoop, jointed to a projection at the side of the breech, and which, when turned to its proper place, is screwed externally to the breech-piece, in the manner shown in fig. 28, below.

Fig. 27.

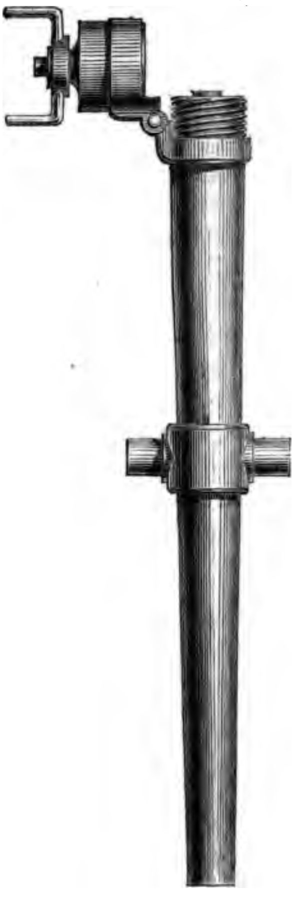
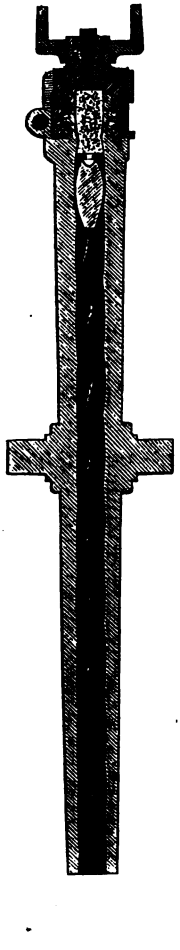


Fig. 28.



To open the breech, the cap is unscrewed and turned aside, leaving the bore of the gun open and clear from end to end. The projectile is then placed in the gun, and the charge of powder, contained in a tin case, pushed in behind it as shown in fig. 28. The breech-cap is then shut and firmly closed by three turns of the handles which work the screw. The vent lies in the centre of the breech-piece, and the gun is fired by an ordinary friction-tube.

The Whitworth guns are all made in masses of homogeneous iron, and bored out of the solid. The large guns are strengthened by wrought-iron hoops applied by hydraulic pressure.

The projectiles are simple, uncoated, hard-metal bolts of various shapes, according to the purpose for which they are employed. They are all made by self-acting machinery, and so nicely shaped that their bearing surfaces fit with the utmost exactitude, the rifling principle being executed by machinery in the workshop, and not produced by the explosion in the gun.

For firing through soft substances and into masonry, tubular projectiles are employed; for piercing thick plates of wrought iron, flat-fronted projectiles, made of homogeneous iron, are used.

For ordinary practice, and where length of range is important, the fore part of the projectile is made to taper slightly, the front being rounded off, and the rear part is made nearly to correspond with the fore, with regard to the degree of taper, but its end is flattened, and sometimes slightly hollowed out. The importance of establishing a proper relation as to shape and relative weights of the fore and hind part of a projectile, is apparent from the fact that a projectile which is so made gives an increased range of more than 25 per cent., as compared with one with a similarly shaped front and the ordinary cylindrical rear.

In the Whitworth gun projectiles of any length, and charges of powder of any amount, may be employed. It is said that the Whitworth 3-pounder fired off 10 shots, placed one on another; and that a projectile 10 diameters in length was fired from a howitzer rifled according to the Whitworth system, without injury to the gun.

Table I.—Ranges obtained at Southport, Feb. 15th and 17th, 1860, of a 3-pounder Whitworth Gun, length 6 ft., weight 208 lbs., diameter of bore 1½ in., charge 7½ oz., at the undermentioned angles of elevation.

Angles of Elevation.	Yards Range.	Deviation from Line of Fire.
3°	1607	½ yard to the right.
,,	1593	Line.
,,	1589	Line.
,,	1588	1 yard to the right.
,,	1577	½ ,,
,,	1575	½ ,,
,,	1573	½ ,,
,,	1568	2 ,,
,,	1552	½ ,,
10°	4171	6 yards to the left.
,,	4179	4 ,,
,,	4224	5 ,,
,,	4122	2 ,,
20°	6760	5 ,,
,,	6784	12 ,,
,,	6720	14½ ,,
,,	6910	2 ,,
35°	8907	22 yards to the right.
,,	8930	10 yards to the left.
,,	9059	11 yards to the right.
,,	9164	23½ ,,
,,	9688	34 ,,
,,	9645	31 ,,
,,	9611	89 ,,
,,	9547	57 ,,
,,	9503	72 ,,
,,	9463	58 ,,

Table II.—Ranges of a 3-pounder Whitworth Gun, at 20° Elevation, Charge 7½ ozs. of Powder.

Yards Range.	Deviation from Line of Fire.
6818	26 yards to the left.
6749	27 ,,
6602	54 ,,
6556	35 ,,
6511	34 ,,
6561	20 ,,
6316	20 ,,
6469	11 ,,
6339	12 ,,

TABLE III.—Ranges of a 12-pounder WHITWORTH GUN; length 7 ft. 9 in., weight 8 cwt., diameter of bore 3½ in., with a charge of 1¾ lbs. of powder, at elevations of 2°, 5°, and 10°.

Angle of Elevation.	Yards Range.	Deviation from Line of Fire.
2°	1280	⅓ yard to the right.
,,	1270	⅓ yard to the left.
,,	1257	½ ,,
,,	1254	1¼ yard to the right.
,,	1208	⅓ ,,
5°	2342	4 yards to the left.
,,	2321	On the line.
,,	2326	I yard to the right.
,,	2333	2 yards to the left.
,,	2298	1 yard ,,
10°	3942	15 yards to the right.
,,	4120	13 ,,
,,	4011	7 ,,
,,	4002	16 ,,
,,	4059	9 ,,

TABLE IV.—Ranges of an 80-pounder WHITWORTH GUN; weight 4 tons, with a charge of 10 lbs. of powder, and a solid shot of 90 lbs. weight, at elevations of 5°, 7°, and 10°.

Angle of Elevation.	Yards Range.	Deviation from Line of Fire.
5°	2544	5 yards to the right.
,,	2604	2 ,,
7°	3503	4½ ,,
,,	3498	6 ,,
,,	3487	6½ ,,
,,	3482	6½ ,,
10°	4700	5 ,,
,,	4409	6 ,,

The author regrets that his application to Mr. Whitworth for an authentic description of his hexagonal gun, illustrated by diagrams, and the results of the experimental trials at Southport, has not been complied with. The printing of this work is so far advanced as not to admit of further delay. The preceding description of his method of rifling, and of his guns, is compiled from his work on 'Mechanical Subjects,' p. 73, Article on *Rifled Fire-arms*, and from the reports of ranges obtained by his guns at Southport, which appeared in the 'Times' and other public journals.

Whilst these sheets were passing through the press, the results of the experiments to test the penetrating powers of the Whitworth hexagonal 80-pounder shot against the floating battery "Trusty," covered with wrought-iron plates 4½ in. thick, reached the author. These trials confirmed the vast penetrating power of flat-fronted hexagonal shot fired from the Whitworth hexagonal 80-pounder, which had been evinced in the experiments against the "Alfred," as stated in page 216, and that without the slightest injury to the gun.

The first shot, fired with a charge of 12 lbs., passed through the "Trusty's" side, making a clean hole. The next shot, fired with a charge of 14 lbs., passed completely through the side—making a clean hexagonal hole—into the main deck, smashing an iron knee and driving in with it splinters of wood and iron. Another shot fired with the same charge, though the hit was oblique, passed through the iron sides, and struck the end of a deck beam, in which it lodged. Another shot pierced the centre of a plate into the main deck, driving in a mass of splinters, and a large iron-bolt, which had evidently been driven through and whirled about by the force impressed upon it by the rapid rotation of the projectile. These interesting experiments completely establish the penetrating powers of the Whitworth flat-headed hexagonal shot at short ranges to be superior to those of any other gun or projectile hitherto produced. The recoil from Whitworth's breech-loading gun is not more than from his muzzle-loader, and is pronounced on competent authority to be moderate.

ON THE RESPECTIVE CAPABILITIES OF THE ARMSTRONG AND WHITWORTH GUNS.

243. The comparative value and importance of the Armstrong and Whitworth guns (so essentially different in construction, dimensions, faculties, and aptitudes, that they cannot be equally adapted to all the requirements of general service) can only be correctly estimated, fairly judged,—in so far as they satisfy respectively the well-established principles and practical maxims of gunnery, which the reader of the present and previous editions of this work will find fully laid down in the articles to

which reference is made in the present work,—and their real-service uses proved by actual experiment and protracted trials, under circumstances resembling, as much as possible, the services and vicissitudes of war.

To project a bolt of iron of 3 lbs. weight from a gun whose calibre is 1½ in., to a distance of 9000 or 10,000 yards, is a wonderful feat; and has been so regarded by the unskilled in the science and practice of gunnery—as if the question at issue were the distance to which a shot could be projected, at elevations producing the maximum range. But this is not the subject of inquiry.

A gun possessing such vast power of range as that exhibited in the experiments at Southport, must have a commensurate long range at small elevations; but here, too, range is not the question, unless it be coupled with efficiency. The real question which experience has to consider, is the actual practical value of extreme ranges produced by maxima elevations for exceptional purposes, compared with the far more important object, —a gun fully efficient for battle purposes of every description at small or minima elevations. If anything essential to the efficiency of a gun be sacrificed to the special and exceptional object of attaining the greatest possible range at the highest elevation, which undeniably is the case with respect to the construction of the Whitworth small-calibred 80-pounder, should that inaptitude for shell-firing be retained or modified? No experienced and skilful artillerist, naval in particular, will hesitate as to the answer he would give to that question. It would therefore be a great waste and misapplication of projectile power, to use any *gun* in the manner exhibited by Mr. Whitworth, in the trials made of his guns at Southport. The range of upwards of 9000 yards was obtained at 35° of elevation! A 24-pounder gun, at its maximum potential elevation, would project its shot to the distance of 5180 yards (Art. 95); but no one ever imagined or heard, in these days, of so preposterous a misapplication of that very efficient shot-gun. No projectiles but shells should be used in vertical firing at high elevations. The French howitzer, used at the attack of Cadiz, threw its shells to a distance of upwards of three miles into that city; but their cavities being filled with lead, to obtain that great range with a suitable increase of charge (Art. 102, Note [a], p. 71, and Art. 193), did little or no harm to the place, beyond crushing or breaking through what they hit or fell upon.

A *shot* projected to a distance of 9000 or 10,000 yards is utterly worthless; but a *shell* projected to that distance by a piece of ordnance of calibre (capacity) sufficient for effective shell-firing, and exploding at the right moment, gives a prodigious power of bombardment of very great importance, and may efficiently perform the office of a mortar-shell. Here the inferiority of the Whitworth 5-in. bore to that of the 7-in. Armstrong 80-pounder is obvious. Power of range has been much vaunted, as if that were the only thing required, and has raised very exaggerated expectations of the paramount power of the Whitworth guns to destroy an arsenal 9000 or 10,000 yards distant; but this can only be done by powerful shells, and a tubular projectile of 5-in. internal diameter must, in order to contain efficient bursting-charges, be so elongated as to act very imperfectly as a shell, because, as Sir W. Armtrong states, although the conditions of a small bore and a very lengthened projectile are conducive to extended range, a very elongated projectile assumes the character of a bolt, and will be less efficient as a shell the more the projectile is elongated.

The great penetrating power of the Whitworth rifled musket is owing to the smallness of the bore (see Art. 597); but it must not be concluded from this that the principle of small bore should be applied to rifled cannon. A very small clean hole made into or through the body of a man or of a horse suffices: not so with respect to an aperture to be made in the body of a ship. The hole should be large and ragged, and therefore the diameter of the projectile as great as is consistent with the requisite form of an elongated projectile.

The maxima ranges of guns, in the modern uses of artillery (and which, in the first uses of artillery, were generally employed on account of the want of strength in the guns of that day to use large charges), have been entirely given up (Arts. 83 and 93), and their uses limited to that which is now called horizontal firing. The great object in the modern science and practice of gunnery, is to construct guns possessing in the greatest degree power of range, precision, and penetrating force (Arts. 133 and 141), with the greatest possible point-blank range, the trajectories of which shall be as low or flat as possible (Art. 268 and 270, Note[b] p. 264).

The effect of a shot does not depend so much upon the angle at which it is projected, as on that at which it impinges on the field or flood of action.

In vertical firing with shot at high angles, the trajectories are so elevated that the projectiles can produce no intermediate effect upon the field of action, and fall to the ground under so high an inclination that they can hit but a point on the plane, and there can be no secondary effect by ricochet.

There is a peculiar inaptitude in elongated rifled projectiles, disqualifying them from being used in vertical firing, which increases with the elevation above point-blank. This unfitness for vertical firing consists in the fact, that an elongated shot continues throughout its flight to move in positions parallel to that in which rotation was impressed upon it while in the gun, so long as rotation acts with sufficient intensity: when the spinning motion ceases, the projectile, like the oblong shot, becomes the most errant, and, excepting at very close quarters, the most inefficient of all projectiles, and has accordingly fallen into disuse. No other method, than that of rotation, has yet been discovered by which to keep conical shot steady to their flight in the direction of their longitudinal axes (see Arts. 195, 196). Oblong shot tumble over, or strike with their side, because they are not made to rotate. The Hale rotating-rocket (Art. 340) loses its directing power as soon as the composition by which rotation as well as range is produced, ceases. The common rocket moves with its point foremost so long only as the stick remains to perform to the rocket the office which the feather does to the arrow; but when the stick is broken, which it very often is in the grazes of horizontal firing, the body of the rocket performs the antics of a squib.

Captain Thistle, of the United States' army, proposed to produce rotation in a shot of conoidal figure by cutting curvilinear grooves on its convex surface; but the rotation not being sufficient to cause the projectile to move with its point foremost, it turned over several times in its flight in a range of 1000 yards, and so proved a total failure (Art. 195). Dr. Minesinger exhibited at Woolwich in 1849 an oblong shot or shell with a four-grooved tail, resembling the first screw-propellers with four leaves, by which to produce rotation, and by resistance behind to tend like the feather of an arrow to keep it straight; but this proved a decided failure. There is no other method by which to impress efficient rotation upon a projectile than by being forced through the bore of a rifled gun.

At ranges within point-blank, the elongated shot, moving in the axis of the gun produced, strikes with its point in the direction of its length; and we have seen with what force the flat-headed Whitworth shot punched or rather gouged, by its rapid rotation —a new element in penetrating power—a hole in the iron plates, and passed through the side of the "Alfred" frigate, at a distance of 400 yards, and, at 200 yards, through the side of the "Trusty" (Art. 243, pp. 216, 221.) But beyond point-blank, elongated shot do not strike, like the arrow, with their points in the direction of their length, but become more and more oblique to the trajectory, in proportion to the elevation at which they were discharged, and which, by rotation on that axis, they retain throughout their flight. Thus an elongated rifle-musket leaden shot, striking at point-blank an iron target perpendicularly to the plane of its surface, spreads equally in every direction into a round patch, the edges of which are ragged, the main portion of the lead flattened in the centre. But such a shot striking the target at a distance which requires elevation, forms an oblong patch of which the vertical length is greater than the horizontal width, in proportion to the obliquity with which the elevated projectile strikes. When the elevation is considerable, the shot, touching obliquely with its point, falls with its side upon the target, and forms a still more elongated patch. These effects are practical demonstrations of what has been above stated in the flight of elongated projectiles.[a] The difference in effect between a rifle leaden shot and an elongated rifle cannon-shot, striking obliquely, is this—that, although the minimum

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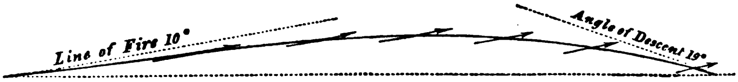
[a] It may easily be seen, by picking up a number of patches at the foot of the target, which of these had been formed by point-blank and which by elevated trajectories.

of resistance no longer obtains, yet the leaden rifle-shot has abundant power to do its work efficiently on bodies of troops; whereas the elongated rifle cannon-shot no longer possesses the maximum, because direct, penetrating power, which it can only exert on material defences, at or within point-blank range when the hit is direct in the axis of its length; but whose penetrating power is vastly reduced when, the hit being oblique, the impact is delivered slantingly upon a larger surface, and the penetration of the shot rather sideways than in the direction of its axis.

Fig. 29.



Applying this to the trajectory laid down in Fig. 19, Plate II., and to the accompanying diagram, fig. 29, we see that elongated shot fired at a target representing the side of a ship, at a distance beyond their true point-blank range, do not strike with their points in the direction of their axes; and the greater the elevation, the more and more oblique the impact on the target becomes; so that, beyond their efficient horizontal ranges, there is no practical advantage in the use of elongated projectiles, save for exceptional cases hereafter to be noticed. Thus the conditions on which the advantages of cylindro-conoidal elongated shot depend—originally proposed and expounded by Newton, in his celebrated problem of the "Solid of Least Resistance," (Art. 179),—are first infringed and then violated. For these reasons, and on that high authority, ranges produced at great elevations are exceptional cases, inasmuch as they deviate from the principles on which minimum resistance, maximum penetrating power, and precision, depend; and therefore do not fulfil the conditions of the case.

It follows from this, that some limits should be assigned to the ranges beyond which the efficiency of elongated projectiles, in horizontal firing, ceases to obtain—a limit which should not exceed 2000, or, for particular purposes, 3000 yards; and within which the main value and most important uses of the Armstrong field-gun for battle purposes will be found to lie. To extend the sphere of action to 3000 yards, would require an elevation of 10° : a great additional departure from the fundamental principle, minimum resistance, on which the precision of elongated projectiles depends, and upon the invariable maxim that elevation is, inversely, the exponent of inaccuracy, even with arms of precision; and, indeed, particularly with them, for the smallest difference in elevation in a flat trajectory occasions very great differences in the ranges of the projectiles to the first graze upon a horizontal plane. From what has been stated in the preceding pages it is clear that elongated rifle projectiles have great aptitude for perfectly horizontal firing, and that then only can they be applied in all the purity of the principles upon which their efficiency depends; but in vertical firing these peculiar aptitudes gradually disappear, and render elongated shells unfit to do the work of spherical 13-in. mortar shells with equal efficiency, within the distances to which mortar shells can be thrown.

The ranges obtained by the Whitworth 3-pounder, at 20° of elevation, show that, though the lateral deviations were small, the differences in the length of range were considerable. The difference between the greatest and the least of the four ranges at 20° is 190 yards (Table I., p. 219). The difference between the greatest and least of the nine ranges obtained from the same gun, at the same elevation and with the same charge, is 502 yards (Table II). The difference between the two ranges obtained by the 80-pounder Whitworth gun, at 10° of elevation, is 291 yards (Table IV., p. 220). The difference between the greatest and least of the twelve ranges obtained by the Armstrong 12-pounder (p. 212), at an angle of 5° of elevation, is only 39 yards. It is not meant by this quotation to imply that Mr. Whitworth's hexagonal gun may not prove as precise as the Armstrong gun at the same low elevation. The longitudinal differences of ranges at 20° in the trials of the Whitworth gun, and the very small differences in length of range obtained in 12 rounds by the Armstrong gun at 5°, are stated to show the vast efficiency of horizontal firing at small elevations; when, at the ranges of nearly 2000 yards with the Armstrong gun, there was only a difference of 39 yards in length of range to the first graze, and the angle under which the shot impinged upon the plane so small, that troops either nearer or beyond the graze would have been exposed to severe loss by the horizontality of that trajectory.

In the summary of experiments made with the Whitworth guns at Southport, which appeared very generally in the public journals, the longitudinal deviations[a] are very erroneously laid down, and do not show the differences in the lengths of range.

Whatever position a spherical projectile may assume, in passing through the air, is indifferent with respect to resistance; and a 13-in. shell is assuredly a more efficient weapon for incendiary purposes in the bombardment of arsenals, at a distance of upwards of 4000 yards (Art. 200), than any elongated projectiles at that distance; and we should be careful how we lay aside that very efficient description of ordnance—the mortar. At distances beyond the reach of 13-in. mortar shells, up to 9000 yards, the new projectiles only will suffice; but it may be very much doubted whether elongated shells, as incendiary weapons, can be made efficient at that distance; and, in horizontal firing, molten iron[b] cannot be used with the Armstrong shells, on account of the heat, which would melt the leaden coating upon which the rifling principle adopted by Sir W. Armstrong depends.

Forced through the air in positions oblique to the trajectory, the resistance of the air to an elongated shot increases; and, acting underneath the projectile, tends to give it a kite-like motion upwards, in the direction of its axis, by which it is sustained in its flight, and to produce a somewhat longer range than is due to the theory and elements of the case.

The accompanying figure, 30, shows the obliquity of the projectiles to the trajectory produced by an elevation of 35°, and to what extent the essential and pure conditions of the principles on which the efficiency of elongated shot depends, are

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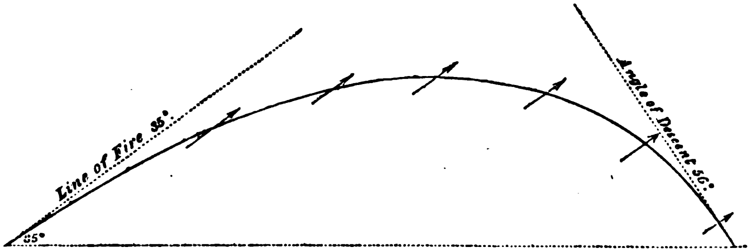
[a] The reader is referred to the articles 'Deviations of Shot, longitudinal and lateral,' 'Excentric Shot,' 'Rotations,' 'Ricochet,' &c., in the Index, and the causes thereof, which are fully explained in those articles.

[b] As an illustration of the efficiency of shells filled with molten iron as incendiary weapons, it may be mentioned that, in experiments carried on from on board the "Excellent" against the "Undaunted," in the present year (1860), the effect produced by the discharge of five shells filled with molten iron was that the vessel experimented upon was set in a blaze which could only be extinguished by firing 68-lb. shot into her water-line so as to submerge her.

first infringed and ultimately violated, with respect to minimum resistance, maximum of penetrating power (for these are convertible terms): because, striking rather with their sides than with their points, penetrating power—so essential to the full effects of a shot, and to the far more destructive effects of a shell—is greatly impaired; and explosion can only be effected by a time-fuze, since the projectile, in falling to the ground, impinges with its heel, as shown in fig. 30.

Fig. 30.



The Whitworth gun, by its flat-headed hexagonal shot, can, as we have seen, gouge a small hole in an iron plate and penetrate into a ship more effectually than any other projectile hitherto tried; but it only makes a small clean hole, with very little splintering, and, not being adapted to shell-firing, now so generally introduced in all naval services,—and which will continue to be practised as the rule of the service so long as timber ships remain in use for ocean fleets,—is not well calculated to be used in the Naval Service.

Guns, particularly naval guns, should be well adapted to fire, with efficiency, either solid shot or shells. If the flat-fronted hexagonal shot, which, after having passed through the iron plates and sides of the "Trusty," in May 1860, lodged in a main-deck beam; and that which, having perforated the iron covering, penetrated 11 in. into the oak timber, and there remained imbedded, had been shells and there exploded, the effects would have been maxima. A shell lodged in the timber would either have blown off the plates or blown in the timbers of the main-deck, accordingly as the line of least resistance—for let it be remembered a shell so lodged is a mine—might be outwards or inwards. All the preliminaries favourable to a maximum effect were prepared in this case, but the weapon was incapable of accomplishing what, in great part, had been effected; and the facts to which reference has been made, are the strongest proofs and illustrations that can be produced of that great defect in the Whitworth system, as it at present exists, in not adapting his guns as well to shell as to shot firing, and which can only be accomplished by enlarging the calibre of his 80-pounders.

In reply to observations to this effect, made in the discussion which took place at the Civil Engineers' Institute, on the 14th February 1860 (p. 135), Mr. Whitworth asserted that his guns are *peculiarly* adapted to shell-firing by being enabled to increase the length of the projectile (which in the Armstrong gun is limited by the chamber) indefinitely, by there being no chamber in the Whitworth gun, and that, by increasing the length of the tubular shell, a proportional increase of bursting-powder may be used. But in a very elongated shell of small diameter, though its interior tubular capacity contain proportionate increases of powder, the bursting-charge is too distended to enable the projectile to act efficiently as a shell. The explosive force of an ordinary spherical shell acts equally in every direction, and breaks the shell into very numerous small splinters; but a tubular projectile, fired from a gun of small calibre, must necessarily be of such length to contain an efficient bursting-charge that it would not break the shell into small fragments, nor act equally in every direction: its force would rather act longitudinally than transversely, from the nature of the case. The elongated shell would probably split, or be broken into a few large fragments. The shell of the Armstrong 80-pounder gun scatters 217 pieces, consisting of fragments of the shell and the pieces of iron packed in its interior. Mr. Whitworth proposes to provide for the breaking of his shell into any desired number of fragments by internal grooves, by which, the metal yielding there to the explosion, the size and number of fragments may be regulated. This is a subject on which extensive trials should be made, to ascertain the comparative merits of the rival guns, as well for horizontal shell-firing as for shot-firing.

In the discussion at the Civil Engineers' Institute, Mr. Whitworth asserted (p. 136) that the elongated form of shot proposed by him is superior to spherical projectiles for ricochet firing. This, the author thinks, is a mistake (Art. 239, p. 200) or at least that this very important secondary effect of projectiles in horizontal firing cannot be relied upon, either on the surface of the sea or on that of the land.

The author's conviction that caution is needful in this respect has been confirmed by recent experiments. Previously to trial against iron plates with one of Whitworth's guns, a shot was fired at the horizon, with an elevation of about 1°, in order to test the stability of the carriage, &c. The projectile, at the end of its flight, made a number of short ricochets, and eventually turned off considerably to the *left*. With an unknown and constantly shifting range, numbers of the most effective hits with spherical shot in action have been from ricochet; and there is no doubt that with elongated projectiles the advantage hitherto possessed by ricochet will be lost, as shots usually turn off to the right. This is one reason, and a very weighty one, why the question of the expediency of introducing the rifle as a broadside gun should be well considered, and satisfactorily settled, before making so important a change in our ships' armament.

All rifled shot, spherical or conoidal, deflect in the direction of rotation; and it is obvious that any form of projectile, excepting the spherical, must be unsuited for ricochet. The deflections of elongated shot of any form are far greater and more irregular than those of spherical projectiles. The more rapid the rotation, the greater the deflection, which, together with the polygonal form of the Whitworth projectiles, render them particularly ill-adapted to ricochet firing.

It follows from this that the effect of ricochet, with elongated projectiles, is lost, or cannot be relied upon, either by land or by sea, in general actions; and, consequently, that efficient use of rifled cannon ceases at the first graze, and therefore that good secondary effects can only be obtained by the projectile being enabled to act as a shell, when it is no longer efficient as a shot. Here the advantages of the Armstrong contrivance for adapting his projectile to shrapnel-shell firing are highly important.

Thus we see that guns adapted to shell as well as to shot firing, are as essential for secondary effects in the land service as they are indispensible in the sea service, to cause the projectile to explode on striking or when lodged in the side of a ship. Nothing can compensate for the lost effect of ricochet. The grazes of spherical projectiles upon a perfect plane are straight as lines; they continue in the line of fire produced to their extreme roll, with considerable effect, moral as well as physical, on fields of battle. At the siege of Burgos, our shot having been all expended, soldiers were employed and paid for picking up shot fired by the enemy, to be used against them, without regard to the differences of windage under such an emergency. Many of our soldiers were seriously hurt, some it was said killed, in attempting to stop 16 and 24 lb. shot which appeared to be rolling like cricket-balls, and as if they might easily be stopped. A soldier tried to do so with his foot, but it fractured his limb, threw him down severely contused, and rolled on with a momentum, though with very little velocity, which would have done great damage in a mass of troops. In general actions on plain battle-fields, the effects of shot after the first graze are often greater than direct hits; and it has been shown above how very serious the loss of ricochet is in naval actions. The author is forced to conclude from what has been stated, and therefore compelled to pronounce, that this defect of the new guns must be considered to detract very greatly from their real-service value, and that very great circumspection, and protracted trials which shall put these doubts at rest one way or other, must be settled ere it would be prudent or safe to introduce these guns into the broadside batteries of ships.

The Armstrong gun, designed principally for shell-firing, is nevertheless a very powerful shot-gun; and may either fire solid shot or shells, and that with the same projectile, by simply either filling the chamber of the shell with bursting-powder, or leaving it void; the contents of the shell, when used as such, being solidified with the shell by the percolation into the interior of the melted lead with which it is coated. But that his gun is not an equally efficient solid-shot gun is admitted by Sir W. Armstrong, in the expression that "the expediency of using the projectile as a shot is to be doubted" (Report, p. 207).

Guns which might either fire shot or shells were introduced into the British Navy in 1838 as an equivalent to the Paixhans gun of 1824, but, unlike the Paixhans gun, our guns could only fire hollow shot, and so the principle could not be efficiently carried out. Mr. Whitworth falls into the other extreme, and makes the calibre of his 80-pounder guns so contracted that they have not capacity for efficient shell-firing.

In page 142 of the Report of the discussion which took place at the Institution of Civil Engineers, in February 1860, it is stated that there is some analogy between the form of an arrow and the long bolt of iron fired from the Whitworth gun to the distance of 9463 yards; and that it would be an important problem, not very difficult of solution, to fire from smooth-bored guns metallic arrows which should carry their weight chiefly in their heads, and keep their longitudinal axes, when projected, coincident with that of the gun. An arrow does not rotate, and, therefore, if well balanced, conforms tangentically with the trajectory: whereas an elongated shot, if it do not rotate, has no precision, wabbles, tumbles over, or strikes with its side, as was the case with the oblong and bar shot of old, and is the most errant and inefficient of all projectiles.

It surprises the author very much that in a discussion conducted with remarkable ability, in which the learned President, and other speakers, evinced the most intimate knowledge, not only of the mechanism of warfare, but of the science and practice of gunnery in all its branches, these propositions should not have been controverted. It would have been a grand discovery upwards of 400 years ago, to shoot metallic arrows from the rude and primitive fire-arms of that day, instead of discharging cloth-yard shafts by human strength from long-bows, or bolts from cross-bows drawn by mechanical power. But "to get rid of the rifling process," and to fire metallic arrows from plane-bored guns (if that project could be accomplished) now that that great object of rifled cannon has been brought in all countries to a state of great perfection, would be a retrogradation in the history of artillery, and be as inferior in effect to elongated projectiles fired from rifled cannon of the present day, as the arrow was to the rude and primitive fire-arms by which that comparatively impotent missile was superseded as an implement of war.

Mr. Whitworth's main object in contracting the bore of his guns, was to give his flat-headed projectiles power sufficient to pierce thick iron plates, with shot of steel, or homogeneous iron, by blows acting upon a small surface, and consequently with greater effect than upon a larger area; and this special object has been effected, but at the sacrifice of adequate capacity to be efficient shell-guns.

If Mr. Whitworth were to increase the calibre of his 80-pounder guns to equality with those of the Armstrong guns, he might acquire for them that indispensable faculty which all naval ordnance should possess, of being efficient shell-guns as well as powerful shot-guns, and that faculty would be obtained at a very immaterial sacrifice of range in the exceptional case of maximum elevation. For calibre is power with the rifled as well as with other cannon, because, although the diameter of an elongated shot, of weight equal to a spherical shot, must be contracted, the calibre should be maintained as much as is consistent with the length which should be given to the projectile, and this condition Sir W. Armstrong satisfies by giving to his 80-pounder a 7-in. bore.

The Armstrong guns *do* combine the efficiency of shot-guns with the very destructive effects of shells; and may, by a simple arrangement, use either.

Sir W. Armstrong has obtained a range of upwards of 9000 yards with his 32-pounder gun; so that, in respect of range, there is little or no inferiority to that of the Whitworth gun: but the projectile of the Armstrong gun, according to his system, is either a shot or a shell, and therefore his long-range may be useful in bombardments at that distance.

The Armstrong 7-in. gun can throw either a shot or a shell of 100 lbs. to the distance of about five miles, with a charge of one-sixth the weight of the projectile. Guns on Sir W. Armstrong's principle, of greater power, are now being constructed, and his 40-pounder gun is probably the lightest that will eventually be used in the Naval Service.

Elongated shot possessing a superiority over spherical projectiles, on account of being less resisted by the air, and retaining more of their initial velocity than the latter, added to their precision, and the lightness of the Armstrong gun, show the advantage of introducing them into the Naval Service as long-range guns, within limits which render their obliquity to the trajectory immaterial; but it may be very much doubted whether, in close action, the smashing and ravaging effects and the large apertures made by spherical shot and shells—fired from a gun of 8-in. calibre—on a timber ship (for such will still be ocean fleets), is not much greater than the effect of any elongated shot. If so, it would not be prudent, for these and other reasons (ricochet) already shown, to displace many of our solid-shot heavy guns from the broadside batteries of ships, until we have some real experience of the new rifled guns; but we might, in the meantime, place the Armstrong guns, mounted on revolving carriages, on the upper-decks; and gradually introduce them into the main-decks of line-of-battle ships and frigates, when experience shall have fully justified that measure.

It may likewise be very much doubted whether elongated rifle shot will supplant spherical projectiles of large calibre for siege and battering purposes, and for knocking down walls of masonry. Breaches are not made in the ramparts of a fortification by the penetrating power of the shot through the escarp; but, after the breach has been traced out and cut through by shot fired with great charges, it is effected by concussions occasioned by the action and reaction of shot fired in volleys with reduced charges, so that the shot may not penetrate but communicate all their motion to the medium by impact.

The nice and delicate instruments and adjustments which Sir W. Armstrong proposes for laying guns with a degree of accuracy adapted to the precision of which they are capable, may, no doubt, be very useful in the land service, but utterly inapplicable in a ship, always disturbed more or less by the floating motion. The rude practice of "watching the roll" of the ship (Art. 500) must still prevail; the seaman-gunner's well-practised eye and the pendulum will still be required in naval actions, at whatever distance, as stated in Articles 474, 476.

It may be important here to mention that, in the 'Occasional Papers of the Royal Artillery Institution,' No. 9. (Feb. 1859), there is a paper by Capt. Noble, R.A., entitled 'On the Theory of Probabilities in Artillery Practice.' In this valuable paper there are given the results of experiments on the ranges and the lateral deflections of shot from the best rifled artillery of the

If the author be right, the preceding observations will greatly disappoint some very exaggerated expectations entertained by the people of this country in general, of the paramount value and importance of long range as the best test of the real power and value of a gun, but which it is the author's great object to reduce to its real-service value.

Professors of mathematics and professional men of science, have, ever since the days of Robins, Newton, and Hutton, applied their knowledge and experience to laying down and expounding the true principles of gunnery, in elaborate tracts; to determining the paths or trajectories of spherical projectiles, with the ordinary elements,—shape and weight of projectile, initial velocity, and the effects of the retarding and accelerating forces. But here, in the flight of elongated projectiles, new conditions, deflections, and anomalies hitherto unknown, appear; which disturb the motion of the projectile, occasion irregular and increasing resistances to oppose its flight, impair its penetrating power, and deprive it of the efficiency of the important secondary effect by ricochet, which, on the flood or on the field, frequently proved more destructive after than before the first graze.

The true principles of gunnery have been fully expounded and correctly laid down in numerous treatises, determining the natures of the curves and the trajectories described by spherical projectiles, with the requisite elements, weight of projectiles, initial velocity, the retarding and accelerating forces; and the author has endeavoured to explain the very different circumstances and conditions which appear in the flight of elongated projectiles, which disturb their motion by resistances and anomalies which first infringe and then violate the fundamental principle on which Newton proposed his "Solid of Least Resistance," with a view to show that elongated projectiles have not, like spherical projectiles, aptitudes for all descriptions of gunnery practice; that the principle of minimum resistance only applies to that efficient use of those arms at distances within the limits already stated, and in which consists the real value of the new guns for battle purposes, on the flood or on the field. These, and not the exceptional case, are the powers of long range combined with efficiency, which will produce great changes in all present day, and a comparison of these with the ranges and lateral deflections of spherical shot from an ordinary brass 9-pounder gun.

The rifled gun was an 18-pounder, weighing 12 cwt.; and the ranges, in forty trials, varied from 1002 yards to 1038 yards, the mean of all being 1019 yards. At the same time, the lateral deviations to the right or left of the mean line of fire, varied from 0 to 48 in., the mean lateral deviation being 20 in. to the right. The ordinary gun gave ranges which, in forty trials, varied from 900 yards to 1138 yards; the mean of all the ranges being 985 yards. At the same time, the lateral deflections to the right or left of the mean line of fire varied from 0 to 24 feet.

From the data afforded by these experimental trials, Capt. Noble determined, by the theory of probabilities, that the probable error of the rifled gun, in range, in a single round, is 7.4 yards; and in lateral deflection, in a single round, is 9.8 inches. Also, that the probable error of the ordinary gun in range, in a single round, is 47.2 yards, and in lateral deflection, 8.8 feet.

The rifled gun, therefore, possesses a very decided superiority over the common gun in extent of range, and also in the accuracy of its fire, with respect both to longitudinal and lateral deviation.

By diagrams ingeniously constructed, in which the best results of several guns that have been tried may be seen on inspection, it appears that the Armstrong guns are the most precise, the Whitworth guns next, after which no other rifled gun came at all near them. Very good results have, however, been of late obtained with guns constructed by Mr. Bashley Britton, Mr. Lawrence, and Mr. Hadden.

Sir W. Armstrong has applied the thorough knowledge which he has acquired of the science and practice of gunnery, with a distinct perception of what is wanted to improve the real-service efficiency of guns, to adapt them the better to battle purposes within rational limits, rather than to the wasteful and useless purpose of obtaining long ranges at extravagant elevations; and the author thinks that the most useful application of such guns is in what is denominated horizontal firing (point-blank or at low elevations) on fields of battle of limited extent.

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bined with efficiency, [illegible]

the naval and military operations of war. In the attack and defence of fortresses, in the choice of positions and distribution of armies, whether for offensive or defensive purposes, in the extension of the fields of action, in the necessity of placing covering positions further in advance than formerly, by occupying posts and commanding positions hitherto unnecessary, by pushing the advanced posts of armies far in advance of their supports and of the main body: these and many other changes in modern warfare, which experience will suggest, and time work out, will be produced by the long-range guns at efficient distances.

The subject of the Armstrong and Whitworth guns attracts, as we see in the article "*Le Canon en* 1860," in the 'Revue Européenne,' great attention in France, and, as the author has occasion to know, in other countries, and is worthy of the attention of competent military authorities here.

The preceding pages were written and put in type long before the article in the 'Revue Européenne' appeared, and the author had previously come to the conclusion, that, having obtained in the Armstrong gun range and precision sufficient for all battle purposes, any additional range, obtained by a sacrifice of the real efficiency of a gun, should be abandoned, and the exceptional long ranges used for exceptional cases as occasion may require, for incendiary purposes at distances beyond the reach of 13-in.. mortars.

SECTION VI.—ON CONVERTING EXISTING PLANE-BORED GUNS INTO RIFLED CANNON.

244. During the last three years many attempts have been making to convert cast-iron guns, of which we have so large a store, into rifled cannon, for firing elongated projectiles; but the additional strain first put upon the gun, has caused a large proportion of the guns used in these experiments to burst; arrangements are now being made for strengthening the 68-pounder gun by coils of wrought iron with which to envelope the gun, and so enable it to resist the strains of the rifle principle and an elongated projectile.

It would assuredly be an important and valuable discovery if by any means the thousands of that very valuable gun which we possess could be transformed into efficient rifled cannon, capable of firing elongated shot of nearly double the weight of their round shot.[a] But little progress has as yet been made in rifling and strengthening this very valuable gun. The bore is perhaps too large for a well-shaped elongated projectile. Sir William Armstrong's plan answers well with a 6·5 bore, but it may be doubted whether it will be possible to hoop the 68-pounders so very strongly as to enable them to bear adequate charges for firing elongated shot of double that weight.

As yet, all attempts to convert these guns into effective rifle cannon have been unsuccessful; and it now seems obvious that a bore which is suitable for a sphere cannot be right for a cylinder. In confirmation of this opinion, written before the experiments referred to, the author quotes the following account of a trial of one of these re-bored guns, as given in the 'Times' of April 19th, in the present year (1860):—"One of the cast-iron contract guns, a 6½-inch bore, rifled for experimental purposes, under Sir W. Armstrong's system, and hooped according to a late suggestion ordered to be adopted by the War Department, was fired at the proof butt, Woolwich, loaded with 16 lbs. of powder, and a 140-lb. cylinder. The test was ordered to be a severe one, as the adoption of the method of rifling and hooping cast-iron guns would mainly depend on the result. The gun bore the trial well up to the 36th round, when it burst into fragments."

Two other cast-iron guns of 6½ in. bore, hooped with iron as

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[a] In the expression used in the Article on Oblong Shot, "that oblong shot which do not rotate tumble over and strike sideways," a new light was shadowed forth on the advantage of the rifle principle applied to cannon. In furtherance of these views, the reader will find, in Art. 234, abstracts of the history of fire-arms loading at the breech, from an early period of the 17th century down to the abandonment of that primitive practice by the introduction of guns bored out of solid blocks, which obtained till 1846 (Art. 183), when Cavalli and Wahrendorff reverted to that method of loading in the construction of their breech-loading guns for firing cylindro-conical and conoidal shot, and also descriptions of the ingenious contrivances for opening and closing the breech and checking the recoil; and in Arts. 238, 240, an account of the failure of those guns in 1850. And it is no disparagement to the many talented men who have applied their skill to accomplish that great desideratum to observe that the author's sketch of the origin and progress of breech-loading guns may have been of some use to them, in showing what was most wanted to accomplish the great object in which Cavalli and Wahrendorff failed, but which Armstrong, and apparently Whitworth, have so ingeniously effected.

before, have since been tested at Woolwich by a charge of 16 lbs. of powder and a cylindrical iron bolt weighing 160 lbs. Both guns withstood the test till the 62nd and 63rd rounds, when the breech of each gun was driven off without a fragment or splinter.

The French have long been trying various forms of grooves and of projectiles to convert their smooth-bored guns into rifled cannon; but, judging from the frequent burstings of these guns that have come to our knowledge, it appears that, however strongly hooped, they are unsafe when rifled, and that the artillery authorities in France have not hit upon any effective plan for rifling their existing smooth-bored guns.

The mode which the French have adopted for converting their 12-pounder field-gun into rifled cannon did not succeed with their 12-pounder gun in the late war in Italy, much as has been vaunted to the contrary.[a]

SECTION VII.—ON THE RELATIVE VALUES OF SOLID AND HOLLOW SHOT.

245. The British shell guns having been compared (Art. 232) with the French canons-obusiers, it is now intended to make a like comparison between the former and the solid-shot guns, which are at present employed in the Naval Service of this country, in order to ascertain whether or not the shell-guns do really possess such qualities, with respect to extent of range, accuracy of fire and penetrating force, as to warrant their appropriation as the pivot-guns of steamers: which assuredly should, with equal or inferior weight, possess those qualities in the highest degree. It is proposed at the same time to ascertain whether or not shell-guns are better adapted than others for the broadside batteries of ships, in which situations rapid firing and extensive perforations are the essential conditions of their action.

246. From the formulæ for V, the velocity (Arts. 64, 66, and 71), it is evident that if shot, of equal diameters, but different weights or densities, be projected with charges whose weights bear the same proportion to the weights of the shot, as $\frac{1}{3}$ or $\frac{1}{4}$, the initial velocities will be very nearly equal, any difference

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[a] See Appendix D., on the Present Organisation of the British and French Artillery.

which may exist arising only from the small difference in the lengths of the charges. Now, since the quantities of motion lost by shot in passing through a short extent of space in air are very small, as may be shown from the formulæ, Art. 63, it follows that, when the gun is laid point-blank, or with a small elevation, the ranges of solid and hollow shot of equal diameters, and charged proportionally to their weights, are very nearly equal. But when the elevation is increased, so that the extent of the range and the time of flight are considerable, the solid shot, from its superior momentum, retains greater velocities at the end of equal times, and thus ranges farther than the hollow shot.[a] Since, also, a hollow shot issues from the gun with a greater velocity than a solid shot of equal diameter, when the charges are equal, and even when the charge of the former is rather less that that of the latter; it follows that, when laid point-blank or with a small elevation, the hollow shot will range farther than the other: yet it will happen, for the reason above mentioned, that by increasing the elevations, so as to increase the ranges and times of flight, the less rapid diminution of the velocity of the heavier shot will cause the ranges to approximate; and, at length, the elevations and times of flight being farther increased, while the charges remain as at first, the range of the solid shot will exceed that of the hollow shot.

247. When the velocity with which a hollow shot strikes an object, as a ship's side, is less than that with which a solid shot strikes such object, provided it penetrate, the magnitude of the fracture, as well as the splintering and shattering effects produced by the hollow shot, will be greater than those produced by the solid shot (see Arts. 161, 162). But when, in consequence of the greater distance of the object from the gun, it becomes necessary to give to the latter a considerable elevation,

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[a] This has been distinctly proved in experiments made on board the "Excellent," with 68-pounder guns, weighing 91 cwt. and 87 cwt., and 8-inch shell guns weighing 65 cwt. and 60 cwt. The lateral deviations of hollow shot were also much greater than those of solid shot when the ranges exceeded 3000 yards. In firing at a target resembling a ship's side, at the distance of 3000 yards, it was found that the different ranges of hollow shot varied from 300 to 400 yards, while the different ranges of solid shot did not vary more than 200 yards.

in order to obtain the required range, the accuracy of the firing and the probability of striking the object are diminished; and, in this case, the solid shot has advantages over one which is hollow; the latter, even if accurately formed, is much more liable to lateral deviation than the other, particularly when fired across the direction of the wind; the deflections are very great in long ranges, and take place principally near the farther extremity of the trajectory. Hollow shot, and especially shells, are more liable than solid shot to irregular rotations during their flight, from their centres of gravity and of magnitude not coinciding (see Arts. 184 to 194). Even when empty, this will arise from the protrusion of the fuze, and the removal of metal to form the fuze-hole, as well as from the unequal thickness of the metal in different places, in which respect shells are seldom perfect; and this irregularity is much greater when the shells are partially loaded with lead, sand, and even with the bursting-powder, any of which is liable to change its place in the shell during its flight. The disadvantage produced by partial loading is manifest from the fact that shells so loaded neither range so correctly nor so far as when they have been entirely filled with the loading material.

248. In confirmation of what has been stated above, the following results of experiments are adduced:—

On comparing together the 8-inch shell-gun of 65 cwt. with the 32-pounder weighing 56 cwt., the former projecting hollow shot weighing 56 lbs., and the latter solid shot, the charges being equal (10 lbs.) for both; it will be found, from the tables of practice on board the "Excellent" (see Tables V. and VI., Appendix B), that, at equal elevations, from 1° to 10°, the ranges of the 32-pounder invariably exceeded those of the shell-gun, the differences increasing with the increase of elevation, and amounting, at 10°, to 300 yards. Similarly, with charges equal to 10 lbs., the ranges of the 32-pounder gun exceeded those of the 8-inch gun, when loaded shells weighing 51 lbs. were fired from the latter, the difference at 10° amounting to 460 yards. The ranges of the 56-pounder guns weighing 98 cwt. and 87 cwt., the former having a charge of 16 lbs., and the latter of 14 lbs., in a still higher degree exceeded, at equal elevations from 1° to 15°, the ranges of the 8-inch gun of 65 cwt., with its charge of 10 lbs., and projecting hollow shot weighing 56 lbs. and 51 lbs., the differences gradually increasing with the elevations, and amounting at 15° to above 800 yards for the 51-lb. shot, and 447 yards for the 56-lb. shot.

The following table, extracted from the practice made at Deal, in 1839, exhibits the relative values, with respect to range, of the 8-inch gun projecting hollow shot, and other natures of iron ordnance projecting solid shot.

Nature of Ordnance.	Weight of Gun.	Length.		Windage.	Charge.	Ranges in Yards to the First Graze, below the corresponding Elevations.					
	cwts.	ft.	in.	inch.	lbs.	P.B.	1°	2°	3°	4°	5°
8-in. Gun	65	9	0	.125	10	474	805	1133	1323	1602	1920
32-pr. ..	56	9	0	.233	10	475	877	1311	1467		
Ditto ..	63	9	7	.233	12	..	..	1366	1581	1832	1998
42-pr. ..	80	10	6	.175	14	..	..	1346	1605	1842	2086
56-pr. ..	97	11	0	.175	16	..	..	1350	1600		

249. The 8-inch shell-gun (65 cwt.) is moreover inferior in respect of range to the 32-pounder gun, solid shot being projected from both. For, from experiments made on board the "Excellent," the charges (10 lbs.) and the elevations (from 3° to 8°) being equal, the ranges of the 32-pounder exceeded those of the shell-gun, by distances varying from 250 to 360 yards. The ranges of the shell-gun on board the "Excellent" compared with those of a 42-pounder gun weighing 67 cwt., charge 10 lbs. 8 oz.; and a 68-pounder gun, weighing 95 cwt., charge 16 lbs. on board the same ship; also with those of a 32-pounder (56 cwt.) at Deal, solid shot being fired from all, presented similar results in proof of the inferiority of the shell-gun. But the most striking instance occurs in the comparison of the above shell-gun with Mr. Monk's 56-pounder, weighing 97½ cwt., charge 17 lbs. (solid shots being fired from each), the ranges given by the latter at Deal (1839) exceeding those of the shell-gun at equal elevations by distances varying from 400 to 590 yards.

250. With respect to the velocities and penetrating forces of shot at different distances from the gun, the following table will show that hollow shot from an English 8-inch shell-gun, with greater initial velocity, preserves at equal distances greater velocity and penetrating power [illegible] hollow shot from the

French canon-obusier of 80; and that solid shot from a 68-pounder gun, with less initial velocity, has, at equal distances beyond 800 yards, greater velocity and penetrating force than the hollow shot from the 8-inch gun. Again, it appears that the 42-lb. and 32-lb. shot have, at equal distances, less penetrating forces than the shot from the last-mentioned gun; and that the shot from the 56-pounder gun has both greater initial velocity and greater penetrating power than those from the 8-inch gun, and indeed from any of the guns above named.

Nature of Ordnance.	Windage.	Weight of Gun.	Weight of Shot.	Charge.	Initial Velocities in Feet per Second.	Distances in Yards from the Gun.	Velocities at the corresponding Distances.	Ratios of penetrating Forces at the different Distances.
	in.	cwt. qrs. lbs.	lbs.	lbs.				
Canon-obusier (80) .	.1378	73 3 14	58.8	10	1323	100	1225	6492
						500	915	3620
						1000	615	1879
8-in. shell-gun, English	.125	Cwt. 65 60	56	10	1418	100	1324	6945
						500	1019	4114
						1000	753	2250
68-pr. ..	.2	95	68	16	1280	100	1211	5812
						500	979	3799
						1000	765	2318
56-pr. ..	.175	98	56	16	1646	100	1546	8934
						500	1213	5499
						1000	913	3115
42-pr. ..	9.2	67	42	10½	1360	100	1273	5489
						500	988	3304
						1000	739	1849
32-pr.[a] ..	.233	56	32	10	1600	100	1486	6819
						500	1116	3846
						1000	803	1991

251. In some trials which were made on board the "Excellent," with solid and hollow shot from a 68-pounder gun, with equal charges and elevations, the range was found to be in favour of the hollow shot from the point-blank direction, to an elevation of 1¾° inclusive; at 3⅛° the ranges were nearly equal; after which, up to 6⅞°, the difference was slightly in favour of the solid shot: also the number of times in which the shots

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[a] The windage is to be reduced to .2 inch, in a new 32-pounder of 58 cwt. From experiments made on board the "Excellent" in 1847, it is concluded that with the 32-pounder gun, 56 cwt., whose reduced charge is 6 lbs., double shotting may be employed with a certainty of penetrating, up to 400 yards; with the 32-pounder, 42 cwt., and charge of 4 lbs., up to 300 yards; and with the 32-pounder, 25 cwt., charge 2½ lbs. up to 200 yards.

struck the object were nearly in the proportion of 5½ to 4 in favour of the denser projectile. In the remarks on these trials it is stated that on the day of the experiment the wind was very fresh, blowing across the range, and that the solid shot were more true in their flight than the hollow shot; partly because the windage of the former was less, and partly because the hollow shot, being lighter than the others, were more affected by the wind.

252. With respect to the relative accuracy in the ranges of solid and hollow shot from an 8-inch shell-gun, it was found that, at the distance of 3000 yards, the differences between the ranges of hollow shot amounted to between 300 and 400 yards, while the differences between the ranges of the solid shots did not exceed 200 yards. Experiments were likewise made with hollow shot and loaded shells, from an 8-inch gun; when it was found that, beyond 1500 yards, the fire with the shells was more uncertain than with the shot; the number of times in which the object was struck by the former being, to the number struck by the latter, as 3½ to 5. It was found too that the shells required half a degree more elevation than the hollow shot to attain the same range; and that, when the shells were quite filled, they ranged farther and more accurately than when not fully charged, on account of the loose powder revolving within them during their flight (see Art. 244).

The subjoined table of experiments is introduced in order to show the different elevations at which, with the given charges, solid and hollow shot projected from four different natures of guns attained the same range, 1250 yards; the object fired at was a target in the Marshes at Woolwich, at that distance from the guns.

Nature of Ordnance.	Length.		Weight of Gun.	Nature and Weight of Shot.		Windage.	Charge.	Elevation.
	ft.	in.	cwt.		lbs.		lbs.	°
56-pr. ..	11	0	97	Solid	56	.175	16	2⅛
	10	0	86				14	2¼
32-pr. ..	9	6	56	,,	32	.233	10	2⅜
10-inch ..	9	4	84	Hollow	84	.16	12	3¼ full.
8-inch ..	9	0	65	,,	56	.125	10	3

From this table, it appears that the 8-inch a degree more elevation than the 32-pounder gun; and it is said to have made much worse practice, notwithstanding the greater windage of the latter.

253. In the absence of experiments carried on expressly for the purpose of determining the relative deviations of solid and hollow shot from the object of aim, at different distances from the gun, the following table, computed from the formula, Art. 92, using the values of the coefficient *k* for the two kinds of shot, is introduced. It is extracted from the table in the 'Suite des Expériences à Gavre,' Paris, 1844 (page 42), and exhibits the horizontal and vertical deviations (supposed to be equal) for a 30-pounder long gun (French) and a canon-obusier of 80.

Nature of Ordnance.	Nature of Shot.	Diameter of Shot.	Charges.		Distances in Yards.							
					656		1094		1750		2188	
					Horizontal and Vertical Deviations.							
		inches.	lbs.	oz.	ft.	in.	ft.	in.	ft.	in.	ft.	in.
30-pr. Long Gun	Solid	6.28	8	4.4	3	7	10	10	31	6	53	9
			5	8.2	3	11	12	2	39	9	59	4
	Hollow	6.33	8	4.4	4	11	15	1	46	10	83	8
			5	8.2	5	3	16	9	51	6	91	10
Canon-obusier 80, No. 1	Solid	8.61	7	11.5	2	3	8	2	22	4	38	4
	Hollow	8.67	7	11.5	4	11	14	5	42	4	72	6

From this table it appears, that, with the canon-obusier of 80, the deviation of hollow shot is, at all distances, about twice as great as that of solid shot.

254. Till recently, as has been observed in Art. 223, the English shell-guns were restricted to the use of single hollow shot, grape and case-shot; but this restriction being manifestly a disadvantage to the service, and its necessity being doubted, at least with respect to the 8-inch gun weighing 65 cwt., experiments were carried on at Woolwich, in 1848 and 1849, in order to ascertain how many rounds the last mentioned nature of gun would stand with double shot; and what charge of powder it would bear, up to the bursting quantity. The experiments decided against the necessity of the restriction, at least for ordnance cast like the gun with which the experiments were made. This was an 8-inch gun, weighing 65 cwt. 3 qrs. 14 lbs., 9 feet long, cast at Low Moor Foundry, which is distinguished

for the strength of its construction in iron. On many other occasions when guns have been burst on trial, a high charge was at once used, but, in the present instance, the first charges were low, and the rest consisted of gradually augmented quantities of powder. Thus two hollow shots, each weighing 56 lbs., and one wad, being used throughout, 60 rounds were fired with 5 lbs. of powder, (half the service-charge for one shot,) then 10 rounds with 6 lbs., afterwards 10 rounds with 7 lbs., and so on, every succeeding 10 rounds having the charge increased by 1 lb., till 230 rounds in the whole were fired; the last ten rounds were consequently fired with the great charge of 23 lbs. These charges were resisted admirably, but the recoil was very great, though the platform was inclined in an angle of 2½°: with a charge of 10 lbs. of powder and one hollow shot, the recoil was 8½ feet; with 5 lbs. and two shots, it was 14 feet 4 inches; with a 10-lb. charge and a single solid shot, 14 feet 10 inches; but, with 10 lbs. and 2 shots, it was not less than 24 feet. The gun was mounted on a ship carriage. In January, 1849, the same piece of ordnance was used for the purpose of trying its efficiency in the discharge of two solid shots of 68 lbs. and a junk wad, when it bore well the fire of two rounds, each with a charge of 20 lbs.; but, at the third round with an equal charge (the 243rd round), and two solid shots, the gun burst, its fragments as well as those of the carriage being driven in all directions. On examining the vent after the 220th round, it was found to have enlarged to .28 inch at top, and 1.13 inch at bottom. This severe trial seems to have established the safety of the 8-inch gun of 65 cwt. when double-shotted, with moderate charges.

255. Experiments have also been made with a new 32-pounder gun of 42 cwt. from the same foundry; its service charge with one shot (solid) being 6 lbs.; and the following results have been obtained, solid shot and double wadding being used throughout. At first 40 rounds with two shots and a charge of 6 lbs. were fired; then 20 rounds with 3 shots and the same charge; next 20 rounds with 3 shots and a charge of 7 lbs.; again 20 rounds with 3 shots and a charge of 8 lbs., and so on, the charge being increased by 1 lb. of powder in every 20 rounds, till it amounted to 11 lbs., when at the eighth round,

with this charge and three shots, the gun burst. In these trials, 404 shots were fired, and 1128 lbs. of powder consumed.

Two 32-pounder guns which had been cast in Belgium, were also tried at Woolwich; and the following table contains a statement of the number of rounds which each gun bore :—

Charge.	Number of Shot.	Number of Wads.	Number of Rounds.
lbs.			
8	2	2	40
8	3	2	20
9	3	2	20
10	3	2	20
11	3	2	9

The last round burst one of the guns, which, in the explosion, struck its neighbour, and damaged it so much, that it only stood one more round with the same charge; at the next round it burst.

In the trials, 287 shots were fired from the first gun, and 959 lbs. of powder were expended.

256. In addition to the considerations of extent of range and precision in firing, it is necessary to contemplate the effects of shot and shells with respect to their powers of impact—a subject of no less importance than either of the others. The penetration of shot has been already treated of in Arts. 82 and 101; and it is intended in this place to notice the effects arising from the impact of shot or shells of different diameters. A solid or a hollow shot striking a mass of timber, as the side of a ship, crushes, fractures, and splits the wood to an extent which depends, in a great measure, on the superficies of the shot, or upon the area of a section through its centre; and, consequently, is proportional to the square of its diameter. Thus, a large hollow shot will make a greater fracture, in consequence of a greater separation of the fibres of the material, than a solid ball of equal weight; though the latter may penetrate deeper, and thereby produce, in other respects, a greater effect on and in a ship. It is evident, moreover, that the destructiveness of shot in action must also be proportional to the number of shots which strike the object at a given distance from the gun. We

have no certain evidence from experiment by which we may determine the average number of hits made by shot on an object at different distances, up to the greatest at which shot can be projected with any chance of striking, suppose 2000 yards; and though, according to M. Piobert (see Art. 139), large shot struck a small object within 600 yards more frequently than smaller shot, yet it appears very probable that at 2000 yards the causes of deflection (particularly wind blowing across the range) would act more powerfully on large than on small shot, and certainly on hollow than on solid shot, and thus cause a smaller number of hits to take place in an equal number of discharges. However, in the absence of sufficient data to determine this point, let it be assumed that the number of hits of shot of different natures and descriptions are equal; and then it may be inferred that the splintering effects of shot are proportional to the squares of their diameter.

This is an important advantage in favour of the 8-inch shell-gun individually; but, on the other hand, it must in fairness be stated that magnitude of fracture is not the only thing to be considered in selecting ordnance for the general armament of ships.

257. It has already been stated (Art. 100) that it may be doubted whether the appropriation of 8-inch shell-guns to the broadside-batteries of ships of all classes has not been carried too far, some ships being armed chiefly with that description of ordnance; and whether it would not be more advantageous to limit, in all cases, the number of shell-guns to a lower proportion, and to combine them with others by a judicious selection of those best adapted to the circumstances of each case.

All vessels, according to their displacement, can only carry a certain weight of metal, of which their armament is to consist and can afford only a limited tonnage for the stowage of their ammunition, projectiles and stores. The weights of the 8-inch shell-gun and of the 32-pounder gun are respectively 65 cwt. and 50 cwt., while the weights of the shot for the 8-inch and the 32-pounder gun, supposing an equal number to be distributed to each, are as 56 to 32, or as 7 to 4: hence it will be found that eleven 8-inch guns are nearly equal in weight to fourteen 32-pounders, their complements of shot being included. Thus a vessel which could carry on her broadside only eleven 8-inch guns might be armed with fourteen 32-pounders.

In engaging an enemy's ship the aggregate magnitude of the fractures made in her side by the shot from the eleven 8-inch guns of her antagonist will be to that produced by the shot from the fourteen 32-pounder guns (assuming that the magnitudes of the fractures made by the shot from the two natures of ordnance, supposing all to hit, are proportional to the number of shots fired and to the squares of their diameters) as 704 to 546; which no doubt is an important advantage in favour of the 8-inch shot. But is not the greater number of discharges made, in equal times, by the fourteen 32-pounders relatively with the discharges of the eleven 8-inch guns, and therefore the greater probability of damage to the opponent, a very important consideration, which should enter into the question of armament? In this case the number of discharges and the proportion of hits, supposing equal skill in gunnery and that both ships fire equally quick, will be as 14 to 11; a disparity which could scarcely be compensated by the greater magnitude of the fractures.

In this proportion, nearly, have the number of guns in many of the ships of the British Navy, new as well as old, frigates, corvettes, and small vessels in particular (the "Thetis," "Inconstant," "Castor," "Cambrian," and "Dædalus," for instance), been reduced, in order that they may carry the heavy 32-pounders of 56 or 58 cwt. with the 8-inch guns. Some frigates have been reduced from 42 guns to 24; others from 46 guns to 24, 26, and even to 19 guns (see 'Return to an Order of the House of Commons,' April 29, 1850).

258. The author ventures, with great deference, to think that in many of the combinations of 8-inch guns with 32-pounders in the armament of ships and vessels, too much consideration has been shown to the weight, and too little to the number of guns. He thinks that the number of shell-guns has been made too great in the broadside batteries of some ships and vessels, several of which, indeed, have the whole of the batteries on one deck so armed—the "Rodney," 26 8-inch guns; "Prince Regent," 32; "Albion," 26; "Indefatigable," 28. These, he believes, were exceptions, permitted for experiment, as in the case

of the French frigate "Psyche,"[*] in consequence of special applications made by their captains.

259. Judging from the armament of their ships, the problem concerning the relation between weight of gun and number of guns is solved by the naval artillerists of foreign nations with greater regard to number than by those of this country. The problem is one that has been much discussed; and practical limitations have been assigned to the number of shell-guns which should be allowed to a ship of war in most of the foreign services; but in none of them has the limit been extended to the armament of whole decks. By a regulation of April, 1838, first-rates in the French navy were to carry 34 canons-obusiers of 30 on the upper decks; but, by a recent regulation (1849), all these were to be replaced by 30-pounder guns No. 3, which shows that, calibre for calibre, guns are preferred by the French to chambered ordnance. By the decree of 1838, the number of canons-obusiers in line-of-battle ships was limited to four of 80, and these were ordered to be placed on the

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[*] The "Psyche" frigate is an exception to this regulation. Her armament as she was fitted out at Brest, in 1845, was as follows:—

Main-deck . . .	18 80-pounders, Paixhans Howitzers No. 2.
„ . . .	2 30-pounders long guns forward.
„ . . .	2 30-pounders long guns aft.
Quarter-deck . . .	4 30-pounders carronades.
Forecastle	4 30-pounders long guns.

This frigate, although rated in the Budget as a 40-gun ship, was built to carry but 32 guns: she had, in 1845, but 30. Her complement of crew was the same as that of a 40-gun ship, viz. 326 men, on the war establishment. Her scantling is much stronger than that of any 46-gun frigate.

The eighteen 80-pounders on the main-deck of the "Psyche" are the Paixhans canons-obusiers of 80 No. 2 (see Art. 229), weight only 53 cwt. 2 qrs. 14 lbs. (the Paixhans gun No. 1 is 71 cwt. 2 qrs. 15 lbs.), charge 6 lbs. 9 oz.; the chamber which, in No. 1 gun, is a cylinder of the diameter of a 24-pounder gun, being in gun No. 2 enlarged to that of a 30-pounder; so that the contraction being less, the operation of sponging is more readily performed, the cartridge more easily got into its place, and the *charge simultanée* facilitated. The canons-obusiers of 80 No. 2 are deficient in powers of range; they are intended for moderate ranges; their largest scales are only graduated to 1300 yards, which admits that they are not efficient beyond that distance, and consequently that the "Psyche" should avoid action at greater distances.

The observation made in Art. 100 on the reduction of the number of guns in a ship's armament, relatively to the displacement, is verified in recent practice by what is related of the "Pique" frigate, which was long under repair in Pembroke Dockyard, when she was rendered capable of carrying 40 guns, her former rating being 36 only.

lower deck;[a] but the number of canons-obusiers was subsequently increased by introducing six others, of the pattern No. 2, in the middle decks of first-rates and in the upper decks of second-rates, and four of the same pattern in the upper decks of third-rates.

According to the decree of the 27th of July, 1849, the numbers of canons-obusiers, and of solid-shot guns on board of French ships of war, are to be as follow:—ships of 112 guns will carry four canons-obusiers of 80 No. 1 on the lower deck, six ditto No. 2 on the middle deck, and six 50-pounder guns; the rest of the armament, from the lower deck upwards, being 30-pounder guns Nos. 1, 2, 3, and 4. The 90-gun ships will carry four canons-obusiers of 80 No. 1 on the lower deck, six of No. 2 on the upper deck, the rest of the armament being six 50-pounder guns and 30-pounders Nos. 1, 2, and 3. The 82-gun ships, new model, will be armed in a similar manner with ten canons-obusiers Nos. 1 and 2. The 80-gun ship, old model, called 86, will carry four canons-obusiers of 80 No. 1 on the lower deck, and four of the pattern No. 2 on the upper deck. The 70-gun ships, old model, called 74, will carry four canons-obusiers of 80 No. 1 and twenty-four 36-pounders on the lower deck. No canons-obusiers will be carried on the upper deck. Frigates of the first class will carry only two canons-obusiers of 80 No. 1. The second and third class frigates and rasées will be armed in a similar manner, each carrying two 50-pounder guns.

260. The proportion of shell-guns varies very much in the ships of the British navy, even in those of the same class. See Parliamentary paper, May, 1849. The first-rates carry twelve 8-inch guns of 65 cwt. and 52 cwt.; ships of the "Rodney," "Albion," and "Prince Regent" class, twenty-six 8-inch guns each; the "Prince Regent," thirty-two ditto, which for experiment are all placed on the lower deck. But it now appears that all our line-of-battle ships are armed on the lower deck

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[a] In conformity with a resolution of the commissions composed of the chief authorities of the navy, maritime engineers and marine artillery (see Paixhans 'Sur une Arme Nouvelle,' also 'Expériences faites par la Marine,' pp. 44 and 58), and in compliance with the opinion and advice of the Comité consultatif de la Marine of the 17th June, 1824, ibid., p. 49.

wholly with 8-inch shell-guns of 65 cwt., and with 32-pounders of different classes in the upper decks.

The extent to which shell-guns should enter into the armament of a ship of war is a subject deserving much consideration, and will be examined in a more advanced part of this work.

261. The disadvantage of shell-guns, compared with solid-shot guns, in respect of the number of blows given, if all the shot of both kinds are fired with equal precision, holds good from the commencement of an action, when the firing is distant, till the crisis approaches, when double-shotting is used. Now, 32-pounder guns, of 56 and 50 cwt., charged with 6 lbs. and 5 lbs. of powder, may commence double-shotting at 400 yards with a certainty of penetration; though, at 300 yards, double shot firing with that nature of ordnance is most efficient (Art. 110); whereas the 8-inch guns, of 65 and 60 cwt., being limited to 5 lbs. charges when firing two hollow shot, cannot commence double shotting with any effect at a greater distance than 200 yards: therefore, a ship armed with 32-pounder English, or 30-pounder French guns, should never approach so near to a ship very extensively armed with shell-guns or canons-obusiers as to be within reach of her double-shotted ordnance. At distances, therefore, between 200 and 400 yards double-shotting can be used with effect from the 32-pounders only; and between these limits the ratio of the magnitudes of the fractures produced by the two natures of ordnance would be as $(8)^2$ to $2\ (6.3)^2$, or as 64 to 79.4 nearly; but as the rapidity of loading with single shot is greater than with double shot in a certain proportion, therefore giving to the 8-inch gun, when using single shot, the benefit of this advantage, the above ratio of the effects of impact becomes, according to the best estimate that can be formed, as 7 to 8⅓. With respect to shell-firing, the 8-inch guns are restricted to the firing of only single shells or shot at distances beyond 200 yards, whilst the 32-pounders may fire two solid shot, or other projectiles, at 400 yards; but as the destructive effects of shells of different diameters increase in a much higher ratio than the squares of their diameters (see Art. 257), it may be presumed that the 8-inch gun will have, in shell-firing, a great superiority over any 32-pounders at that distance;

it must be considered, however, that solid projectiles from 32-pounder guns, fired in greater numbers than the shells, in equal times, and with their high degree of penetrating power, may produce destructive effects equal, if not superior, to those which are expected from the 8-inch ordnance.

It must be remarked that the recoil of the 8-inch gun exceeds that of the 32-pounder gun; with the charges above-mentioned, the velocities of recoil are 16.2 feet, and 15 feet per second, respectively; and, the weights of the guns with their carriages being 78 cwt. and 68 cwt., the momentum of the recoil of the 8-inch gun exceeds that of the 32-pounder gun in the ratio of 7 to 5.7 nearly. In comparing together the practice with two solid shots and that with two hollow shots, it must be borne in mind that there is always some risk of failure with the latter, since one or the other of the two is frequently found to be broken in pieces in the gun when fired with considerable charges, although, by experiments recently made, it appears that this very seldom occurs when, suppressing the wad, the shot are placed in contact with each other. With respect to the lighter 8-inch guns, they are incapable of being fired, either with one solid or with two hollow shot.

262. It is, in general, only in direct broadside action at close quarters that double-shotting should be applied; when, if on either side any errors should be committed in such practice, serious consequences may arise from want of sufficient penetrating power. In all oblique and raking fire, single shot and heavy charges, from all natures of ordnance, are required, particularly in raking a ship by the head, in order to break through the great masses of timber at her bow, and penetrate into and throughout the interior, for which purpose the single shot is most efficient. This observation on the importance of great penetrating power is again touched upon here, in order to introduce the very valuable and instructive Reports, of which an account has been given in Art. 109, when speaking of the brilliant action between H.M.S "Shannon" and the United States' frigate "Chesapeake" June, 1813. The details there given, present service-target proofs of facts which cannot but be highly instructive, and show that even in that celebrated action there were several instances of a deficiency of penetrating power.

Whether the charges of powder were too small, the weight of metal projected too great, or the powder of the "Shannon" was deteriorated, is not known; the last circumstance is highly probable, for this was undoubtedly the case in the unfortunate but gallant action of the "Guerrière." These documents thus convey warnings of the extreme importance of insuring abundant penetrating power in all cases, and afford notices of many other useful facts to which reference will hereafter be made, particularly in the article on the effects of Grape Shot, Part IV., Section iv., and in the account of the action between the "Shannon" and "Chesapeake" in Part V.

263. The destructive effects of shells on ships are assumed to be proportional to the cubes of the diameters, upon the principle that the effects produced by the explosions of live shells depend on the quantities of bursting-powder they contain, which, being as the volumes of the shells, are evidently in that proportion. In strictness, however, this law holds good only for shells which are fired into and explode in earth, where they act as mines. In such cases, live shells are used with great advantage; for example, in the attack of fortresses, when they serve to destroy ramparts of earth,[a] make breaches in scarps of masonry, or for the purpose of rendering them practicable for assault.

By analogy, however, a shell lodged in a ship's timbers, and there exploding, is supposed to act as a mine, with a force depending on its charge; that is, proportional to the cube of its diameter. The greatest effect which a shell can produce in and on a ship, in action, is evidently that which takes place when it penetrates into and lodges in the side or body of the ship, and then explodes.[b]

A shell suspended between decks, amid-ships, and then exploded, acts with equal force in every direction; and in such

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[a] "Les bombes lancées horizontalement produiront en crevant des entonnoirs proportionnés aux quantités de poudre dont elles seront remplis."—*Bousmard*, 'L'Effet des Bombes horizontales sur un Ouvrage en Terre,' vol. i. p. 303, pl. 30.

Shells so fired were applied with great skill and [illegible] siege of Mooltan.

[b] "Le tir de ces projectiles n'aura toute l'efficacité [illegible] qu'autant qu'ils conserveront assez de vitesse [illegible] des navires."—'Expériences exécutées à Ga[illegible]

circumstances, the effect upon the crew would unquestionably be more destructive than if the shell were moving with great horizontal velocity when it bursts. Again, a shell placed in contact with the deck above it, and then exploded, would blow up the deck, and likewise produce destructive effects in lateral directions. Also a shell placed on the deck, and then exploded, would, no doubt, make a prodigious breach in the deck below it, drive up the deck above, and act severely in lateral directions. The shell which exploded by accident on board the "Medea" whilst cruising with the squadron blockading Alexandria in 1840, took place on the lower deck just above the shell-room; killed the bombardier who was unscrewing the cap, wounded several of the crew, knocked down all the bulkheads from the captain's cabin to the boilers, broke three of the beams on the lower deck; forced up some of the planks of the upper deck, and produced, for a considerable time, much panic among the crew, and threw the whole squadron into consternation. These are portentous proofs of the terrific effects, physical and moral, produced upon a ship by the explosions of shells at rest within her, even though not imbedded in the mass of her sides or body; and the like effects must be expected to ensue should an enemy's shell be planted or lodged in the ship before the explosion takes place.[a]

264. It is this faculty of shells by which they act as mines that renders them most destructive to ships. In the experiments carried on at Brest during the years 1821 and 1824 (*Paixhans*, 'Sur une Arme Nouvelle,' pp. 38, 62), at Portsmouth in 1838, and at Woolwich in 1850, the terrific effects of shell-firing on and in a ship, when the shells, having penetrated sufficiently into the timbers to lodge and explode there, took full effect,

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[a] Experiments were made in the Marshes at Woolwich, Nov. 19, 1850, with a view of testing the effects of metal and wooden fuzes; and, on this occasion, shells were fired from 32-pounders and 8-inch guns against a strong bulkhead. The quantities of bursting-powder were 1 lb. to each of the 32-pounders and 2¼ lbs. to each of the 8-inch shells; the charge to each gun being 8 lbs. Several of the shells exploded on striking the bulkhead. One of the 8-inch shells struck the ground short, and afterwards buried itself at the bottom of the bulkhead: it did not burst till after the next shell had been fired, when it exploded with tremendous effect, tearing the massive timbers into hundreds of fragments and scattering them about, besides breaking and twisting the numerous bolts with which the wood was held together.

were strikingly exemplified. But the numerous failures of fuzes in those experiments[a] show that time-fuzes, which are essential to enable a shell to act as a mine, are very inefficient in horizontal shell-firing. It is found that four fuzes out of five are extinguished on striking the water, and about one in three on striking a ship; if the shell strike with the fuze end forward, which is generally the case, it is found that the timber, by its resistance, forces itself into and effectually plugs the fuze.

In the experiments made at Portsmouth, with shells buried in earth,[b] and in others with shells embedded in masses of timber,[c] the explosions which took place afforded also the strongest proofs of the prodigious power of shells acting like mines. In these circumstances, the comparative effects produced by the 6.3-inch and 8-inch shells, respectively, were proportional to the charges, or as the cubes of the diameters of the shells.

265. In the experiments, No. 13 of 1847, and No. 26 of 1849, the shells were buried in earth at considerable depths, or embedded in masses of timber. Such as were lodged in earth formed regular mines, whose charges in exploding compressed the earth in every direction, according to well-known laws, forming what is technically called a "globe of compression," the craters having their axes in the lines of least resistance; while

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[a] Analysing the shell experiments of 1838 against the "Prince George" hulk, at 1200 yards' distance, it appears that, on the 22nd of November, 7 shells were fired, of which 3 did not explode.

Nov. 23rd.—4 shells were fired; 2 did not explode.

Nov. 29th.—10 shells were fired; 7 did not explode, and, none that grazed survived.

Nov. 30th.—12 shells were fired; 6 passed over the hulk, and, of the other 6, 2 did not explode.

Dec. 1st.—31 shells were fired; 16 did not explode, and all that grazed were extinguished.

Dec. 3rd.—22 shells were fired; 8 did not explode, 1 burst short, 1 passed over the hulk, grazed, and was extinguished, 1 went over, made three grazes, and then exploded.

Thus, out of 80 shells that struck, 38 did not explode.

In the ricochet experiments at Southsea, in 1838—

Oct. 27th.—10 shells were fired; of which 2 burst.

Oct. 30th.—14 shells were fired; 3 burst.

Oct. 31st.—8 shells were fired; none burst.

So that only 5, out of 32 shells fired, burst in ricochetting.

[b] Experiment No. 13, 1847—"Excellent."

[c] Experiment No. 26, 1849—"Excellent."

the shells lodged in timber, from the fibrous nature of that material, formed irregular wounds of considerable length, and detached large masses of splinters, but in a manner to show little analogy between the effects of shells embedded in the two different mediums: yet the shell which explodes when lodged in the side or body of a ship is, in fact, a mine; and, as such, is capable of producing the most destructive effects. But to obtain this effect on so small an area as a ship occupies on a horizontal plane, from shells projected at a considerable elevation, as in what is called vertical firing, is a very difficult matter, and the practice forms a very different case from that of shells projected horizontally (Art. 268). Concussion-fuzes,[a] or percussion-shells, are best adapted to the latter, but are inapplicable to the former. Time-fuzes, therefore, must continue to be employed in horizontal shell-firing, though, for this purpose, they are not always to be depended on.

Even when good and safe percussion or concussion shells shall have been obtained,[b] time-fuzes will, nevertheless, be required, in the naval service for shell-firing at troops on shore[c] at open

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[a] It may here be necessary to explain to some readers wherein consists the difference between the terms "concussion" and "percussion," applied to fuzes and shells. A "concussion" fuze is provided with an internal mechanism, so nicely adjusted as to withstand the first shock which the shell receives—viz. that occasioned by the explosion of the charge—and resist any other that may be occasioned by grazing short, while it shall yield to the concussion occasioned by the impact of the shell on the body struck; this concussion, by shaking the burning composition of the fuze into the loaded cavity of the shell, instantly causes the latter to explode. A "percussion" fuze or shell is one fitted or filled with a chemical composition of highly explosive character, which bursts the shell at the moment of striking, without being previously ignited.

[b] The recent inventions of Sir William Armstrong entirely fulfil, by some chemical action, the conditions required of such fuzes. See Art. 241, p. 207.

[c] The answer to question 45, page 11, of the 'Catechism on Naval Gunnery,' used on board the "Excellent," states "that fuzes, not being always driven with the same weight or force of blow (that is, by hand), do not burn equal parts in equal times; and it is recommended to ascertain experimentally the rate of burning of the batch of fuzes intended to be used, by trying one or more with a pendulum, before the practice commences"—a caution highly necessary from the deterioration of fuzes, in long services on foreign stations, from heat and damp. This observation carries the author back to a time when, in the command of an extensive brigade of 8-inch howitzers, he had ample experience of this, and of the difficulties, uncertainties, and intricacies involved in the whole question of fuzes.

It then appeared to the author that the operation of driving fuzes might best be performed by mechanical agency, which alone can give that perfectly boats crowded with troops, ships filled with men on their upper decks; also for the bombardment of towns and fortresses, and the destruction of storehouses, barracks, or magazines (Art. 200); for all which purposes mortar, and not howitzer, shells are required, with time-fuzes to cause the shells to explode after having penetrated to their basements. Without time-fuzes, what would Lord John Hay have done at Bilboa,[a] or Sir R. Stopford at Acre? (See Art. 201.)

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equable compression to the composition which is requisite to ensure equality in burning.

For this a machine was contrived, by which each addition of composition received an equal degree of compression throughout, by hammers or mallets, of equal weight, falling freely through equal spaces, with nice adjustments by which the spaces of descent of the hammers might be accurately maintained throughout the operation.

The fuzes thus driven were found to burn much more equably than those driven by hand; and by this machine a great many fuzes might be driven at the same time, with the same moving power. The machine was of a very rude and imperfect construction, having been made for the trial. Perhaps the author was not wrong in principle in proposing such a machine; and, having often since witnessed much error and uncertainty in shell-firing on service, he has looked back with regret that some such process had not been adopted. Having read the very just observation quoted from the "Excellent," and considering that the description of shell-firing to which this note relates demands the utmost perfection that can be given to this little implement, the author conceives that it may not be unworthy the consideration of the able and distinguished officer who now presides over the Laboratory Department to apply his skill and ingenuity to devise some instrument more constant and unerring than the arms and hands of men, which exert very different degrees of physical force, however long habituated they may be to that particular occupation.

[a] The practice of H. M. S. "Phœnix" in May, 1837, at St. Sebastian, was extremely efficient. All accounts concur in attributing to the unexpected but timely arrival of the steamers, and the extraordinary effects of live-shells, the success of the attack made by the Queen's troops on the intrenched position of the Carlists. Shell-firing against troops on shore had been previously tried, nearly in the same place, from some of the British frigates acting on the north-west coast of Spain in 1811, and in the naval operations of 1812. These were undertaken before the campaign was opened on shore, to distract the attention of the French forces in the north of Spain, and thus prevent their detaching, as was intended, a large portion of those troops to reinforce Marshal Marmont; also to intercept and break up the communication which the French still carried on by sea with Bayonne; and further to succour and supply the guerilla corps with arms, ammunition, and stores. For these desultory enterprises, the author, then serving in the north of Spain, directed the issue of 5½-inch shells to the British frigate the "Surveillante," and some other 24-pounder frigates, to be used against any French "colonnes mobiles" which might be endeavouring to oppose or prevent the landing of arms and supplies to the guerillas, should those columns expose themselves to the fire of the ships at distances which neither case nor grape shot could reach, nor round shot be used with advantage. The shells were applied by the late gallant Sir George Collier, his first lieutenant O'Reilly, and other meritorious

266. From experiments carried on at Gavre, in France, in 1836, it is found that a projectile will not lodge in a mass of timber unless it penetrate to a depth nearly equal to its diameter; the strength or elasticity of the fibres forcing the shell out,[a] if the penetration be not deep enough to allow the fibres to close behind the projectile, and thus keep it embedded in the wood. It is from this circumstance that, in ordinary shell-firing from ships which are continually varying their distances, charges sufficient to obtain the necessary penetration and ensure the lodgment of the shell, must always be used, and fuzes prepared for corresponding times of flight; but the percussion or concussion fuze obviates all these complications.

In horizontal shell-firing considerable velocity is required, that the shell may have sufficient penetrating power to act as a shot,[b] if from any defect in the fuze it fail as a shell; for, if the striking velocity and penetrating power be small, the explosive action is rather towards the exterior, on which side the line of resistance is the least, than towards the interior of the ship; and this is the reason why shells that do not strike with considerable horizontal velocity so frequently explode outwards, and throw their fragments back. (See shell experiments of 1838 against the "Prince George" hulk, at 1,200 yards.) With a little more penetrating power, the explosion may take place both ways. If an 8-inch or a 10-inch shell, either of which constitutes a

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officers, with great skill and effect, in a manner to furnish strong proof that, for such purposes, live-shells with time-fuzes might always be used with great advantage.

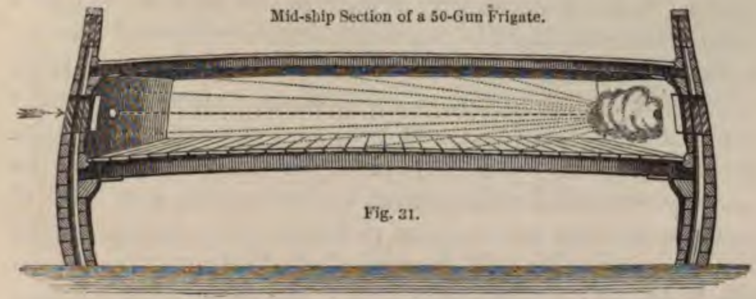
In attacking a redoubt, under the protection of which the Turkish ships had run on shore, in the operations of 1807, a considerable body of Asiatic troops, together with a part of the crews of the ships, having remained on the beach, were dispersed by a few shells from the "Pompée."—James' 'Naval History,' vol. iv., p. 181.

[a] This frequently occurred in the shell experiments of 1838, by which it appears that many shells rebounded on striking, from not having penetrated sufficiently.

[b] A remarkable proof of the importance of this occurred in the shell experiments of the 22nd of November, 1838—round No. 5, when a 32-pounder shell penetrated the side of the hulk "Prince George," below the water, lodged behind a rider, and made an opening in the side, which allowed the water to rush in with considerable force: the perforation was in such a position that the carpenters who were present stated that it would have been impossible for them to have plugged or stopped the leak from the inside: the shell did not explode. Had the fuze acted concussively, no such serious penetrating effects could have been produced.

powerful mine, should hit and lodge in a vessel anywhere below the water-line, and explode outwards, it might prove most serious, and even fatal to her; whereas, if it should hit anywhere above the water-line, and act outwardly, the effect would not prove very injurious to the ship, and not at all so to the crew.

267. The maximum effect of horizontal shell-firing with time-fuzes is when the shell perforates the near side of an enemy's ship, crosses the deck as a shot, penetrates into the other side just so far as that the line of least resistance may be inwards, and then exploding, scatters its fragments back into the ship (fig. 31.)[a] It thus combines, in one and the same projectile, the effects of both shot and shell; but this requires a rare and almost miraculous concurrence of the conditions and circumstances under which the firing is made.



Mid-ship Section of a 50-Gun Frigate.

Fig. 31.

268. In vertical shell-firing against a ship, the great difficulty and uncertainty is to hit the object,—a mere speck in the amplitude of a long range; but if a shell should chance to fall upon a ship, it must either lodge in her or pass through her bottom and sink her. In this practice the fuze must burn long enough to exceed somewhat the time of flight. In horizontal shell-firing the conditions are very different: the probability of hitting is very great; and, in close action, in a smooth sea, may be considered certain; but the difficulties and uncertainties relating to the fuze become then very great. The horizontal velocity is such that the shell passes over large portions of the

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[a] The targets, intended to represent parts of the sections of ships, as in fig. 31 above, and fig. 32, p. 266, consisted of piles driven into a mud-bank at low-water: the bank, when not covered by the sea, exhibited on its surface the grazes of the fragments which passed beyond the surfaces of the targets.

range in times so short, that the smallest error in the estimated time during which the fuze will burn, destroys the effect. The shell may either explode prematurely, or may pass through both sides of the enemy's ship without exploding. The latter will be most frequently the case, from the great care which must be taken that the shell should act as a shot in the event of the fuze being extinguished on grazing the water or striking the ship. On an average, the probabilities of the former event happening and not happening are as 4 to 5, and of the latter as 1 to 3 (see Art. 264).

269. From what has been stated in the preceding Articles (264 to 268), it is evidently essential to the efficiency and simplicity of horizontal shell-firing, that the shells should be of a nature to explode with the utmost certainty on striking the object. It became, therefore, of vast importance to endeavour to obtain either an infallible concussion-fuze, or a safe and efficient percussion-shell (see the definition, Art. 265, Note [a], p. 258), which may be free from the danger arising from unscrewing the cap of a metal fuze (Arts. 263, 286), and may not require to be introduced into the gun before the cap is taken off; so that the gun may be loaded with shell as quickly as with shot. It is of equal importance that the vital principle of the shell should not be destroyed in its flight by being immersed in water, in grazing, which so frequently extinguishes the fuzes of the common and concussion shells, nor be liable, like them, to be choked by the fibres of the medium struck.

Should such weapons of destruction be obtained, their effects upon and in ships will depend mainly on the number of impacts, in a given number of rounds, on such solid parts of a vessel as present sufficient resistance to the blows to occasion the explosion of the shell, by which, together with the horizontal force of the latter, the fragments may be driven through the side and into the ship with power sufficient to produce an effect similar to that which is depicted in fig. 32, p. 266.

The explosive agents contained in a percussion-shell being necessarily so fortified as to withstand the resistance of a graze and the reaction which produces the rebound, and being capable of exploding only when a more violent shock of impact takes place, it follows that a percussion-shell might perforate a slender or unrigid body without exploding, and even enter a port and pass across the deck to the opposite side of the ship, without producing any effect as a shell.

It may, therefore, here be remarked that neither a concussion-fuze nor a percussion-shell are suitable weapons to be used for dismantling purposes (see Part IV., Sect. IV.); for although a shell may be capable of bringing down a mast by a direct hit, whether it burst or not, and would infallibly fell a lower mast, did it explode on striking, yet this is but a remote probability; and therefore shells whose explosion depends upon striking a resisting body with great percussive force, would be wasted if fired at the rigging; and in general it may be said that although shells which do not explode will produce as much damage to masts, sails and rigging, as shot of the same diameter, yet this equality of effect would be obtained by a projectile which costs two or three times as much as a shot: shell-firing with such an object must therefore be enormously expensive. Shells may, no doubt, be used with considerable advantage for dismantling purposes at considerable distances, particularly in chasing or when chased; but for this they should have time-fuzes and should burst at a suitable distance short of the ship (Part IV., Sect. IV.).

270. It has been stated (see Articles 139, 256) that large projectiles are found to strike objects more frequently than small ones of equal density, fired with proportional charges;[a] but that some of the causes of deflection (as a strong wind blowing across the range) act more powerfully on large projectiles, especially those that are hollow, than on solid shot; and that the probability of large hollow projectiles striking an object as frequently as solid shot, diminishes as the distance of the object increases; also that the deflection is most apparent towards the end of a long range (Art. 247).

When large and small projectiles are, both, shells or hollow shot, and are fired with charges which are to each other as the densities of the projectiles, the same law obtains: the inferiority of precision in the smaller shell, with respect to the proportion

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[a] *Piobert*, 'Traité d'Artillerie,' tom. ii. p. 270. *Ward*, p. 28, Metz experiments, 1816 to 1825; and 'Suite des Expériences à Gavre,' 1844.

of hits, is manifest, and increases with the distance of the object, on account of the greater surface of the smaller sphere, compared with its weight, and consequently with its momentum. The smaller shell has, in fact, less power to overcome the resistance of the atmosphere, and therefore does not retain its velocity so long as the larger shell.

But when large and small projectiles are not of equal density —the former being a shell or hollow shot, and the latter a solid ball—the case is materially altered, and even reversed.

Lieutenant Ward, in his excellent treatise, already so frequently noticed, as well as all other naval authorities, lays it down as a principle that, at long ranges and with guns of different calibres, the probabilities of hitting a given object are as the squares of the diameters of the *balls*, supposing all to be of equal density, and to be fired with proportional charges.[a] But when the densities are so unequal as those of hollow shot, or shells, and solid shot, whether of the same or of different diameters, the probability of hitting, in distant firing, is in favour of the denser projectile; and it appears from the experiments of 1838, made on board the "Excellent," that this was found to be the case at short ranges likewise.[b]

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[a] This maxim teaches an important lesson in favour of solid-shot guns of large calibre, which appears not to have been without profit to the service to which Lieut. Ward belongs.

[b] On the 18th of October, 1838, on board the "Excellent," 11 rounds of single shot were fired from a 32-pounder, 9 ft. 6 in. long, and weighing 56 cwt., against a target set up at a distance of 400 yards; the charge was 8 lbs. and the elevation half a degree. At every round the target was struck; but at the fifth its top was just grazed. The gun was worked by 13 men, and the time in which all the 11 rounds were fired was 7 mins. 10 seconds. On the same day 11 rounds of single shot (hollow) were fired against the target, at the same distance, from a 68-pounder gun, 9 feet long and weighing 65 cwt.; the charge was 10 lbs., and the elevation $\frac{5}{8}^{\circ}$. At the first, second, and fourth rounds, the target was struck; but at all the others the shot fell short, except at the 11th round, when it fell close to the right staff; and at the 6th and 8th rounds the shot was deflected to the right hand. The gun was worked by 15 men, and all the 11 rounds were fired in 7 mins. 40 seconds.

On the same day also 11 other rounds of solid shot being fired from the same 32-pounder gun, with an equal charge and elevation, there were three hits, one of which was in the bull's-eye, and three other shot touched the target: while 11 hollow shot being fired from an 8-inch gun, weighing 68 cwt., with a charge of 10 lbs. and an elevation equal to $\frac{1}{2}^{\circ}$, two only hit.

Experiment, 17th of October, 1838.—15 rounds of hollow shot being fired from an 8-inch gun, of 65 cwt., charge 12 lbs., elevation $\frac{1}{4}^{\circ}$, at 400 yards, and

The author has been at great pains to examine very closely the important problem of the probability of hitting small objects of equal and different surfaces, under all varieties of circumstance; and he would refer the reader to the subjects of probabilities and deviations which are stated at Articles 139, 140, and 146. Also to Articles 161, 162, 163, 249, and 250, for the results relating to ranges and penetration which have been obtained from experiments made on board the "Excellent." Reference may also be made to Articles 250 and 251 for the relative accuracy of solid and hollow shot, and of solid shot and shells.

271. Although, as has already been shown (Art. 264), the destructive effects of an exploding shell are the greatest when it is embedded in a material whose fragments may be torn and scattered in every direction, and consequently that the maximum effect which a shell is capable of producing on and in a ship is when the shell lodges in some part of her mass and then explodes; yet so great are the difficulties of obtaining such a result in practice, that it has become a highly important object to endeavour to obtain some safe method of causing shells to explode, whilst moving with great horizontal velocity, on striking a ship; and the effects of horizontal shell-firing we are now to explain.

The actions of shells which explode on striking some solid part of a ship, though extremely formidable both to the vessel and to her crew, are far less so to the ship than those of an embedded shell; and the two cases are essentially different, since, if the percussive agent, whatever it be, perform its pecu-

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the same number of rounds of solid shot fired from a 32-pounder gun, of 56 cwt., charge 10 lbs. 11 oz., elevation ⅜°, the last five rounds double-shotted, same distance, the 32-pounder gun made the best practice.

With respect to the accuracy and penetrating power of solid shot fired from 32-pounder guns at 1200 yards, the following results were obtained from the Experiments on the 17th of October, 1838.—Six rounds of solid shot being fired from a 32-pounder gun, 50 cwt., charge 8 lbs., elevation 2⅜°, there were five direct hits; and one shot ricochetted and struck the hulk; the penetrations were 22, 25, 36, and 48 inches. The two first penetrated directly or diagonally into perfectly sound wood; the last diagonally into solid but unsound wood.

Five solid shot being fired from a 32-pounder gun, 46 cwt., charge 6 lbs., elevation 2¾°, all struck the object directly. Penetration 39 inches diagonally, through sound plank and into solid timbers.

liar office, the shell to which it is attached cannot lodge in the wood. When a shell explodes in passing through a ship's side, the effect resembles that which accompanies the explosion of a spherical case-shot after being projected from a gun: the splinters, usually fifteen or sixteen in number, are carried forward into or across the ship in diverging paths, whose directions are compounded of that of the original projectile force and of those which the splinters would take from the action of the bursting charge alone. The cone of dispersion formed by the splinters (fig. 32) has frequently been observed by the author when standing in a line perpendicular to the axis of the cone, or in the direction of the target. The paths of the splinters, being thus in the directions of the resultants of the two forces just mentioned, have not a great lateral divergency; and therefore the risk of casualties, at some distance from the original direction of the shell, is small compared with that which attends the explosion of an embedded shell. Whilst it is admitted that the force and effects of the explosion of an embedded shell on a ship are in general more destructive than those of a shell which bursts in passing rapidly through the side, it is equally true that the latter are more destructive than the former upon the gun-crews of the adjoining, and still more upon the opposite, guns, when both batteries are manned, and upon all the people on the fighting-decks within the limits of the cone of dispersion.

Mid-ship Section of a 50-Gun Frigate.

Fig. 32.

The 32-pounder gun most frequently used in the experiments referred to in Art. 270, Note [b], p. 264, in the comparison with other descriptions of ordnance, was the 56-cwt. gun, the windage of which (see Tables V. and XXIV., Appendix B, and

Art. 204, Note) is excessive, being .233 inch, whereas that of the gun against which its range and precision were tried is only .125. This old pattern gun is the only specimen of naval ordnance of former times remaining in use. It is no doubt a powerful gun, from its length and service-charge, but it is defective in precision on account of its excessive windage: it is therefore very much to be desired that the new 32-pounder of 58 cwt., length 9 feet 6 inches, charges 10, 8, and 5 lbs., windage .2, proposed by Colonel Dundas, should be sanctioned, and forthwith provided, at least for trial. It may then be determined what more can be done towards the improvement of that valuable class of gun, and particularly whether the windage might not be reduced to .175. The 32-pounders of 45 and 42 cwt. (Monk's guns, B. and C.) have only .173 windage, and all the guns bored up from 24-pounders only .123; and there can be no reason why the new 32-pounder of 58 cwt. should have more. The pernicious and discreditable anomaly which still exists with respect to the windage of 32-pounders (Art. 204, Note) will then in a great measure disappear.

272. From all the preceding statements of the relative practice with shell-guns and the new ordnance for projecting heavy solid shot, it appears that, for power of range (see Arts. 248, 249, 251), for penetrating force (Arts. 161, 250), and particularly for accuracy of practice (Art. 270, with the Note [b]), the solid shots fired from the long and powerful guns recently constructed are more efficient than hollow shots from shell-guns. By many experiments (see Arts. 251, 252) it is found that the deviations of hollow shot from the point of aim are greater than those of solid shot. The inferiority of shell-guns would, however, be amply compensated by their great capacity for throwing projectiles of superior magnitude, either hollow shot or shells, if, as was generally the case during the last war, a ship could always attain a position for action within 1500 yards (Art. 252) without previously suffering serious damage: yet one disadvantage to which a ship carrying shell-guns would still be subject is that, being chambered, those guns are not so favourable as others for quick loading (Art. 226).

Shell-guns and shell-firing are, as yet, untried in actual combat, in broadside-batteries; but there can be no doubt that, in a future war, a ship armed chiefly with shell-guns, and not carrying with them a due proportion of solid-shot guns, by which it may be adapted for action at great distances and at close quarters, will have to endure the serious ordeal of much distant firing, in which the superior accuracy of solid shot, in their flight, will give to the opposing ship, if more abundantly provided with such projectiles, and if its crew have equal skill in gunnery,[a] a decided advantage over the other (Art. 257).

It appears therefore, to the author, to be a great mistake to suppose that the propulsive power of steam, and the effects anticipated from shell-guns, will cause actions at sea to take place at close quarters only, and to be decided in a few minutes. Steam gives the means of avoiding, as well as of closing to action, and when that giant power shall have been applied to line-of-battle ships, as well as to other vessels of war, as a locomotive battle power, naval evolutions will be capable of being executed with the utmost precision; and hence the principles of naval warfare with steam as well as wind will require to be well studied and practised by naval officers, in order that they may qualify themselves for the various operations to which the new power in alliance with the sail will give rise. (See the 'Treatise on Naval Warfare with Steam,' by the author). The destructive effects of shell-firing at short distances, and the extension that has been given to the projectile powers of artillery for very distant firing, far from tending to render close action unavoidable or preferable, and naval battles of very short duration, will, it may rather be presumed, cause actions at sea in general to be commenced at great distances, and be conducted with the utmost circumspection, tactical skill, and practical science.

273. The final struggle at close quarters will, no doubt, be preceded by efforts even more strenuous than those employed on former occasions to cripple the enemy at a considerable distance, whilst endeavouring to close, as in the actions between the

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[a] "L'artillerie est une science très compliquée. L'officier des marine qui possède cette science est le maître de celui qui l'ignore: c'est une assertion qui deviendra, pour vous une vérité évidente, en proportion des connaisances réelles que vous acquériez dans là science de l'artillerie."—*Général Du Bourg*, L'Organisation de la Marine,' p. 358. Paris, 1849.

"Macedonian" and the "United States" (see Part V.). No longer will a ship be permitted, with impunity, to run down, end-on, against her opponent; nor, without serious damage, will divisions of fleets in line a-head, as at Trafalgar, be permitted to advance, almost unscathed, against the broadside-batteries of heavily armed ships waiting to receive, and, with improved gunnery, well prepared to meet that mode of attack. Of this we find distinct warning in all the commentaries that have been written on the naval actions of the late war. (See *De la Gravière*, vol. ii., pp. 185, 188.) Seeing the progress which is now being made by foreign nations in introducing into their ships new and more powerful guns, with the doubts which begin to be entertained of the superiority of canons-obusiers and the incendiary system (*De la Gravière*, 'Guerres Maritimes,' vol. i. pp. 98, 99, and other writers; see also Arts. 257, 261), we cannot fail to be convinced that distant firing will be the ruling practice on which success will principally depend in future war. This will require a corresponding armament of long and powerful guns in our ships of war, and particularly in steam-vessels. At present the heaviest solid-shot gun in line-of-battle ships of the British navy is the 32-pounder! while shell-guns are preferred for the bow and stern armament of steamers. It is important to remark here that the weight of the French 30-pounder shot is about 32¼ lbs. English, and that the French 36-pounder shot weighs nearly 39 lbs. English.[a] The new French 60-pounder (weight of shot 66 lbs. English), tried at Gavre in 1848, though not yet adopted as a naval gun, is nearly equal to our 68-pounder, which the author has no doubt will hereafter be applied to the naval service.

It will not indeed be always in the power of the commander of a ship, however desirous he may be of avoiding close action, to be able to accomplish that purpose; for in thick weather, or in a dark night, vessels may unexpectedly fall in with and be very near before they discern each other. These contingencies may

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[a] 'Aide Mémoire Navale,' p. 664. A new 50-pounder gun, which, by a regulation of the 27th July, 1849, was to have entered largely into the armament of the French navy, has since been withdrawn from the batteries of ships.

happen, and a close action may be thus suddenly brought on; but it may be presumed that the occurrence of such surprises will be as rare as they have been in former wars between ships armed in the usual way. Either the ships may come together by accident, and then the surprise will be mutual; or one of the two, previously knowing the position of the other, may take advantage of the obscurity to approach her unseen; but this implies a difference in the degrees of vigilance on board the two ships which is scarcely within the limits of probability. Should the surprise be mutual, the disadvantage will certainly be on the side of the ship which is not armed with shell-guns; if both are so armed, and of equal strength, it is evident that they may then engage on equal terms.

274. The 10-inch shell-gun is no doubt a formidable piece of ordnance; its shell in exploding is a powerful mine; but it is inferior in range to the heavy guns now in use in the British navy, excepting the lower classes of 32-pounders. The weight of the 10-inch shell-gun, when first introduced, was 84 cwt.; but this was increased to 86 cwt., by surrounding the breech and charging-cylinder with an additional 4 cwt. of metal, and taking away about 2 cwt. from the forepart, by which means it has more "preponderance," and is made to approximate nearer to the new principle stated in Art. 216. The small proportion of windage given to the 10-inch shell-guns (.16 of an inch—the same as a common howitzer—the 68-pounder gun having .2 of an inch) is also an improvement. A 68-pounder gun (Art. 218) may be used for firing 8-inch shells as well as 68-lb. shot. For shell-firing, indeed, it is not superior to the 10 or 8 inch guns, because shells will not bear higher charges than those established for shell-guns; but a 10-inch gun for firing hollow shot is inferior in range to a 68-pounder gun with solid shot. The difference of weight between these two pieces of ordnance is only 9 cwt., but the superiority of the latter in power of range, accuracy, and penetrating force, is of vast moment in steam warfare.

Comparing a 10-inch shell-gun of 84 cwt., charge 12 lbs., and a hollow shot of 84 lbs., with a 68-pounder gun of 95 cwt., charge 16 lbs. and solid shot, in respect of their range, we see that at an elevation of 1° the difference of range is 142 yards, at

2° it is about 190 yards, in both cases in favour of the latter; at 3° the 68-pounder gun ranges about as far as the 10-inch gun does at 4°; the range of the former at 4° is greater than that of the other at 5°; and at higher elevations the differences in favour of the 68-pounder increase considerably. At 15° the range of the 10-inch gun is 3060 yards, and that of the 68-pounder gun .3660 yards (Tables V., VI., Appendix B). If we compare the trajectories of a hollow shot from a 10-inch gun, and of a solid shot from a 68-pounder, the elevation of the former gun being 5° and that of the latter 4°; also the ranges of the 10-inch shot and the 68-pounder shot being, by the experiments, 1600 yards and 1760 yards respectively, the angle of descent for the solid shot is much less than for the hollow shot; or the former, near the end of its flight, approaches much nearer than the other to a horizontal direction; and the chance of hitting a small object near the extremity of the range of a shot is manifestly greater in proportion as the trajectory[a] approaches, in that part, nearer to a horizontal direction; that is,

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[a] The practice of representing the trajectories of shot may be very advantageously employed to exhibit the comparative curves in which projectiles move; and, from thence, the circumstances which determine the relative efficiency of shot and shells, of different diameters and weights, when projected from ordnance of equal or different dimensions and weights, at various elevations, and with various charges of powder. The author has laid down, by means of the first equation for y, Art. 83 (the second, or third equation for y, on page 56, is more simple but rather less accurate), the trajectories, among others, of a solid shot from a 68-pounder gun, and a hollow shot from a 10-inch gun, the ranges 1737 and 1670 yards, at the respective elevations of 4° and 5°, having been taken from the results of experiment (1835, 1849); the inconvenient magnitude of the scale has, however, deterred him from having them engraved for this work. In order to obviate any misapprehension which may arise on the part of the practical reader, with respect to the correctness of such tracings, from an opinion that, because they are made by means of a theoretical formula, they may differ materially from the figures of the paths in nature—the author thinks it right to observe that such difference cannot exist. The ranges having been given by experiment, the initial velocity, or the height due to it, may be obtained from the formula itself without the uncertainty which may attend the direct computation of that element by the formula for V., Art. 64, or otherwise. The ordinates of the curve, corresponding to any assumed values of x, may therefore be determined with as much correctness as simplicity, the value of c, for the particular nature of projectile, being determined as in Arts. 62, 63. In the examples alluded to, the range of the 68-pounder shot is, by experiment, greater than that of the 10-inch shell, while its elevation is less; therefore the curves must intersect one another near the end of the range, and the angle of descent of the hollow shot be necessarily greater than that of the solid shot. On this depend the

as the angle of descent is less. It should be added, that hollow shot, being greater than solid shot of equal weight, are more liable than the latter to suffer lateral deflection from the action of wind and other causes (Arts. 144, 247, 251).

Commander Dahlgren, of the United States' Navy, in his 'Treatise on Shells and Shell-guns,' concurs (Art. 252), with the author in preferring greatly as a pivot-gun the 68-pounder of 95 cwt. to the 10-inch shell-gun, which is deficient in accuracy, force, and power of range. He states that 10-inch shell-guns of the original British pattern were adopted in the United States' Navy; but, being found deficient in the essential qualities of length of range, accuracy, and penetrating force, have been discarded from the United States' Navy, and replaced by a more efficient gun.

275. The British shell-guns, as analogous ordnance to the French canons-obusiers (Art. 223), are well adapted to the sea-service; the British 8-inch gun of 65 cwt. is superior to the French canon-obusier No. 1 (Art. 232), and is perhaps the best chambered gun ever produced, here or elsewhere. But, as has been shown in Art. 226 and the Note, great objections attach to all chambered guns, which, though, in part, obviated by the expedient of the cork wad (Art. 527), are not removed—the defects being inherent in their construction. Chambers are, however, necessary evils in the naval service, in ordnance of such large calibre as 8 inches and 10 inches; because, if their bores were cylindrical throughout, they would be too weak round the seat of the powder to stand the explosion of even a very diminutive charge; and it would therefore be necessary to fortify an unchambered gun of that calibre by casting it at least

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limits within which an object may be struck, and it is capable of being ascertained with all requisite accuracy.

The computation of the ordinates from the formula, and the manner of tracing the curve, should be taught in all schools of scientific gunnery; the practice of doing so is capable, if the work is laid down on a scale of sufficient magnitude, of giving very correct notions concerning the various circumstances on which the probability of a shot or shell taking good effect, at a given distance, depends. This subject is of particular importance where the comparative trajectories of solid and hollow shot are required, on account of the different degrees of rapidity with which the projectiles lose their velocities in passing through the air, and the consequent increase in the inclinations of the descending branches to the horizon, as the projectiles approach the end of their flight.

30 cwt. heavier than it now is. But this additional weight, for vessels of equal "displacement," would disable them for carrying an equal weight of ordnance without greatly reducing the number of guns; and, in the vessels, there would not be space, even if they could carry the same number of the heavier gun, to stow the additional number of men required to work such heavy ordnance.

But why impose the evil of chambered ordnance on the land service? The cork wad must, in that case, be adopted in the land, as well as the sea, service, for without it there would be frequent miss-fires.[a] Objections to weight as limited by "displacement," and want of space for the accommodation of additional men required for working the guns, do not attach to the land service; and consequently the question, cleared of those conditions, rests solely on the comparative merits, faculties, and capacities of the chambered and unchambered guns, as best adapted to the distinct purposes for which they were designed—the one to fire shells or hollow shot, within limited distances—the other to fire solid shot with superior power of range, accuracy, and penetrating force, at great distances.

276. It appears by Tables V. and VI., Appendix B, that the range of a 32-pounder of 56 or 58 cwt. at an elevation of 1° is very nearly equal to that of a 10-inch gun at 2°, and about 200 yards more than the range of the 8-inch gun (65 cwt.), at 1°; the range of the 32-pounder at 2° is greater than that of the 10-inch gun at 3°, and about equal to that of the 8-inch gun at 3°. Again, the range of the 32-pounder at 3° is fully equal to

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[a] "In 8-inch guns with conical chambers, to insure the reduced cartridge being set sufficiently home it is *most essential* that spherical cork cartridge tops of 5½ inches diameter and 2¼ deep, should be fitted inside these cartridges when sent on board, without which the guns *will frequently miss-fire*."—'Instructions for the Exercise and Service of Great Guns and Shells.'

But no cork or other tapering wads are provided for this ordnance in the land service (Art. 527, fig. 64), where there is more need of that expedient than in the sea service, because land batteries, which should always have some command over the object or plane in front, are necessarily often placed in such elevated positions for coast defences as to require great depression in firing at any object upon the plane of the sea, by which a reduced cartridge would be far more liable to slide from its place in a conical chamber than in horizontal firing, and thereby occasion miss-fires more frequently than on board a ship. —AUTHOR.

that of the 8-inch gun at 4°, and considerably greater than that of the 10-inch gun at 4°. At 4° the range of the 32-pounder gun is about equal to that of the 10-inch gun at 6°, and nearly equal to that of the 8-inch gun at 6°; the range of the 32-pounder at 5° is very nearly equal to that of the 8-inch gun at 7°, and fully equal to that of the 10-inch gun at 7°. Again, in more distant firing, the 32-pounder of 56 or 58 cwt. at 10°, ranges very nearly as far as the 8-inch gun at 13°, and quite as far as the 10-inch gun at 14°. At 1600 yards the 10-inch shell-gun would be firing shells or hollow shot at about 5° with a full-service charge of 12 lbs., the 8-inch, at about 4°, whereas the 32-pounder of 56 or 58 cwt., with a charge of 10 lbs., would be firing solid shot at the same distance at about 3°. At 2000 yards the elevations for the 10 and 8 inch guns would be respectively 7½° and 7°, whilst the 32-pounder would be firing its solid shot at a little more than 5°. See likewise shell and shot experiments of 1838, "Excellent" (Art. 270, Note [b], p. 264).

The results given in those tables are conclusively in favour of the 32-pounder of 56 or the new one of 58 cwt. The 56 and 68 pounder guns have a still greater superiority over the shell-guns; and, therefore, a grievous error would be committed in preferring the latter to the former for the armament of coast batteries in general.

277. The comparative values of solid and hollow shot, and consequently of unchambered and chambered ordnance, have been well laid down by Lieut.-Colonel Burns, of the Royal Artillery, on his 'Cards'—excellent codes—for the guidance of the practical artillerist.

Why has the whole tribe of carronades, which at first were so victorious (Art. 151), disappeared? because they are chambered ordnance, which, though capable of firing solid shot, are incapable of doing so with certainty and effect, excepting in close action; and when properly opposed by solid-shot guns, at long ranges, were overpowered, and ultimately beaten out of the service. It is not meant by this to disparage shell-guns by comparing them with carronades, but to show the defects of chambered ordnance as shot-guns (Arts. 126, 226).

The unfortunate selection of chambered instead of unchambered ordnance of the same calibre, in 1812, cost the allied army, under the Duke of Wellington, nothing less than the failure before Burgos. Had the so-called 24-pounders, which, being chambered, were only 5½-inch howitzers, been really 24-pounder guns, Burgos would have been taken.

It is commonly said that 8-inch shell-guns of 52 cwt.—an inferior and inefficient class of shell-guns, of which vast numbers have been provided, but which are rapidly and justly falling into disfavour and disuse in the naval service (Art. 223)—form a large portion of the present siege-train service; not, it is hoped, to interfere with the usual proportion of the good old 24-pounder—a capital siege-gun—but to be used as howitzers; for they are incapable of serving with efficiency as battering ordnance (excepting against earthen works, *Bousmard*, vol. i. pp. 97, 98, 279, 283), or for ricochet firing, with shot; and they are very inconveniently heavy howitzers for siege service. In siege operations, howitzers are not usually required till the siege is far advanced; they are used to ricochet the covered ways, to shell the places of arms, and when the place is about to be assaulted; for which purposes less weighty howitzers would be sufficient.

278. The Russian navy during the war with Turkey in 1829 consisted of five divisions, each comprehending nine line-of-battle ships, six frigates, eight corvettes and brigs, with eight steamers. This force was afterwards augmented, in each division, to twelve line-of-battle ships with a corresponding number of frigates and smaller vessels. The total establishment of the Russian fleet before the war in 1854 consisted of sixty ships of the line, armed with from 70 to 120 guns; thirty-seven frigates of from 40 to 60 guns; seventy corvettes and brigs; forty steamers, and two hundred gun-boats. The system of manning is by establishments of *Equipages de Ligne*, as in France (Art. 38, Note, p. 24). Of this vast naval force three-fifths are stationed in the Baltic, and two-fifths in the Black Sea. In the former there were, in March, 1854, thirty-two sail of the line, armed and ready for sea, in the arsenal or harbour at Cronstadt, with the full proportion of frigates and smaller vessels; and in the Black Sea, at Sevastopol, thirteen sail of the line, ready for sea, chiefly sailing-ships.

The Russian steam navy at the present time (1860) consists of 240 vessels: of this number 192 are afloat and 48 in process of building. The relative proportions of the various classes of ships may be seen by referring to Table XXIII., Appendix B., which exhibits the comparative strength of the English, French, and Russian navies.

The Russian three-decked ships carry a mixed armament of canons-obusiers, French pattern, and heavy solid-shot guns[a] on the lower deck, 36-pounder long guns on the middle deck, 36-pounders No. 2 on the main deck, and 36-pounders No. 3 on the quarter-deck and forecastle. Two-decked ships have the same natures of guns on their lower, main, and upper decks, as the three-decked ships have on their lower, middle, and upper decks.

The armament of the "Pallas" frigate, of 1600 tons measurement, which was pierced for 54 guns, but carried during the peace 50 guns, may be taken as a correct specimen of the general armament of the Russian frigates. The "Pallas" is provided with 30 guns on the main deck; viz. twenty-six 24-pounders (9 feet long), weighing 50 cwt., and four 8-inch shell-guns (65 cwt.), British pattern; she carries on the forecastle two 24-pounders similar to those on the main deck, and six 24-pounders (6½ feet long) of 30 cwt. On the quarter-deck she has twelve 24-pounders of 30 cwt.

The Russians have no percussion-shells, nor have they adopted the French Billette shell (Art. 310, and Note). They prefer time-fuzes, and use the metal screw-fuze. It was with these that they set fire to and burned the Turkish squadron in Sinope Bay (Art. 313).

The Russian 36-pounder is superior to our 32-pounder, and their 24-lb. shot is equal in weight to the 22-lb. English. A new 50-pounder (the weight of its shot nearly equal to 55 lbs. English) is being prepared for the Dutch navy: this is an excel-

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[a] Judging from the fact stated in note p. 315, communicated to the author by Vice-Admiral Deans Dundas, concerning the nature of the shot picked up at Sinope, these guns must have been 42-pounders (equivalent to guns firing shot of 38 lbs. weight, English). Such guns are known to be in use in the Russian Navy.

lent gun, weighing 4624 kilog. (equal to 91 cwt.); its preponderance of breech $\frac{1}{22}$, and the length, from the base ring to the muzzle, 3638 millim. (equal to 12 feet nearly). The Danish gun-boats are armed with long and powerful 60-pounder guns (the weight of the shot equal to about 67½ lbs. English). The weight of a Danish 36-pounder shot is 39 lbs. 11½ oz., and of a 30-pounder shot, 33¾ lbs. English.[*]

These facts demonstrate the prevalence of an opinion that distant firing with powerful solid-shot guns will be the most effectual means of avoiding or counteracting the destructive effects which shells would unavoidably produce if the ship which uses them were by any chance to gain the requisite proximity. As to hollow shot, there is no such projectile in the United States' Navy. Commander Dahlgren observes (page 236), concurring with the author in the objections as to the extensive uses of hollow shot in the broadside batteries of British ships, "That it is difficult to comprehend what possible purpose is to be effected by the adoption of hollow shot, if their cavity is not filled with powder so as to obtain the ulterior advantage of explosion. The substitution of explosion for impact is the end and object for which shell-guns were created; to fail in so applying them, by using hollow shot or uncharged shells, renders shell-guns so used worse than useless, and accordingly hollow shot are entirely disused in the United States' Navy." These observations are very just, and go a great way to enforce the restrictions of shell-guns to their legitimate purposes, and thereby to diminish their number in the broadside-batteries of ships of the line, which should be the most formidable at any distance, and substitute, where displacement is sufficient, guns that are well adapted to fire either solid shot or shells, but which have no occasion to use hollow shot; and this should par-

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[*] To convert the weights of foreign ordnance and shot, in pounds, into English pounds, the following table may be used:—

Add to the number of	Danish pounds	$\frac{5}{48}$	of that number.
	Dutch ditto	$\frac{1}{11}$	ditto.
	French ditto	$\frac{1}{12}$	ditto.
	Spanish ditto	$\frac{1}{72}$	ditto.
Subtract from the number of	Swedish ditto	$\frac{1}{18}$	ditto.
	Russian ditto	$\frac{1}{11}$	ditto.

James' 'Naval History,' vol. i. p. 42.

ticularly apply to our monster frigates, the "Diadem," "Mersey," &c., which, though built expressly to match the United States' monster frigates, are armed with the very gun, the 10-inch shell-gun, which the United States have banished from their service as deficient in power of range, accuracy, and force.

279. With respect to the United States, the naval authorities of that country were, till lately, cautious not to commit themselves by an extensive adoption of shell-guns: they now seem to try at any cost every recent improvement in the construction and armament of their ships of war; they appear, however, to adhere to the practice of building vessels of large dimensions, and arming them with a small number of heavy guns, in preference to a great number of light ones; as if they would endeavour to preserve, for their navy, the advantages which they had in the war of 1813 over British frigates, from the superior range of the guns.[a]

They appear now to consider that naval actions will, in future, be decided by shells, and that those which can bear the heaviest bursting-charges will have the greatest advantage. With respect to arming their ships, they consider that the guns on the upper decks should be such as have long ranges; the remainder may be of larger calibre, and effective at moderate ranges, within which the issue of an action will be almost always decided. ('Report of the Secretary of the United States' Navy, 1856').

280. The United States have now six vast steam frigates:—the "Wabash," the "Minnesota," the "Roanoke," the "Colorado," the "Merrimac," and the "Niagara." The "Merrimac," which is considered as an experimental ship, was, in the latter part of 1856, in the Southampton Water, where she was visited by Sir George Seymour, the commander-in-chief at Portsmouth, and several distinguished officers of the British Navy. From the description given of her, it appears that her length at the

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[a] In the proof trials 1852-3-4, the American guns are said to have stood 1600 and 1700 rounds without bursting. Shells have been adopted in the American navy, not because their guns could not bear solid shot with safety, but because shells striking and penetrating an enemy's ship, and there exploding, would produce destructive effects far superior to those caused by solid shot.

load-water line is 257 feet, her extreme breadth 57 feet 4 inches, and her draught of water 24 feet. The heights of the gun deck-ports above the load-water line are 9 feet forward, and 12 feet aft. Her gun deck-ports are 3 ft. 8 in. long, and 8 ft. 6 in. asunder. Her burthen is 3197 tons. The ship is pierced for 60 guns, but, at present, she carries only 40. On her upper deck she has 2 10-inch pivot-guns of a new pattern, each weighing 107 cwt., and 14 8-inch shell-guns, old pattern, or 56 cwt.; and on her main deck are 24 9-inch guns of 83 cwt.; she has, besides, a few brass guns for boat-service. The 10-inch guns are chambered, and have been proved both with shell and shot; the shells are fitted with time-fuzes. The guns are peculiarly formed, being enormously thick at the breech, where they terminate almost hemispherically; they are well polished, and, instead of beds and quoins, they are provided with elevating-screws. The locks of the guns are on the hammer principle, with a back-spring action. Each gun is provided with 100 rounds of shot, and 150 filled cartridges. The gun-carriages on the main deck have but two truck-wheels, which are in front; and to facilitate the running up of the gun, the after end of the carriage is to be raised by means of handspokes which are furnished with rollers.

Her starboard and port engines have each two cylinders 6 feet diameter, with a 3-feet stroke, and are formed on the double piston-rod principle; these are placed on opposite sides of the shaft, and close to it; each cylinder has its condenser at the side, and the air-pump opposite to it. The steam is cut off, on Stevens' principle. The greatest speed ever attained by the "Merrimac" is said to have been 7 knots per hour, and this was under favourable circumstances.

281. The vast steam frigate "Niagara" was during the year 1857 in the Thames, but devoid of her armament; she appeared to sit gracefully on the water, and the beautiful lines of her dark hull showed themselves to great advantage. Her total length is 375 feet, and her extreme breadth 53 feet 6 inches; her burthen is 5200 tons. She had then on board only 4 small guns; but, when fully equipped, she will carry 12 Dahlgren guns, 11 inches diameter in the bore, and weighing 14 tons; these are to discharge solid shot, each weighing 270 lbs., or shells of 130 lbs., and the former are said to range

7000 yards. It is said that, when fully armed, her draught of water is 25 feet, and that, under sail alone, she can run 16 or 17 knots per hour. Between the bulwarks whispering-pipes are laid from the quarter-deck to the forecastle, by which the orders of the officers can be transmitted with speed and certainty.

This ship has three cylinders, each 6 feet in diameter, with a 3-feet stroke, which are placed on the starboard side, horizontally across the vessel, and the condensers are on the port side: the motion of the pistons being from side to side. The shaft, upon which the whole force is brought to bear, is 119 feet long and 50 inches in circumference. The propeller is of brass, and consists of two fans nearly 19 feet in diameter, with a pitch of 32 feet. There are four boilers, on the vertical tubular principle, and, when working at a pressure of 20 lbs., making 45 revolutions per minute, the power is stated to be equivalent to 2000 horses. The average daily consumption of coals is said to be 50 tons. It is stated that, when fully armed, the crew is to consist of 750 men.

The United States' paddle-wheel steam frigate "Susquehana" was also in the Thames in the year 1857. Her burthen is 2436 tons, with a nominal power of 950 horses. She carries twelve 8-inch broadside shell-guns, each weighing 63 cwt., and 9 feet long; besides these she has two pivot-guns forward, and one aft, each 10 feet 10 inches long, and weighing 105 cwt.; these are to throw 8-inch solid shot.

SECTION VIII.—ON THE STOWAGE OF SHELLS AND THE PRECAUTIONS NECESSARY TO PREVENT ACCIDENTS IN SHELL-FIRING.

282. Great alterations have been made in the armament of the British Navy since the regulation of July, 1848. Shell-guns have been introduced to a much greater extent, and the complements of shells for all rates and classes of H.M. ships and vessels[a] have been considerably augmented, as exhibited in the following table:—

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[a] See statement, No. 128, in the Appendix to the Second Report of the Select Committee on Ordnance Expenditure, 1849.

Number of Shells per Gun or Carronade, supplied to all Classes of H.M. Ships or Vessels of War.

				Per Gun, or Carronade.	
SHELLS filled with Powder and fixed to Wood Bottoms	All Bow and Stern Pivot-Guns			60	
	10-in. Side Guns			40	
	8-in. Side Guns and Carronades	For the first six		40	No more than 500 Shells, 8-in., to be supplied to any one Ship (the difference to be made up in Round Shot*).
		For the second six		20	
		For the remainder		10	
	6-in. or 32-pounder	Steamers, Side Guns, and Carronades		10	No more than 500 Shells, 6-in., to be supplied to any one Ship (the difference to be made up in Round Shot*).
				Total Numbers.	
		Sailing-Ships	First Rates	450	
			Second Rates ("Princess Charlotte" Class)	450	
			Other Second Rates	350	
			Third Rates	300	
			Fourth Rates	200	
			Fifth Rates	160	
			Sixth Rates	120	
			All Sloops	100	
			Brigs, "Espoir" and "Dolphin" Classes, with 3-in. Fuzes only	50	

Note 1.—The following numbers of empty Shells with White Metal Fuzes will be supplied for Drill in addition to the above proportion:—

1st, 2nd, and 3rd Rates	6
4th, 5th, and 6th Rates	4
All other Ships and Vessels	2

Note 2.—When Ships cannot stow all the filled Shells allowed, empty ones are to be supplied to complete the proportion without Boxes, but with the proper number of Fuzes and quantity of Powder. The quantity of Powder required for filling Naval Shells is:—

10-inch	5 lbs. 8 oz.
8-inch	2 lbs. 4 oz.
56-pounder	1 lb. 12 oz.
32-pounder	1 lb.

Note 3.—No Shells for Guns or Carronades of a lower calibre than 32-pounders of 25 cwt. and 17 cwt. respectively.

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* When the proportion of Shells amounts to more than the maximum allowance of 500 of each nature, Round Shot should be substituted for the Shells withheld.

PROPORTIONS OF FUZES, of different kinds, supplied to H.M. Ships or Vessels of War.

FUZES ..	Moorsom's	Three to every four Shells, 10 and 8 in., for Pivot and Side Guns. Two to every three Shells, 6-in., for Sailing-Ships. Three to every four Shells, 6-in., for Steamers.
	Graduated or Time, 3-in.	One to every four Shells for Pivot and Side Guns. One to every three Shells, 6-in., for Sailing-Ships. One to every four Shells, 6-in., for Steamers.
	Spare 4-in.	One to every two Shells with 3-in. Fuzes.
	Metal White, for Drill	One to every empty Shell supplied for Drill.
		But, until the store of Moorsom's Fuzes admits of a larger supply, Fuzes will be issued as under:—
	Moorsom's *	One to every four Shells, 10 and 8 in., for Pivot and Side Guns. One to every three Shells, 6-in., for Sailing-Ships. One to every four Shells, 6-in., for Steamers.
	Graduated or Time, 3-in.	Three to every four Shells, 10 and 8 in., for Pivot and Side Guns. One to every three Shells, 6-in., for Sailing-Ships. Three to every four Shells, 6-in., for Steamers.
	Spare, 4-in.	One to every two Shells with 3-in. Fuzes.
	Short-Range	One to every three Shells, 6-in., for Sailing-Ships.

NOTE.—No Vessel under a Sloop, commanded by a Commander, is to be supplied with Moorsom's Fuzes.

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* The Board's Order of 2nd May, 1853, $\frac{A}{1125}$, directs Moorsom's Fuzes to be supplied to one-half the established number of 10 and 8 in. Shells instead of one-fourth, and 3-in. Fuzes to the other half.

To provide space for the stowage of these increased complements of shells, great alterations have necessarily been made in the internal fittings of all ships and vessels.

283. In line-of-battle ships the shell-rooms for 6-inch shells have been obtained by converting the upper part of the shot-lockers before the main-masts into rooms for their reception. A space about 4 ft. 6 in. deep has thus been taken from the shot-lockers, and appropriated to the stowage of 6-inch shells instead of the shot formerly contained in that space. This arrangement is sufficient to enable two-decked ships to receive their additional complement of 200 6-inch shells; but in three-deckers it is found necessary to make more room by unfixing, emptying, and removing as many of the 8-inch shells as may be necessary—one 8-inch shell occupying nearly as much space as two of the others.

The two 8-inch shell-rooms, in line-of-battle ships, are abaft the main-mast, one on each side of the passage under the scuttle. Over the loaded shells there is space sufficient for a considerable number of empty shells, which may accordingly be placed in compartments on the crown. Shells fitted with 3-inch fuzes are placed in one of these shell-rooms, and those fitted with short-range fuzes in the other. The 4-inch fuzes are considered as "spare fuzes," and kept for distant firing.

DIMENSIONS of the 8-inch SHELL-ROOMS in SHIPS and VESSELS of different RATES, according to Regulation. No two Shell-Rooms are, however, exactly of these dimensions.

Rates.	Guns.	Complement of Shells, distributed equally in two Rooms.	Athwart Ships.		Dimensions Fore and Aft.		Height.	
			ft.	in.	ft.	in.	ft.	in.
First Rates ..	110 to 120	420	9	5	5	2	6	0
Second ditto ..	92[a]	600	12	3	5	2	5	10
	84	360	9	3	5	1	5	10
Third ditto ..	74	200	7	0	5	1	6	1
	70	200	8	3	4	3	5	7
Fourth ditto ..	50	240	8	3	4	3	5	7
Fifth ditto ..	44	100	4	1	5	0	5	4
	36	100	6	0	5	0	5	7
Sixth ditto ..	26	80 In one Room.	7	2	4	7	6	3½

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[a] The 92-gun ship is armed with twenty-four 8-inch guns—the 84 has only eight: hence the difference in the complement of shells, and the capacity of the shell-rooms.

DIMENSIONS of the 6-inch SHELL-ROOMS in SIXTH RATES, CORVETTES, and SLOOPS.

Rates.	Guns.	Complement of Shells.	Athwart-Ships.		Fore and Aft		Height.	
			ft.	in.	ft.	in.	ft.	in.
Sixth Rates ..	22[a]	80 Stowed in two Shell-Rooms.	2	9	4	7	4	3
Corvette ..	18	80	4	3	3	0	5	6
Brig	16	80	4	3	2	6	4	7
Brig	12	60 In one Room.	7	10	2	1	4	9

The dimensions of the shell-rooms in the "London," 92, and "Formidable," 84, are:—

	"London."			"Formidable."	
	ft.	in.		ft.	in.
Height	5	0	.. ..	5	10½
Fore and Aft	2	11½	.. ..	2	8
Athwart-ships	9	0	.. ..	7	10

The two last dimensions being dependent on the size of the shot-locker, no fixed quantity can be assigned to them for other classes of vessels; but it appears that room sufficient will be found in ships of inferior classes, to stow the additional shells in the present shell-rooms, and in the spaces allowed for passages.

The DISTANCES between the Load Water-Line, and the Tops or Crowns of the Spaces allotted for the 8-inch Shell-Rooms, in the undermentioned Ships and Vessels, are—

	Class.		ft.	in.
Caledonia	120	.. ..	6	8
London	92	.. ..	8	0
Formidable	84	.. ..	5	8
Benbow	74	.. ..	4	0
Cumberland	70	.. ..	4	6
Vernon	50	.. ..	7	4
Resistance	44	.. ..	7	0
Pique..	36	.. ..	5	6
Alarm[b]	26	.. ..	3	6
Dido, corvette	18	.. ..	2	10
Bittern	16	.. ..	2	3
Espiègle	12	.. ..	2	10

The water-tanks intervene between the 8-inch shell-room and the ship's side, and should therefore always be kept filled. The

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[a] Old class, carrying only two 32-pounder guns, and twenty 32-pounder carronades.

[b] Besides the "Alarm," 26, we still have a small class of sixth-rates (formerly the 28-gun frigates), which now carry only two 50 cwt. 32-pounder guns, and twenty-two 32-pounders of 40 cwt., and which therefore take a complement of eighty 6-inch shells, instead of 8-inch, as in the cases of the "Alarm," "Vestal," and "Trincomalee" classes.

chain-cables, shot-lockers, and spare hawsers, as well as water-tanks, lie between the 6-inch shell-rooms and the ship's side in these classes, to render the rooms inaccessible to shot.

The shell-rooms in frigates being sufficiently large to receive their complements of 6-inch shells in addition to those of 8-inch, there is no necessity for emptying and removing any of the latter.

The operation of passing shells through the tiers to the main hatchway, in frigates, requires so many hands, and is so slow, that it has been found necessary to make a new scuttle, immediately over the present one, to communicate with the main deck, as in ships of the line, to admit of two shells being passed up at the same time.[a]

Sloops are provided with 6-inch shells only; and, of the established number, one-fourth are fitted with "Short-range Fuzes;" as many are stowed away in the shell-room as it will hold, and the remainder are placed empty in the wings of the bread-room.

The shell-rooms of smaller brigs are constructed in the wings, or spaces on each side of the bulk-heads of the magazine.

DISTANCES between the Load Water-Lines and the Tops or Crowns of the Magazines (Column 1) in the undermentioned Classes of Ships and Vessels, and the difference in feet and inches between the *Heavy* Service and *Light* Service Water-Lines (Column 2)[b].

		1.		2.	
	Class.	ft.	in.	ft.	in.
Caledonia	120	5	6	1	6
London	92	5	6	1	4
Formidable	84	6	0	1	3
Benbow	74	5	6	1	3
Cumberland	70	6	0	1	2
Vernon	50	4	10	1	0
Resistance	44	3	6	1	0
Pique	36	2	4	0	10
Alarm	26	3	4	1	0
Dido, corvette	18	2	0	0	8
Bittern	16	1	9	0	6
Espiègle	12	1	7	0	6

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[a] In the French frigate "Psyche" (see 'French Armament,' in the forthcoming work on 'Shell Warfare') a scuttle is opened in the deck between the guns, through which the shells are handed up, for the service of every piece. (See the new method of handing up cartridges for the supply of the gun-decks, Art. 540).

[b] The figures in the last column denote the "rise" of the respective ships on the supposition that they have exhausted two months' water and provisio —as much, probably, as any British man-of-war consumes before replenishi either water or provisions, unless extraordinary circumstances have prevent the replenishment from taking place.

DISTANCE from the LOAD WATER-LINE to the Crown of the MAGAZINES and SHELL-ROOMS of the undermentioned Screw-Propelled Ships.

Ship's Name and No. of Guns.	Fitted with Dell's Hexagonal Powder-Cases.				Shell-Rooms.	
	After Magazine.		Fore Magazine.			
	ft.	in.	ft.	in.	ft.	in.
Royal Albert, 121	4	10	6	3	5	3
Agamemnon, 91 ..	4	9	5	9	2	3
Majestic, 80 ..	6	6	5	0	6	5
Cressy, 80	4	9	3 5	6 6*	4	3
Tribune, 31 ..	3	3	2	5	5	2

* Before the ship was adapted for the reception of a Screw-Propeller.

In the "Prince Regent," which has lately been armed and fitted to a great extent for shell-firing,* there is space sufficient for the stowage of 740 8-inch shells.

The 6-inch shell-room is before the main-mast, having two doors which open into the main-hold, lined throughout with copper, and 9 feet 6 inches wide, 5 feet 3 inches long, and 6 feet high. The top of the space for loaded 8-inch shells is about 5 feet below the load water-line, or 2 feet below the orlop-deck.

284. To avoid as much as possible the inconvenience and danger of filling and fuzing shells on board of ship they are in general sent on board in boxes, each containing one shell.

The space required for stowage is computed from the dimensions of the boxes (fig. 33), which are as follow:—

	For the 10-inch Shells.	8-inch Shells.	32-pounders.
	Inches.	Inches.	Inches.
Length	12	10	8.2
Width	12	10	8.2
Depth	12½	11	8.8

The bulk of 100 10-inch Shells in boxes is about 87 cubic feet.
" 8-inch Shells " 64 "
" 32-lb. Shells " 38 "

But such is the difficulty of finding stowage for the large equipment of shells in boxes of the above dimensions that it is

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* Thirty-two 8-inch guns of 65 cwt. on the lower deck; thirty-four long 32-pounders of 56 cwt. on the main deck; and twenty-six 32-pounders of 42 cwt. on the quarter deck and forecastle. The lower deck of the "Queen" was, in 1849, armed with 8-inch shell guns, displacing the 32-pounders of 56 or 58 cwt.—Parliamentary Paper, No. 128, 1849. The whole of the lower deck of the "Royal Albert" is armed with 8-inch shell guns of 65 cwt.

proposed to substitute for the boxes a wooden fuze-cover, as represented at AB in fig. 34. For the purpose of carrying or suspending the shell, the cover AB is attached by a rope to the wooden bottom CD; and between these plates the shell is confined, but so that it may be easily detached from them when it is to be introduced into the gun. The height for stowage would be thus reduced from 8.8 inches, which is that of the box, to 7.6 inches; and the breadth from 8.2 inches to 6.25 inches. The French, experiencing the like want of room, propose to suppress the box and to trice the shells to the beams.

Fig. 33.

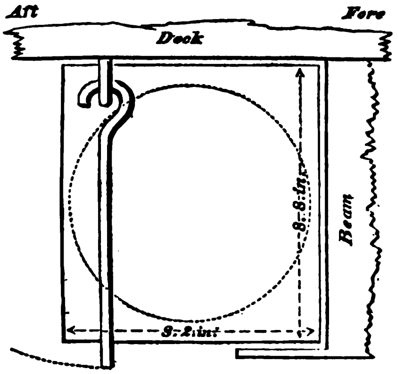
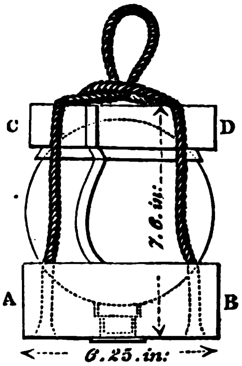


Fig. 34.



285. Wood fuzes having been found perishable, or to deteriorate by damp or heat in the vicissitudes of naval service, and more liable to be accidentally ignited than metal fuzes,[a] all sea-

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[a] The following awful catastrophe occurred on board H.M.S. the "Theseus" in 1799, from the explosion of French shells, fitted, as shells are in that service, with wooden fuzes:—

Captain Miller, when in command of the "Theseus," having a great desire to try the use of shells fired from ships; and having obtained seventy 36-pounder and 24-pounder shells from a French store-ship which had been captured, directed the gunner of the ship to stow them in a secure place; and sometime afterwards, to examine and see that the shells were fit for use. For this purpose the shells were brought up and placed on the quarter-deck.

Whilst the gunner and his mate were so employed, the fuze of one of the shells took fire, the shell exploded, and set off all the rest in quick succession! The ship was instantly in flames, in the main rigging and mizen-top, in the cock-pit, in the tiers, in several places about the main-deck; the whole of the poop and after part of the quarter-deck were blown to pieces, all the booms service shells, before they are shipped, are now fitted with metal screw-fuzes, whose lengths are 4 inches, 3 inches, and 1¼ inch (see figs. 35, 36, 37, opposite), and these are protected by metallic caps.

Exclusive of the advantage of these metallic fuzes, on the ground of safety and that they suffer no deterioration from long custody on board ship, shells fitted with them burst with greater violence than those which have wooden fuzes. The diameter of the fuze-hole for the former being only .9 inch, whilst for the other it is 1.2 inch, the larger tap permits the escape of the charge in some degree; and thus, either the shell is not broken or it bursts with comparatively little effect. An 8-inch shell with a wooden fuze requires a charge of 22 oz. of powder to burst it, but a shell with a metal fuze bursts with a charge of 16 oz.; a 6-inch shell with a wooden fuze requires 14 oz. of bursting-powder, whilst a metal-fuze shell of the same nature requires only 5 oz. A shell with a metal fuze is therefore a much more powerful mine when it explodes on being fired into an enemy's ship than a wood-fuzed shell of the same nature. On all these accounts, therefore, wood fuzes have been abolished in the naval service.

286. To avoid danger in supplying guns with shells, the latter should be brought up in their boxes, the fastenings of which should not even be loosened till the shell is required to be put into the gun, and the cap of the fuze should not be taken off or unscrewed until the shell is actually introduced into the gun; the cap is then removed, and the shell is pushed home, the

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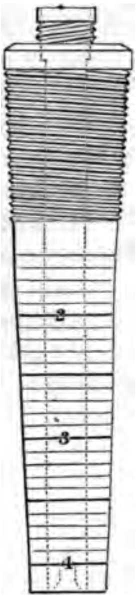
destroyed, and eight main-deck beams broken. Captain Miller, the gunner and his mate, and 32 men were killed; 42 men were wounded; 9 men jumped overboard and were drowned. The ship was reduced to a perfect wreck, and nothing but the great exertions of the surviving officers and crew saved her from total destruction.

Shells fitted with metallic fuzes are not liable to such a deflagration as this; yet it appears (Charpentier, 'Essai sur l'Artillerie de nos Navires de Guerre,' p. 167) that the French, notwithstanding the fragility of wooden fuzes, their liability to break in the gun, the perishable nature of wood, the chemical action of the composition, and the difficulty of preserving them from humidity on board a ship, prefer wood to metallic fuzes; their argument being that these are conductors of heat, which wood is not, and are raised to such a temperature by the inflammation of the charge, and the ignition of the priming and contents of the fuze, as to set fire to the powder with which the fuze is in contact, before the shell arrives at its destination.

rammer-head having a cavity in it to receive the head of the fuze, and thus protect the priming from contact with the rammer.

The precaution of not unscrewing the cap of the fuze till the shell is in the gun is of the utmost consequence. A terrific accident occurred in the shell-room, or on deck, on board H.M.S. the "Medea," by the ignition of a fuze in unscrewing the cap (Arts. 263, 269), and the like accident occurred on one other occasion.[a] The screws have since, as a preventive, been fitted on the outside of the fuze (see fig. 38), and this method has been found to succeed.

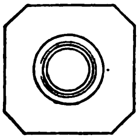
Fig. 35.



4-inch or Spare Fuze.

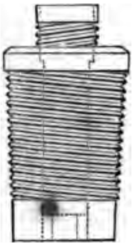
Fig. 36.

3-inch Fuze.

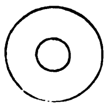


Plan.

Fig. 37.

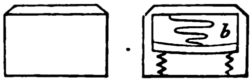


Short-Range Fuze, 1¼ inch long.

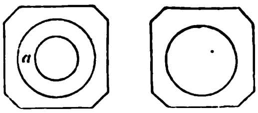


Plan.

Fig. 38. Cap.



Elevation. Section.



Plan of the Top. Plan of the Bottom.

The Caps for Short-Range Fuzes have a ring turned on the face, as at *a*, which is filled with red sealing-wax: the other caps are quite plain. Each cap has a brass wire spring, and a piece of buff leather in it, as at *b*, to keep the priming in its place.

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[a] While the crew of the "Hogue" were being exercised at Plymouth, one of the men, in taking the cap from off the fuze of an 8-inch shell, turned the screw the wrong way, by which the fuze itself became unscrewed; the consequence was that, when the shell was fired, it split the gun (one of 50 cwt.) near the muzzle in three places. Such an accident having occurred in a mere experiment, and with trained seamen-gunners, what dangers may not be apprehended in a naval action, and, through our insufficiency of skilful bombardiers, with men imperfectly trained?

287. As it may not be practicable to bring up shells from the shell-room rapidly enough for quick broadside firing after an action shall have commenced, two or three shells per gun, enclosed in their boxes (fig. 33,) or fitted with fuze-covers (fig. 34, p. 287), are, before going into action, placed on shelves behind, or triced to the beams of the fighting-decks amidships; the reason given for this arrangement is that shells so placed are less exposed to the danger of being struck by the enemy's shot, than in any other position on the deck.[a]

288. Quick broadside shell-firing will not in general commence till the distance is within that which admits of the short-range fuze being used, viz. 600 yards, for if the firing commence at great distances, it would be necessary to begin with the 3-inch fuze, and then change to the short-range fuze; or, if the distance be much greater, to commence with the 4-inch fuze, then change to the 3-inch fuze, and ultimately to the short-range fuze; but any change made in the class of fuze in action is highly inexpedient, and should be avoided, if possible. If, however, ships are furnished with so large a supply of shells as not to be obliged to reserve them for close action, shell-firing may commence with 8-inch guns as soon as the ship gets within the distance corresponding to the time of the 3-inch fuze, viz. at 1,800 or 1,900 yards. In such cases, officers must bear in mind that the necessity of a change in shell-firing, from one class of fuze to another, is as great as that of the change from one

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[a] By a recent General Order, issued to the fleet in the Baltic, the number of shells to be placed on the fighting-decks of ships going into action is increased from four to five; the whole to be ranged on the opposite side to that engaged; and cases of reserve ammunition hung up amidships ready at quarters. This increase in the number of loaded shells and cartridge-cases will multiply, in proportion, the chances of shells being struck and exploded, and of ammunition being ignited. Nor does this arrangement appear to be preferable to that of stowing shells amidships on shelves behind the beams; for the side not engaged at the commencement of the battle may suddenly require to be manned for action on that side, alone, or on both sides at the same time; which, in either case, will necessitate the immediate removal of the shells from the side not originally engaged. It may therefore be inferred that the action thus to be prepared for is such that one side only will be required for action; and this can only be in the attack of fortresses or other stationary objects, when each of the attacking ships shall have taken a fixed position in which to bring the guns of a single broadside to bear on the object of attack; but, in so far as the attack may be against walls of stone, shells, as *has* been already observed, had better remain in the shell-room.

charge of powder to another, and may be made with equal facility.

289. From the difficulty and inconvenience there would be, in action, in reducing the lengths of fuzes or the times of their burning, in order to suit the distances at which shell-firing may be carried on as vessels approach each other, time-fuzes have been divided into three classes, as stated in Art. 285. By this very necessary arrangement the inaptitude of time-fuzes to horizontal shell-firing is in some degree remedied; for although, in changing the class of the fuze, it is theoretically true that a jump is made from one class to another in respect to time, without relation to other circumstances, and that there is obviously a large margin for error in taking any one time-fuze as constant when all other circumstances, as distance, charge, elevation, and actual time of flight,—to all of which the fuze should be nicely adapted,—are variable, yet practically this classification is an important element in the use of time-fuzes. Where the 4-inch fuze of 20 seconds ceases to be suitable, the class of 3-inch fuzes of seven seconds and a half comes into use; and when the distance of 600 yards is attained, the short-range fuze takes the place of the other. Shells fitted with any one of these different fuzes are calculated to range the corresponding distance with the lowest charge before exploding. At shorter distances, shells so fitted might penetrate both sides without exploding. In Table I., Appendix B., the times of flight have been made intentionally longer than are strictly necessary, by $\frac{1}{4}$ of a second, to obviate any risk of the explosion taking place before the ship fired at is struck. Should the explosion take place prematurely, it is obvious that the projectile would be lost both as a shot and a shell. This quarter of a second would allow for any little error that might exist in the fuze from a defect of length. If the fuze be too long the error is of less moment, since there would be at least a tolerable certainty of the shell exploding soon after striking, from the shortness of the column of composition then remaining unconsumed.

290. The 4-inch fuzes, fig. 35, are driven with fuze-composition, and are intended for distant firing; their full time of burning being twenty seconds. They may be cut off, or bored into, or reduced with the slitting-saw, or bored up with the fuze-

auger as occasion may require; but it must be observed that if the 4-inch fuzes are cut into with a slitting-saw very deeply, the lower part of the fuze is liable to be broken off by the concussion of the charge; the composition may then be disturbed, and, consequently, premature explosion may take place.

The 3-inch fuzes, fig. 36, are driven with mealed powder; their time of burning is seven seconds and a half; they are not to be cut off, but may be bored into, or down, from the top, when to be used for distances under 1900 yards. The 1¼ inch, or short-range fuze of .35 of an inch of fuze-composition, fig. 37, is, with the priming, intended to burn a short two seconds.

Metal screw-fuzes possess this great advantage, that they do not protrude so much as common fuzes above the surface of the shell, and, being firmly screwed into it, they are not so liable to be broken or knocked out, either in the gun or on striking and passing through a ship's side.

291. To ascertain the comparative capability of shells having metallic screw-fuzes, with metallic caps, to resist the explosion of a contiguous shell, nine shells so fitted were placed in a pile, and one of those most covered by the others was exploded. None of the fuzes of the other eight shells were ignited by the explosion, as undoubtedly would be the case with shells having common wooden fuzes with canvas caps.

From the above experiment it was concluded, that shells fitted with metallic fuzes would be proof in all cases against the explosion of a contiguous shell; but it appears, by subsequent experiments, that this is not an invariable fact. It is now known that any loaded shell at rest, when struck by a solid shot, fired with even a moderate charge, from a sea-service gun, will be exploded; if not with as much violence as when burst by its own fuze, yet with force sufficient to scatter in every direction, and to considerable distances, any other shells that may be placed together.

Sixteen shells were piled on the top of each other, on the mud, about 40 yards from the "Excellent," and fired at with a solid shot from a 32-pounder gun of 56 cwt., charge 6 lbs.; the result was, that the shot, on striking the shell, broke it, exploded the powder it contained, and scattered the other shells in every direction. Nine were driven into the sea, the rest into the mud, and could not be found. It was "*thought*," but this is not certain, that only the shell that had been struck exploded. This experiment was repeated with the like result.

"It follows," states the Report on this experiment, "that a shot will explode a shell on striking it; and although with less force than in the ordinary manner, yet sufficiently so to render such an explosion disastrous: consequently great care should be taken in action to expose shells as little as possible."

292. To account for the explosion of a shell on being struck by a shot, it has been surmised, that the shot first breaks the shell, and in doing so, elicits a spark which fires the bursting-charge contained in it.

There is reason to doubt this. The powder which the shell contained, exploded, according to this supposition, when in a state of dispersion; it could not therefore have strength sufficient to scatter the other shells in every direction, so far and so forcibly as in the experiments by which that effect was produced. The only rational way of accounting for this fact is, that the powder contained in the shell was ignited contemporaneously with, or at least instantaneously after, the breaking of the shell by the blow; and this could only be by the powder in the shell having been exploded by the percussion. This will also account for the detonation being less than usual, while the force of the explosion was still so great as to produce the above-mentioned effects.

293. The direct and secondary effects produced by firing a solid shot into a pile or mass of shells, were first exhibited in Holland by the following experiments, to ascertain whether the effects that might be produced in a ship in action, by a shot striking a rank or pile of shells, were as destructive and serious as the author had stated in Art. 252 in the third edition of this work.

For this a pile of 430 shells in their boxes, ranged three deep, was fired at with solid shot at a considerable distance. At every round that hit, 3 or 4 of the shells were broken, and their contents exploded, without the usual "report," but with sufficient violence to derange the whole mass, and to set fire to the fuze of a shell which had not been struck: by which *contre-coup*, the shell exploded with its full force!

294. These results being far more formidable and alarming, than those obtained from the previous experiments (Art. 291), by which the explosion of a shell on being struck by a shot was fully proved,[a] the author deemed it his duty to communicate to the First Lord of the Admiralty this confirmation of the apprehensions which he had long entertained of the extreme danger of stowing ranks and multiplicities of live-shells on the fighting-decks of ships in action; and he strongly recommended that a course of experiments, similar to those made in Holland in 1852, should be undertaken at Portsmouth, to try whether it is safe and prudent to leave in force the regulation which prescribes that all ships on going into close and the closest action should have two shells (increased to five by a late regulation, Art. 287, Note) per gun of every nature and description, placed, ready for use, on their fighting-decks. This was accordingly done. The author did not attend the experiments, but the following are the results as communicated to him by several naval and military officers, his friends, who were present; and for the accuracy of which he can vouch.

A mass consisting of sixteen 32-pounder 6-inch shells, in their boxes (fig. 33), some fitted with 3-inch, others with short-range metal fuzes (figs. 36, 37), were piled in three tiers, one above another, but only one tier deep (so that no more than one shell could be struck by the same shot): the mass was then fired at with a solid shot from a 32-pounder gun of 56 cwt., with a charge of 10 lbs., at about 60 or 70 yards' distance. The shell struck was broken to pieces, the powder it contained exploded, as in the preceding experiments, without much detonation, but with force sufficient to demolish or injure many of the adjoining boxes, to break the strappings by which the shells were fixed to their wooden bottoms, and to scatter the shells in various directions to different distances. These were the immediate and direct effects. The secondary effects were, that the fuzes of two shells which had not been struck were ignited, though capped, by the explosion of the shell which had been hit, and

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[a] It was thought at the time that this explosion produced the secondary effect of exploding a shell which had not been struck directly; but the explosion of the latter shell was caused by the ignition of its own fuze.

both burst with full force! A large splinter passed over the ship from which the gun was fired, 60 yards distant from the mud bank on which the shells were piled, and fell within the dockyard. Thus the blow of one shot caused, directly and indirectly, the explosion of three shells! The experiment was repeated with the same results upon the pile; the secondary effect was the explosion of one shell by the ignition of its fuze.

To try whether 8-inch shells or hollow shot are as liable to be broken by the blow of a solid 32-pounder shot as the 6-inch (32-pounder) shells in the previous experiment, a number of 8-inch empty hollow shot (unloaded shells), in boxes, were piled in three tiers, and fired at with a solid shot from a 32-pounder gun of 56 cwt. with a charge of 10 lbs. Two of the hollow shot were broken into pieces, some of the splinters were driven forward to a distance of 500 yards; the remaining hollow shot scattered in every direction, though to no great distance, but all the boxes were broken or much injured.

Had the empty hollow shots been loaded shells, the powder contained in those which were struck would have exploded with greater force than the 6-inch shells, in proportion to the cubes of their respective diameters, and the effect upon the other shells, in driving them out of their boxes, scattering them about the deck, and igniting the fuzes of shells not struck, would evidently have been far more serious than in the preceding case. The object of the experiments being to ascertain the amount of danger produced by solid shot striking shells, the greater as well as the minor effects should have been tested; but this not having been done, the experiments were imperfect with respect to the former object: this may, however, be pretty accurately deduced from the results obtained in the case of the 6-inch shells, which show how much more formidable and disastrous the like trial against the same number of 8-inch live-shells would have been.

295. Shells fitted with short-time fuzes frequently act by concussion, from the column of composition being dislocated on the shell striking the side of a ship; in this case the explosion is almost instantaneous, and the effect very destructive. The displacement of the fuze-composition in the gun by the shock of the discharge is prevented with considerable certainty by an

ingenious contrivance, adverted to in Art. 265, Note [a], p. 258, which gives to the short-range fuze a high degree of value in horizontal shell-firing.

296. To obtain the advantages specially, which the short-timed fuze gives incidentally, the production of a good and efficient percussion-fuze, which should fulfil all the conditions stated in Art. 269, would, it was considered, be a most important discovery for horizontal shell-firing. For the attainment of this end, efforts displaying *great ingenuity* have long been making with every prospect of success by an able and accomplished officer, Captain Moorsom, of the Royal Navy, in his percussion-fuze, which being intended to explode on striking a sufficiently resisting body, may be used at any distance, and the fuze having no other cap or cover then a kitt plaster, which need not be removed when the shell is put into the gun, the loading is performed as simply as with a shot, care being taken, however, to enter the shell with the fuze outwards, lest the explosion of the charge should damage it; and that the rammer-head should be made slightly concave with a hole in the centre, to receive the head of the fuze (for it does protrude a little, at some sacrifice of accuracy in the flight of the shell), to protect the fuze from injury in ramming home.

297. It was generally imagined, and such was the author's opinion, that percusssion or concussion shells would be more liable to explode by the action of their fuzes, if struck by shot, than common shells; on the principle that a body made explosive would, on striking a resisting medium with a sufficient amount of force, be as likely to explode as if, being at rest, it were to receive the blow of a shot moving against it with the same momentum. But this does not appear to be the case; whether it arises from the circumstance that a percussion-shell is so contrived as to resist the shock produced by the firing of the charge, and to require, in order to be exploded, a second shock—that of impact; or that a shell, when struck by a shot, is broken before there is time for the percussion principle to act, is doubtful. This, at least, is proved, that percussion-shells are not less liable to have their contents ignited or exploded by the blow of a shot than common shells; for all loaded shells, however they may be fuzed, or if not fuzed at all (the fuze-tap being

stopped by an iron plug), will be broken by the blow of a solid 32-pounder shot, fired even with a reduced charge of 6 lbs., as in the experiments of 1847; and in every case their contents will be exploded, as was fully proved by the experiments of 1853, in which a solid 32-pound shot, fired into a mass of 70 or 80 percussion-shells, broke four of them and ignited the powder they contained, deranged the whole mass down to the lowest tier, and displaced many of the shells from their cases. It was also found that when a percussion-shell struck a percussion-shell, both were broken, and the charges which they contained exploded.

298. Were shells stowed according to regulation, or distributed throughout the fighting-decks in positions deemed least accessible to shot, the extreme cases stated in the preceding account of the experiments, in which the shells were piled or massed together, could scarcely happen. The chances of shells being struck by shot will depend, first, upon their number and the positions in which they are placed on going into action; secondly, on the number, which must be brought up in quick succession after the action has commenced, and, again, upon where they are placed. The complements of shells for all ships and vessels have been so largely increased since the publication of the third edition of this work (see Art. 282 of the present edition), that great difficulty has been experienced in providing shell-rooms sufficiently capacious to contain them, and in distributing throughout the fighting-decks the large number required for immediate use, in positions the least liable to be struck by shot.

The method proposed in the Report on the experiments of 1847, Art. 291, is to trice the shells close up to the deck between the beams amidship, inside a fore-and-aft carling, in which position it is stated that the shells can only be struck by shot coming in at right angles to the side of the ship.

By the method now in use (*Admiralty Order of the 8th December*, 1849) two shells for each gun are placed in boxes on shelves between the beams (fig. 33, page 287), in which position, it is stated in the instructions for shell-firing, these can only be struck by shot coming in at right angles to the keel—that is, as admitted in both methods, when the antagonist ship is abeam, which is precisely the position for action in which the shells are most exposed to be struck.

299. The figures 39, 40, 41, opposite, show the method of stowing filled shells, two for each gun, on the lower, middle, and upper decks of the "Royal Albert."

Fig. 39 is half of the athwartship section, showing half the beam from the middle line of the ship; the live-shells there represented being two for each gun on that side. The like supply of shells for the guns on the other side being in like manner placed on shelves behind the other half of the beam.

Fig. 40 is a transverse section of the beam, the shell being placed behind it.

Fig. 41 represents on a smaller scale an entire beam with four shells behind it, from which it is plain that there are as many ranks of shells, consisting of four in each rank, as there are guns on a side, all exposed to be struck by broadside fire from an antagonist ship.

In addition to this supply of shells, the fore and main hatchways are fitted with shelves inside, by, and above the *combings*, upon which twenty-four shells in their boxes are placed. The main hatchway, containing the shells for the aftermost guns; the fore hatchway, those for the foremost quarters; the shells being, it is said, somewhat protected from shots coming in *abeam*, by the sides of the hatchway, and from raking shot, either before or abaft, by the beams between which the hatchways are placed. In the directions for thus filling the hatchways it is enjoined that the boxes should be placed as low as possible, the better to protect the shells; but it is found that this alone is not sufficient to protect the tops of the shells, at least 6 inches of the boxes being exposed.

300. In a recent regulation drawn up by Admiral Chads, and adopted by a General Order, the complement of shells on the fighting-decks, on going into action, is increased from 4 to 5 per gun; so that in a ship's battery of 15 guns on each side, there will be 75 shells.

301. Applications having been made to the Admiralty in 1858, to increase the number of live-shells stowed on the fighting-decks of ships, from 2 or 3 to 10 shells per gun, and to equip the "Diadem" and other vessels in this manner, the

Admiral Commanding at Portsmouth—in transmitting to the Admiralty the Report of the Committee to which that proposition had been referred, and with which they had generally concurred—strongly recommended their Lordships to consider attentively the results of the experiments at Portsmouth (Art. 294), and

SKETCH showing the Method of securing FILLED SHELLS against the sides of the *beams*, *two for each* GUN, on the Gun Deck, the Middle and Upper Decks, of the "Royal Albert."

Athwartship Section.

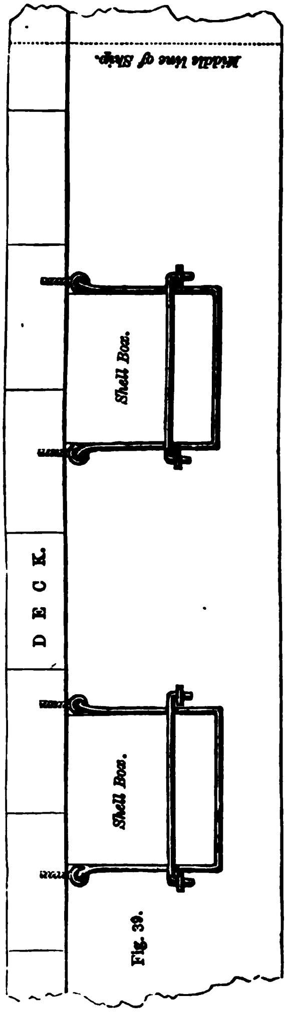

Fig. 39.

Transverse Section.

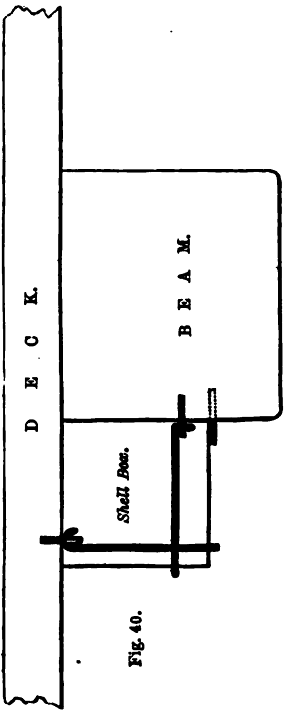

Fig. 40.

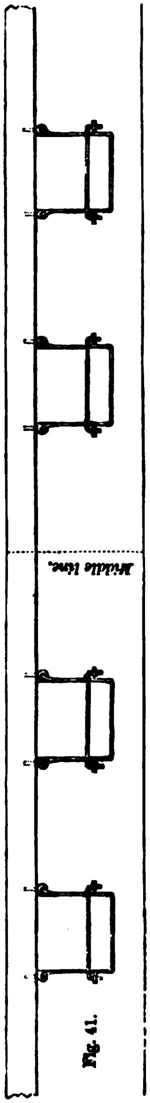

Fig. 41.

the observations made by the author (see Arts. 304, 309, 320 of the present edition), before their Lordships should come to any decision on the subject.

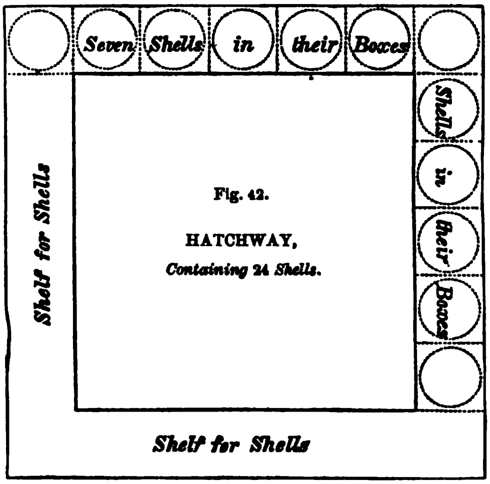

Fig. 42.

HATCHWAY,

Containing 24 Shells.

In reply to the recommendations of the then Admiral Commanding at Portsmouth, experiments were ordered to be made at Cumberland Fort, in June 1858, to ascertain whether percussion-shells struck by 32-pound solid shot explode, in like manner as time-fuzed shells, as proved in the preceding experiments; and moreover to ascertain whether any percussion-shell, which had not been struck, might not have become dangerous, by the shock it had received by the explosion of the charge in the gun having performed that first alteration in the shell which makes it explosive by any subsequent adequate shock.

The first trial was made by firing a 32-pound shot at 40 percussion-shells in their boxes arranged in three or four tiers. On the first trial, two shells exploded; three in the next trial, and all the boxes destroyed.

To ascertain whether any such alterations had taken place in the internal condition of the shells which had not exploded, several of those which had been contiguous to the shells which had exploded by the blow of the shot were fired from a 10-inch shell-gun, with the ordinary charge. The result was that several of those apparently uninjured shells exploded at the muzzle of the gun, by the shock they received from the explosion of the charge. This proves that percussion-shells do undergo a change from the shock occasioned by the explosion of a contiguous shell, and so become explosive by any adequate second shock. It would therefore be fraught with danger to infer that percussion-shells, which had resisted a first violent shock, were sound and might with safety be stowed on the deck, and efficiently used by the double action being unimpaired. There is therefore a peculiar hidden and treacherous character in percussion-shells, which consists in an uncertainty as to whether they may not have been rendered explosive by some previous shock. The proof to which percussion-shells are subjected, by being let fall from considerable heights upon masses of stone or metal, only shows that they do not explode by the first shock, but become explosive by any adequate shock or concussion to which they might be thereafter exposed in the course of service.

302. When the action commences, the shells, triced to, or placed behind, the beams, are used first; then the shells in the hatchways; and, in proportion as they are expended, supplies must be brought up in quick succession, to enable the battery to keep up quick shell-firing; for if this be interrupted, from want of shells, the guns must be loaded with shot, which, requiring an alteration in the elevation used in firing shells and a different charge of powder, would be extremely disadvantageous. The supplies of shells brought up from the shell-room, during the action will neither be triced up to, nor be placed on the shelves behind the beams; but will be placed on the deck, behind each gun. This circulation of the shells, and manner of placing them, is a new condition of the case, in which it is impossible to compute, by the doctrine of chances, how many may be struck by shot, but every shell put into the guns will have to undergo that ordeal; and it appears to be impossible that they should all escape. The complements placed on the decks are so large, that they cannot be dispersed and isolated: some must be grouped together. Those in the hatchways are in mass; those behind the beams in ranks: and it is vain to suppose that either a "carling," or a "combing," or a beam, can protect the shells from the impact of solid shot, capable of

perforating any beams, or of penetrating from 22 to 48 inches into sound oak (Art. 161). The expedient of stowing twenty-four live-shells in the fore and main hatchways, is, in fact, to establish two *expense* shell-rooms on every fighting-deck! Surely that is a desperate measure. And is not the contraction of such an important thoroughfare extremely objectionable? It was an invariable rule of the service, and for very sufficient reasons, to batten down the hatchways before going into action, leaving only the scuttles, through which ammunition was handed up.

The question tried and solved by these experiments is one of fact, and not of chance. It is no doubt possible, but very improbable, that in a ship in action, or a target hulk, having on her fighting-decks the regulated number of live-shells, &c., no shell may be hit, and consequently no explosion of this description take place; but it does not follow that there is no danger of such a catastrophe: one ship in a fleet might escape the danger, whilst another might have twenty of her shells struck, and exploded. The author founds his conviction upon no theory, but upon well established facts: he thinks he will be considered, from this, and his other practical works, to be a practical man; or, if a theorist, that it is on matters of exact science, that admit of no mistake. Those are theorists who would disregard the facts of the case, and stake the results upon the most uncertain of all theories—the doctrine of chances.

303. The preceding experiments are sufficient to account for the frequent explosions of grenades, collected in the tops of French vessels in action, to throw down upon the decks of their enemy's ship:—"In the action with the 'Hoche' and her consorts (1798) a shot from the 'Foudroyant' struck the 'Bellone's' mizen-top, and ignited some hand-grenades which had been placed there for use against the enemy; these set fire to her rigging and sails, and, but for the prompt exertions of the crew, would have burnt the ship."—James' 'Naval History,' vol. ii. p. 130.

304. When the shell system was first introduced in the French navy, and imitated in that of Great Britain, it was asserted there, and believed here, that loaded shells were liable to no such accidents as those demonstrated in the preceding experiments: for that gunpowder contained in iron shells, *globes de fer*, must, it

was said, be less dangerous than powder enveloped in bags of serge;[a] that no danger was to be apprehended from the accidental ignition of a fuze well luted, the shell to which it is attached being, moreover, shut up in its case, and deposited in the shell-room; and that hundreds of shells might be placed there with far less danger than as many barrels of gunpowder, which we are habituated to place in ships' magazines.[b]

But it has since been abundantly proved, that these opinions and assumptions—for such they are, never having been verified by actual experiment—are utterly erroneous; for powder contained in an iron shell placed upon the deck of a ship in action, is by no means so safe as a cartridge. In the one case the blow of a shot explodes the contents of the shell with great force; whereas, in the other, it only breaks the cartridge and scatters the powder. It appears, too, that fuzes, however well capped and luted, may be ignited by the explosion of a contiguous shell when struck by a shot. One should, therefore, have thought that strict attention ought to have been paid to the regulations, enjoined in the French navy, and likewise in ours, viz.: that shells should be stowed away in the shell-room, as soon as they are shipped, and there remain untouched until required to be put into the gun; that no shells should upon any account be placed anywhere else, and that shell-firing should be confined to shell-guns (Art. 286). But the reverse has been done. Vast numbers of live-shells, increased by a late regulation from 4 to 5 per gun, are accumulated on the fighting-decks of ships in action. Shell-firing, at first the exception, is now the rule in the British navy; and in all other respects the precautions deemed indispensable, before these dangers were known, are now either relaxed or abandoned, notwithstanding the proofs which have been given that those dangers exist.

305. The moral effect produced upon the crew of a ship in action, by the unexpected explosion of one of her own shells,

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[a] "La poudre, enfermée dans des globes de fer, sera évidemment moins exposée aux accidens que celle qu'on emploie dans des barils de bois ou des gargousses de serge."—*Paixhans*, p. 84.

[b] "En résumé: quelque centaines de bombes à bord, bien lutées et encaissées dans leur soute, seront infiniment moins dangereuses que les centaines de barils de poudre auxquels on est habitué."—*Paixhans*, p. 86.

would naturally be far greater than that occasioned by the explosion of an enemy's shell: a contingency which the crew must be prepared to expect. It has been well said, by a gallant naval officer, that the panic occasioned by the explosion of one of her own shells on the fighting-deck of a ship in action, would be greater than that produced by the bursting of one of her guns, and what *that* is, we know by the effects produced by the bursting of a gun on board the "Redoubtable" at Trafalgar; the "Isis" at Copenhagen; the "Cæsar" on the 1st of June, 1794; the "Ambuscade" in action with the "Bayonnaise;" the "Princess Royal" at Toulon; the French gunnery-ship "l'Uranie" in exercise in 1852, &c. &c. The effects upon the material of a ship produced by the bursting of a shell are shown in the case of the "Medea" (Art. 286), and the experiments mentioned in Arts. 291, 294.

The worst enemy to be dreaded in naval action is internal explosions; panic is the invariable accompaniment of them. The great object sought to be attained in all the improvements in the material and service of naval artillery, has ever been the prevention of accidental explosions of powder in ships during action, and security against fire. For this the flannel cartridge was introduced, in order to avoid the danger of pieces of a paper cartridge—lurking in the gun, or flickering about like touch-paper between decks—being brought in by the wind after the gun is fired, or by indraughts of air through the ports. For this, also, was introduced the quill-tube, in order to get rid of the priming of loose powder; and the lock, to banish the lighted match. In former times no ship was allowed to fire a salute, far less to go into action, until all the fires had been extinguished.

By a wise and resolute disuse of hand-grenades in the tops; the avoidance of all firing from aloft among the sails; by careful inspection on the part of the officers; and, in general, a wholesome dread of all incendiary projectiles from which the French suffered so severely during the late war, our ships have been more free from accidental fires than those of any other nation, and there is no instance on record of an English ship of war blowing up in action, during that protracted period.

But now receptacles (shells) containing gunpowder, infinitely more dangerous than cartridge-cases, and these, to boot, are accumulated on the fighting-decks of ships; and, with respect to fire, actions will now be carried on in the midst of heat and smoke mingled with sparks, in steam-propelled ships, particularly on the upper decks; and this, with every respect and value for the introduction of that giant power so successfully applied to the propulsion of ships of war, adds unquestionably a new element of danger arising from fire, which demands more than ever the utmost precaution to expose as little as possible any explosive or ignitable bodies upon which it might act. From this, together with other dangers and contingencies relating to their machinery, it has been truly said, "that steam-vessels, compared with sailing-ships, have vastly more vulnerable or vital points than they, and far more to dread from fire."—'Report on the National Defences of the United States, 1852.'

306. The author has considered attentively the numerous instances which are to be found in naval history of the panic which is invariably created by any unexpected catastrophe of the description above alluded to. Suppose a ship having vast numbers of live-shells on her decks to take fire, either in action or not; what is to be done? The magazine may be flooded, and the powder immediately rendered innocuous; but the shells, whether in the shell-rooms or on the decks, are impervious to water. Those in the shell-room cannot be got at, or at least got out in a hurry; those on its decks should be immediately thrown overboard; but all this can scarcely be expected of a crew in a state of panic. In the case of the "Ajax," even without the presence of these terrible agents, on the alarm of the ship on fire being given, 380 men jumped overboard, and 250 of the crew perished. (James' 'Naval History,' vol. iv. p. 301.)

307. There can be no doubt, that if a solid shot were to penetrate into a shell-room with much force, and strike a row of shells, as in the Dutch experiment mentioned in Art. 293, and in those of 1853, there would be an end of that ship. Is it quite certain that the shell-rooms of ships in general are sufficiently below the water-line to be perfectly secure against such accidents? Their crowns should be, at least, six feet below the load water-line ('"Excellent" Experiments,' No. 10, pp. 22, 23). Are they so in all cases? It appears from the table given in

Art. 283 that, excepting in first and second rate ships, the crowns of shell-rooms are not so much as six feet below the load water-line, and still less are they below light water-line: in all smaller vessels, down to the lowest class, the shell-rooms are less and less safe. It must be remarked, likewise, that when a ship in action heels off from her enemy, as when fighting her weather-guns, she exposes much of her side between the actual and general water-line; also when she heels towards her enemy, her deck may be penetrated by shot; and again, when engaged at a considerable distance, a shell, fired at a high elevation, may descend upon her deck. The author saw a shell fall upon the deck of "L'Aigle," British frigate, when in action in the Scheldt in 1809; it penetrated into her bread-room, and there exploded within a mass of bread in bulk. Had the bread-room been a shell-room there would have been an end of her.

308. Nor can the crowns of shell-rooms or magazines be lowered in steam-propelled ships in particular; for so much space is occupied by the engine (the great object being to keep this entirely below the water-line) that it is not possible to stow the large complement of shells, under a less height. In order, therefore, to provide sufficient space for the stowage of shells, their rooms must be made proportionally longer. Hence the necessity of making ships of greater length is mainly attributable to the vast capacity required for the stowage of shells, each of which being placed in a rectangular box, absorbs a very large portion of the interior of the ship. Powder, packed in hexagonal cases, is stowed compactly and with no loss of space.

309. It was first enjoined peremptorily, by regulation, that shells should always be stowed as far as possible from the sides of a ship; but live-shells are now stowed in increased numbers on the fighting-decks of ships, either on shelves between and near to both sides of the deck, or massed on the side opposite to that engaged.[a] So that, in the first case, a shot might strike and explode a whole rank of several shells; and, in the latter case, strike a mass of shells so placed. These regulations cannot be all right or rational. The discrepancy between the former rule (Art. 286) and the recent regulations is most alarming as to the

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[a] See New General Order, June, 1854.

future, and the author, being certain that the original precaution was well founded, while the relaxation is perilous in this respect, as well as in others, strongly urges the necessity of a return to the first method, confirmed as its advantages have been, by the results of experiments, which concur in proving the danger of stowing live-shells anywhere but in rooms appropriated for their reception.

310. The French, as well as ourselves, have long been experimenting on percussion-fuzes, and appear, from what is stated by M. Charpentier and other authors, to have brought an instrument of that description to perfection in the Billette shell.[a]

Thus it appears that the naval forces of the two great maritime Powers are both provided with appalling weapons of mutual destruction, and were prepared, if unhappily there had been occasion, to use them, *à outrance*, against each other's ships, in a barbarous and ignoble strife, in which it seems the only question is, which shall be burnt first! We know the dangers of the shell system, and it is our duty to provide against them. The French, it should be observed, experienced very numerous terrific proofs of the treacherous and suicidal effects of incendiary and combustible projectiles in action with our ships and fleets in the course of the war of the Revolution; a detailed account of these will be given on a future occasion. It is sufficient for our present purpose to state, that, exclusive of numerous comparatively trifling explosions, "Qui s'est trop souvent renouvelé dans la longue et funeste guerre de la Révolution,"[b] four or five ships of the line, six frigates and smaller vessels, were either burnt, blown-up, or so terribly damaged by their own incendiary and combustible weapons, as to be incapable of further resistance,

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[a] "Les boulets creux employés sur la flotte doivent désormais être assujettis au mécanisme percutant, de l'invention de M. le capitaine de corvette Billette. Nous avons dit les raisons que ne nous permettant pas de nous étendre sur ces projectiles, d'invention nouvelle, raisons que le lecteur saisira aisément."—'Essai sur le Matériel de l'Artillerie de nos Navires de Guerre,' p. 164. M. Billette had previously applied the fulminating principle to the ignition of the fuzes of sea-service grenades, to be thrown by hand, or tossed by *bracelets* (a sort of sling, one end of which is strapped to the right arm of the user) from the tops of French ships on the decks of the enemy's vessel; and all French ships of war are now largely supplied with these incendiaries, viz., ships of the line with 300, and frigates with 250 and 170, according to their classes.—*Charpentier*, p. 174.

[b] *De la Gravière*, vol. i. p. 97.

without injuring or destroying one of ours; and that in those awful catastrophes many hundreds of Frenchmen perished; whilst numbers of those who threw themselves into the sea to escape the fury of a more relentless element, were rescued from a watery grave by the humanity and intrepidity of British seamen,[a] who in the heat of action, at great risk to themselves, and with some loss in killed and wounded, succeeded in their humane attempts.

311. We feel deeply sensible of the atrocious character which such a system of warfare must assume, and in which we may be involved; but the adoption of that system by us will cast no slur upon our national character, for self-defence is the first law of nature, and the first duty of nations; and we are provided with abundant means to try the shell system in war, if unhappily it should be forced upon us. But are we quite prepared, in all respects, to carry out the incendiary system on equal terms with those from whom we have to a great extent already imitated it? The French naval shells contain incendiary bodies,[b] which, when ignited by the bursting of the shell, are scattered about in every direction, burn with far greater intensity than *la roche à feu,*

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[a] In the action of the 13th July, 1795, the "Alcide," 74, set fire to herself with her own grenades. Of the 615 men on board, 300 were saved by the boats of the British ships. (*De la Gravière*, vol. i. p. 97. James' 'Naval History,' vol. i. p. 271.) The "Achille," at Trafalgar, set herself on fire in the same manner, when closely engaged with the "Prince." "As soon as Captain Grindall perceived that his opponent was on fire, and her crew jumping overboard, he sent his boats to the rescue, which, together with those of the 'Swiftsure,' Captain Rutherford, soon after aided by those of the 'Pickle' schooner, and the 'Entreprenante' cutter, effected their noble and generous purpose."—James' 'Naval History, vol. iv. pp. 74-77.

[b] "Ces cylindres sont les mêmes pour tous les projectiles creux; et ils ne diffèrent entre eux que par leurs dimensions, qui varient suivant le calibre des projectiles.

"La nouvelle composition dont on se sert pour garnir les cylindres, brûle avec beaucoup d'intensité, et donne un grand développement de chaleur ainsi que beaucoup de fumée pendant sa combustion; en sorte que cet incendiaire remplace avec avantage la roche à feu et les mèches que l'on employait pour obtenir le même effet.*

"Le département de la Marine a adopté ce perfectionnement; et un tableau, indiquant le mode de chargement des projectiles creux et la composition du nouvel incendiaire, a été envoyé dans tous les Arsenaux Maritimes pour que les artificiers aient à s'y conformer."—'Essai sur le Matériel de l'Artillerie de nos Navires de Guerre,' par F. E. A. Charpentier, Colonel d'Artillerie Marine, p. 165; 'Aide Mémoire Navale,' p. 270; and *Gassendi*, p. 179.

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* The quantity of this composition put into the shell of the canon-obusier of 80 is .270 k. (9.53 oz.); and into the canon-obusier of 30, .150 k, (5.3 oz.).

develop more heat, and give out dense smoke during the combustion, which must interrupt for a considerable time the working and aiming of the guns. The incendiary faculties of these *cylindres incendiaires* must increase prodigiously the chance of setting fire to any antagonist ship in close action, with comparative safety to that from which they are discharged, unless the opponent possess and use the like means. If he do, then must the issue be tried by the practices and artifices of the *brûlotier*, and both combatants perhaps, or at least one, will surely be burnt. If we disdain to descend to such a practice—and this, so far, appears to be the case—then we must endeavour to act in some other way which shall not expose us so disadvantageously to the terrific effects of a destructive weapon which we scorn to use. What would Nelson have said to this incendiary warfare?[a]

Red-hot shot, too, a *projectile incendiaire* which Napoleon denounced ('Mémoires,' tom. i.) as a dangerous, troublesome, and *difficile* weapon, so repugnant to the feelings of Frenchmen as to have been renounced, will again come into use, if not in ships, at least in coast batteries (witness the fate of the "Christian VIII." Danish ship-of-the-line, Art. 354), and, no doubt, shell-equipped ships will, much more than others, invite a return to that practice. Notwithstanding the assurances contained in the 'Aide-Mémoire,' p. 438, that "Le tir à boulets rouges est aujourd'hui presque inusité," and Charpentier's observation ('Essai sur l'Artillerie Navale,' p. 183), "que l'usage de faire rougir au feu les boulets des batteries de côte a beaucoup perdu de son ancienne faveur," several vessels of the combined fleets in the Black and Baltic seas were struck with red-hot shot. Two lodged in the "Vauban" at Odessa, which obliged her to retire out of action to have them extracted, which with the aid

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[a] *Translation by the Hon. Capt. Plunket, from De la Gravière*:—"Having witnessed the destruction of 'L'Alcide' and 'L'Orient,' Nelson considered *l'incendie* as the greatest danger of a naval action. Before the battle of Trafalgar commenced, he ordered all the hammock-covers on the sides of the 'Victory' to be well watered, and to throw into the sea or remove everything that could serve to aliment fire. It was to this pre-occupation, above all, that the absence of musketry in the tops of the 'Victory' may be attributed. Nelson thought that a careless discharge, a fortuitous explosion, might set fire to the tops and rigging, and become the cause of a frightful accident. This, in fact, happened in that very battle to the French ship 'L'Achille.'"—[He might have added, the "Redoutable."]—vol. ii. p. 224.

of some carpenters sent from a ship of the line, was effected, when she rejoined the squadron in action. The practice of firing red-hot shot from land-batteries is not without its danger. A 32-pounder of 56 cwt. burst at Gibraltar in October, 1852, in using hot shot, by which fatal accident three officers and ten men were either wounded or killed. The gun broke into many fragments, some of which were thrown to distances of 140 yards. Another melancholy accident of this description, for which no satisfactory cause has been assigned, took place at Malta in May, 1854. The gun burst into eight pieces, one of which was thrown to a distance of 100 yards: one man was killed, one lost his leg, and three were wounded; three of the officers present miraculously escaped imminent danger; the carriage on which the gun burst was broken to pieces; the carriage of the gun next on the right was broken; and the gun thrown into the ditch. The expansion of the shot by being raised to red-heat is less likely to have occasioned such an accident with this gun than with any other; for its windage is greater. However this may be,—were such a catastrophe to happen in a ship, it might be fatal to her. This resumption of the use of red-hot shot in land-batteries cannot be revived in ships, without extreme danger. It may be said with respect to steam-ships, that as they have furnaces in which shot may be heated without any difficulty, so the case should be exceptional with respect to them; and this appears to have been so at Odessa, where red-hot shot were fired from the "Terrible;" but there is already so much danger of fire in all ships by the incendiary system now in use, that it were better not to add another element to those perils.

We find in the chapter on Projectiles, in M. Charpentier's work 'L'Artillerie de la Marine,' that experiments have been made at L'Orient and Brest, with a new description of missile, denominated "*asphixiants*,"[a] because it develops a deleterious

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[a] "Une nouvelle espèce de projectiles, dits asphixiants, parce qu'ils ont en effet la propriété de produire par le développement de gaz délétère l'asphixie immédiate des êtres organisés, ce qui les rendrait surtout redoutable pour les navires ennemis, sur lesquels l'agglomération d'un grand nombre d'hommes dans un espace resserré en favoriserait puissamment l'effet suffocant."—'Essai sur l'Artillerie de nos Navires de Guerre,' p. 185. In 1851 experi-

gas, which produces the immediate suffocation of all organized beings." Whether those truly diabolical weapons, as M. de la Gravière denominates all such means (vol. i. p. 98), have been adopted in the French navy, is not known; but they stand in type as one of the weapons of the new French system of warfare.

Rockets are included in the category of projectiles adopted in the French navy for incendiary purposes (*Charpentier*, p. 200). They are said to be "particulièrement propres pour les navires à vapeur, qui ont la faculté de s'approcher aussi près que possible des côtes, et compenseraient d'ailleurs avantageusement sur ces navires le petit nombre de bouches à feu que leur nature permit d'y placer." The Rocket system is explained further on (Art. 331 et seq.).

312. The "Vengeur" was sunk in the battle of June 1, 1794, by the fire of the "Brunswick," 74, Captain Harvey. When in a sinking state, all the boats of the "Alfred," "Culloden," and "Rattler" cutter, that could swim, were sent to save as many as they could of her people. Thus 213 men were saved by the boats of the "Alfred," whilst those of the "Culloden" and "Rattler" rescued nearly as many more.[a]

But these noble and generous impulses—these humane exertions—far from being cherished and practised, will be smothered and repressed in that merciless, ruthless, and inglorious system of warfare for which we have been compelled, with the utmost repugnance and at enormous cost, to prepare. The black flag displayed over the depository of the sick, the wounded, and the dying, in a besieged fortress, is ever held sacred by the usages of war, as marking a locality appropriated to purposes of humanity. There the medical officers—non-combatants—perform their mournful duties in safety; the sick and the wounded are no longer exposed to the casualties of war; and the dying depart in peace. But what shall be said of that inhuman system pre-

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ments were made secretly at Brest with boulets asphixiants, under the direction of a special committee appointed for the purpose.

The author learns, with great regret, that some awful experiments have been made, with fearful success, in the Royal Arsenal, with projectiles asphixiants, combining in a frightful degree incendiary with suffocating effects!

[a] James' 'Naval History,' vol. i. p. 164, Chamier's edition.

pared for naval warfare, in this age of enlightened humanity, which would advisedly, purposely, and deliberately consign the whole of these, and all other survivors, to indiscriminate and instant death or mutilation? A ship may be sunk in action; yet, as we have seen, there is always time to remove the sick and wounded, and save the survivors; but who shall approach a ship on fire to rescue her crew from the sudden and awful effects of that merciless and barbarous system, the object of which is to set fire to her at heart, and if possible blow her up?

313. A melancholy realization of the evils depicted in the previous article marked the commencement of the late war with Russia (1854), at Sinope, where the Russians proved that they well understood, and can effectually use, the weapons which they, too, have imitated from France; and, from what they effected, they may learn what they have to expect in return, when, in combat with ships armed in a similar manner, they shall be exposed to the incendiary projectiles of their opponents, as well as to the suicidal effects of those which they carry on board of their own ships.

> "—— neque enim lex æquior ulla,
> Quam necis artifices artę perire suâ."
>
> —'Artis Amatoriæ,' lib. i. v. 655, 656.

In the burning of the Turkish squadron the Russians only did that which our noble ships are expressly designed, and fully equipped, to do: it was not effected by percussion or concussion shells; neither of which, as has been already observed (Art. 265), are so destructive on a ship, nor so likely to set her on fire, as shells coming in with fuzes blazing, and especially if they lodge before they burst. The Russians have not adopted either, but use shells having screw metal time-fuzes attached; and with these the Turkish ships were either blown up by the shells, which lodged and then exploded in their interior; or which ignited, by their fuzes as well as by their explosion, the powder circulating on the fighting-decks, and thus occasioned so much panic among the crew that they were unable to extinguish the fire; in consequence of which the whole of the Turkish squadron was either burnt or blown up: thus verifying the prognostication of General Paixhans, expressed in his original work:—" Enfin la grande faculté incendiaire des canons-à-bombes sera de mettre de feu aux poudres qui circulent pendant le combat; effet terrible, qui causera une déflagration totale, que rien ne saura empêcher"[a]—the very catastrophe which occurred at Sinope, as reported by the Commission of naval officers sent by the French government, at the request of General Paixhans, to inquire into the facts and circumstances of the destruction of the Turkish frigates.[b] The Turks have great cause to dread incendiary warfare in general, and Russian shells in particular. A large Turkish squadron was wholly burnt in that manner by the Russians in the bay of Tschesmé in 1770. The Greek Brûlotier "Canaris" and others destroyed a Turkish squadron and many Turkish ships in the war of the Greek Revolution by setting them on fire; and the services of the "Karteria," under the command of Captain Hastings, during that war, further inspired the Turks with terror of the incendiary warfare, which that commander prosecuted with red-hot shot and shells; by the former of these, principally, he obtained his successes. We may, however, rely upon it, and take warning accordingly, that this mode of naval warfare, which the Russians were the first to practise, and which proved so destructive at Sinope, will be used from land-batteries with still greater effect against ships, in proportion to their magnitude, and with more safety to themselves than when employed ship against ship, fraught as it is with danger to the users, as stated by Paixhans and others.

Shells fitted with time-fuzes combine the incendiary with the explosive quality, whereas percussive shells are purely explosive. The Russians prefer the former shells; and, in order that there may be time for them, before bursting, to set fire to the ship in which they lodge, they use rather long fuzes. It is to this circumstance probably that the gallant young Lucas owed his life, and his comrades their preservation, while, by his heroic conduct, the ship was saved. Percussion-shells are useless for an attack on stone walls; and in the incendiary warfare carried on by

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[a] *Paixhans*, 'La Nouvelle Force Maritime de la France,' p. 78.

[b] It is very probable that these shells may have contained *cylindres incendiaires*, described Art. 311, Note [b], as in the French naval service; but that the projectiles used by the Russians on that occasion were not boulets asphixiants, as has been stated, nor percussion-shells, the author has it in his power to state on the authority of the Commission mentioned above.

British ships against works which may be burnt, they are not so efficient as time-fuzed shells.

314. The affair of Sinope, in which the Paixhans shell system was first used in war, forms so important an epoch in the history of the new system of naval warfare, that the reader will naturally expect to find some account of that conflict in these pages; and much interest is given to that subject by an important paper written by General Paixhans, and entitled 'Observations sur l'Incendie, dans la Mer Noire, des Bâtimens Turcs par la Flotte Russe.' The observations are dated 15th of February, 1854, and were published by authority in the 'Moniteur' a few days afterwards. In that document it appears to have been his principal object to point out the errors committed, as he thinks, in France—and this applies to us in a greater degree—of constructing ships of greatly increased magnitudes, and concentrating in them multiplicities of explosive and ignitable bodies, instead of the reverse, as proposed by him and approved of at the time (pp. 20, 22 of the work above quoted). He states in his original work, and in his recent publication, that, as a few of his canons-obusiers in a comparatively small vessel are capable of destroying any ship however vast, costly, and well manned, so no ship should be armed with more than four or six canons-obusiers; no shells should be exposed on, or be conveyed to great distances along her fighting-decks. He adds that horizontal shells fired with skill from a ship so equipped will destroy any vessel, and this with the greater certainty in proportion as she is large; because the circulation of powder, and the accumulation of projectiles for the service of a greater number of guns, must multiply, in that proportion, the chances of an entire explosion of the vessel; and he therefore strongly recommends that, instead of investing in a single vessel the vast sum of money required to construct a ship of 80 or 130 guns, armed and fitted for shell-firing, thus risking the total loss of the ship, and the lives of a thousand men, on one fatal chance, it would be better to lay out the same sum of money in constructing two or three smaller vessels, which might together carry that amount of armament and the same number of men.

Observations on the Burning of the Turkish Frigates by the Russian Fleet in the Black Sea.

[In a letter written by General Paixhans, and published in the 'Moniteur,' February, 1854.]

THE Russian ships at Sinope,[a] not only had a superiority, two or three fold, of guns, but, moreover, the advantages of an armament of a different nature from that of the Turks. The Russian admiral, after having explained in his official Report the manner in which he commenced the combat, states, "Our vessels, having entered the "bay and taken their positions, canonaded the enemy with a well-"directed fire. In less than five minutes, a ship-of-the-line, Grand-"Duc-Constantin, destroyed the battery under her fire; and the "enemy's frigate anchored near to that battery, on which was "directed principally shells from the Paixhans guns on the lower "deck of the Russian ship, blew up. A short time afterwards the "Ville de Paris, Russian ship-of-the-line, blew up by her shells "another Turkish frigate." Another Russian account sent to Berlin states, that in the second tack of the Russian ship Constantin the Turkish frigate carrying the admiral's flag blew up also.

Every one will allow that, in seeing my name thus placed, it was natural for me to feel the necessity of making some observations on this occusion; the publication of these, however, I deferred that I might affirm nothing until I should have other information than that given in the Russian bulletins.

To obtain these I addressed myself to the French Ambassador in Turkey, in consequence of which an investigation was made at Sinope, and I select the following passages from the reply to my questions:—"None of the Turkish ships destroyed had any Paix-"hans guns; their largest pieces of ordnance were of the calibre "of 24, and there were but few of these."—"The land batteries "were not armed with Paixhans guns, but with cannon of small "calibre."—"Those batteries were in a very defective (pitoyable) "state of defence." Then comes a description of the projectiles used by the Russians, some of which not having exploded, enabled the commission to explain them exactly. After having described them the Report proceeds, "One of these projectiles had lodged in

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[a] The gallant General designates the Russian attack of the Turkish squadron at Sinope as iniquitous, on the ground, probably, that the attack ought not to have been made under the political circumstances then existing. It may, however, be considered as iniquitous from the fact that the Russians used shells in the action; for such was their superiority in number and calibre of guns (they were heavily armed: many 68 and 42-pounder solid shot fired by them were picked up at Sinope), that, instead of burning the Turkish ships and exterminating the crews, they might have taken the whole squadron without firing a shell, and have brought away the surviving men as prisoners of war. The ships might have served to increase their own effective force.

" the earth near one of the batteries, and, on exploding, projected " its splinters to distances of about 300 or 400 metres." Then the Report states that the Turkish officers, interrogated as to the effect of these projectiles, were unanimous in attributing to them the setting fire to the greater number of the Turkish ships, and in stating that the fire (incendie) was followed by their explosion or blowing up. The Report concludes with these words, "The " Turkish Colonel of Artillery sent from Constantinople to inspect " the state of the forts is so much impressed with this truth that he " urgently demands that Paixhans howitzers be supplied.' '

The facts of the case having been thus certified, the following are my observations:—

The canons-obusiers named as above were tried first at Brest in 1823 (qy. 1821 and 1824?), and from these experiments, as well as others made elsewhere, the great destructive effects of that piece of ordnance have been generally inferred. Several distant facts of war have since added to those proofs; and recently the English Admiral P. said to M. B. that, if two vessels armed with these guns were to fight, it might happen that in a few instants one would disappear in the air and the other under the water. In short, in the disastrous combat of Sinope the effects produced on the Turkish frigates, all of which perished, and even on the town, have but too distinctly proved what will in future be the issue of maritime combats, every navy in Europe and in America having adopted that nature of ordnance.

Whatever be the sad impression resulting from these facts, it is impossible to throw the least blame on the introduction of that new arm. For, if blameable, why should Governments the most enlightened have hastened to adopt it? Improvements in arms have never been rejected any more than other improvements. Is it not established in history, that the more powerful the arms, the less bloody have been the wars? The truth is, that with naval artillery whose effect will be prompt and decisive, a comparatively small vessel, well using this powerful artillery, may make herself feared by the largest ship; but, when the weak is put in a state to be no longer despised by the strong, the means employed should not be unfavourably judged. Will it not be, on the contrary, fortunate for all maritime nations to be able to arm their ships, their coast-batteries, and their seaports, with ordnance the most capable of repelling aggressions, against which the ancient artillery was often comparatively ineffectual?

As to the deplorable disaster of Sinope, the Turks displayed the most admirable energy, but foresight had prepared no chance for the success of their courage. They exposed themselves to a most unequal combat, in opposition to the soundest counsel. The largest pieces of ordnance in their ships were 24-pounders; there were few of these, and the ships were in a roadstead under the protection of batteries to which they had only given the semblance of an armament. And it may be affirmed that, if a part of their naval armament, and, above all, their land-batteries, had consisted of *canons à bombes* properly served, the Russian ships could not have approached without receiving a severe lesson; land-batteries firing much more accurately than those of ships, which are always more or less agitated by wind and water.

That which has lately happened in the Black Sea, and that which may soon take place elsewhere, is that which will always happen in favour of any power which may first use effectually and ably a new weapon of war; and this truth, if unfortunately war should ensue, is about to appear in another manner, by the musket, which is now receiving such remarkable improvements in its range and accuracy of fire.

To these observations the General adds the following, which he remarks will, perhaps at no remote period, prove useful to France.

1st. Guns which fire shells horizontally will destroy any vessel, and will do this with a greater certainty in proportion as the vessels are large, because the circulation of powder and projectiles during an action, being more multiplied for the service of a greater number of these guns, will multiply the chances of an entire explosion of the ship. From this fact results the important question whether, instead of concentrating in a single ship of 80 or 130 guns and 1000 men, and exposing that large quantity of military and financial power, and that amount of lives, to perish suddenly, it would not be better, from motives of humanity and considerations of economy, to lay out the same sum of money in constructing two or three much smaller vessels, which might together carry the same amount of armament and the same number of men? Our principal ships, being then far less enormous and drawing less water, may enter a greater number of our ports, which at present are limited to five, accessible to large ships. The construction of three smaller vessels would neither require so much time, nor timber, nor be so costly. Our fleets would then find at home, and in our colonies, more ports of refuge accessible to them, and they would find more points accessible to attack on the coasts of the enemy. The battery of a frigate may, as well as the battery of a large ship, carry the means of keeping at a distance or of destroying an enemy. In the combat of two or three such ships against one adversary of colossal magnitude, the latter may doubtless, if near, be able to destroy either of the others singly, but these might concentrate upon him, at a distance, mortal blows, and remain masters of a field of battle from which the greater ship will have disappeared.

Without entering into the details, I shall add, that, in considering the different maritime and commercial conditions of other nations, it will be perceived that the mode of warfare best adapted to our country should rather be a system of desultory and unexpected expeditions and offensive cruises, than the heavy and disastrous system of regular battles and general actions. A hundred powerful and rapid frigates will evidently be more useful to France, than 40 or 50 ships-of-the-line; and this change of system is supported by two authorities of great weight—that of the Emperor Napoleon I. towards the end of his career, and the decisive facts of our recent history. Other powers may indeed adopt the same change, but, if it were not to give this notice too wide a circulation, it would not be difficult to demonstrate that, if a general abandonment of the expensive system of fleets were to take place, France would have little to lose and much to gain.

2nd. With an arm the effect of which is very destructive, the advantage will evidently be in favour of those who know best how to give it length of range and accuracy; thus, both in our actual armaments and in the progress to be made, these two conditions, together with a superiority of calibre, should above all others be satisfied; to this I shall add, that if the same effects could be produced by lighter pieces of artillery of the same description, and which do not require vessels of such great draught of water, nor expose so many men, we should have resolved a problem which, together with great speed in our steamers and greater numbers of them, would give to France a system of naval economy which suits her in the highest degree.

Improvements in arms have never been rejected any more than other improvements; and it is established in history that the more powerful the arms, the less bloody have been the wars. In general, on the land as well as on the sea, to enable combatants to keep distant from each other by increasing the range of their arms, is to reproduce that effect which happened when firearms superseded the pike and the club, and gave to science and address an invincible superiority over brute force.

One cannot tell whether nations will ever obtain from their governments the abandonment of warlike conflicts by sea and land, in which flows the best and most valiant blood of the peoples; but, until that period arrive (if ever it arrive!), those who increase the power and the range of arms, will at least constrain combatants to keep distant from each other, and will therefore have acted in a sense favourable to civilisation and to humanity.

(Signed) GENERAL PAIXHANS.

Paris, 10*th February*, 1854.

315. Before entering further upon this important document, the author will endeavour succinctly to explain, as he has often been recommended to do, for the information of the general reader, and of naval and military officers who may not have acquired a competent knowledge of the Paixhans system, from better sources, the principles, effects, objects, and dangers of that new system of naval warfare which has now become an object of intense interest and vast importance to the country.

The reader, if an adept in the practice of artillery, should remember — if not, he should be informed — that the shells which produced those very extensive ravages upon the "Pacificator" hulk in the experiments made at Brest, in 1821 and 1824,[a] upon the evidences of which the French naval shell

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[a] The "Pacificator" hulk, of 80 guns, was moored in the roadstead of Brest, at 300 toises (639 yards) from a small *ponton de service* (a lighter), on which the gun was placed. The first shell struck the vessel low, made a fracture 8 inches diameter, perforating the side, which was there upwards of 28 inches thick, and *exploded in-board*, committing very extensive ravages. It set the ship on fire; and she would have been consumed, had not men been sent to work the pumps, which had been previously prepared. The second shell perforated the quarter-deck, and carried away two planks; after this it struck the main-mast, taking off a splinter 3 or 4 feet long, and 9 inches deep, *and then burst*, carrying off an iron hoop 10 feet in circumference, weighing 130 lbs., a large fragment of which was driven with great force against the opposite side of the hulk. The splinters of the shell did vast damage to the materials, and must have carried off a great many of the crew, had the vessel been manned. The third shell perforated the side between her ports, broke off an oaken knee, 7 feet long, and from 6 to 13 inches thick, which, with its iron bolts, weighed upwards of 200 lbs.; it *then exploded*, knocking down upwards of forty planks, placed to represent men at quarters, and doing very extensive damage to the material.—*Paixhans*, pp. 38, 39, 40.

In the experiments made at Brest in September, 1824, a shell penetrated into the hulk at 3 feet above the water-line, and then exploded, making an opening of nearly 3 feet square, ravaging, tearing, and separating the planks above and below. The Report states, p. 54, that had that effect taken place at the line of flotation it would have very soon sunk the ship. Another shell exploded in the hulk, and set her on fire, and would have burnt her had not prompt measures been taken to prevent it.

So at Portsmouth, in 1838, in the shell experiments against the "Prince George," and in others more recently made, the most destructive effects in the hulk were produced by shells which lodged and then exploded. Assuredly no such formidable effects could have been produced by concussion or percussion shells; and it must be observed that the latter have never, or rarely, been found, in the experiments made with them, to set the hulk target on fire. They pass too quickly, and burst too soon, to communicate their incendiary qualities to the medium through which they pass. They may blow up cartridges and powder-bags, but not directly set fire to the ship. The extremely destructive effects of Paixhans' shells in war is a great fact, which has been proved at Sinope. The performance of percussion-shells is a subject which has yet to be tested.

system was founded, were loaded shells, having fuzes attached, which, ignited by the explosion of the discharge in the gun, continued to burn for a time somewhat greater than that of the estimated flight, and then exploded; thus producing the maximum effect which any shell is capable of producing on a ship. But, as has been already explained in Article 267, so much difficulty has been experienced in getting a *time-fuze* to fulfil the conditions of the case, that it appeared preferable to our naval authorities to sacrifice that precarious advantage to the minor effect, which may be obtained with greater certainty, by causing the shell to explode on striking any resisting part of the body of a ship.

But General Paixhans—considering that the maximum effect of one of his shells is far more destructive on a ship than any percussion or concussion shell can possibly be, and that, should the former take its fullest effect, it would prove more fatal to the ship than perhaps all the percussion-shells that might be fired at her—adheres to that description of fuze to which his system is indebted for its success experimentally, and for its ultimate adoption. We have seen, in the affair at Sinope, that the Russians have much reason to be satisfied with the destructiveness of such shells; and we may be sure that they will be used in any naval action, ship against ship, and likewise from fortresses and other land-defences against fleets, if these should be so indiscreet as to attack in that manner such formidable positions: and, in truth, it must be said, that in any encounter, large ships, particularly three-decked ships of 120, 131, or 140 guns, are marks so large as scarcely to be missed, even at considerable distances; that their frames are so thick and stout that no shell could pass entirely through them; and, consequently, that any shell which hits the hull will lodge in her body, and, embedded there, will, by its explosion, produce the destructive and terrific effects of a mine sprung in her interior.

This is the Paixhans system, as stated in the General's original work, and in the subsequent exposition; in both of which the essence is declared to be, to avoid the error of building large ships, and the equipment of any ship so extensively for shell-firing as necessarily to expose her to the greater risk she would thereby run of being set fire to, or blown up, by her own weapons. It is added that the effects of this system upon an enemy consist rather in the destructive powers of a few canons-obusiers, in comparatively small and swift vessels drawing little water, than in accumulating many in the same huge ship. Into these extremes, however, both France and England have rushed, but England furthest,[a] in rivalry to each other: out of so expensive, dangerous, and extravagant an extreme, both may hereafter have occasion, if the General is right, to retrace their steps.

316. Adverting to what General Paixhans has stated in his original work, and in the letter above referred to, there can be no doubt that there will now, more than ever, be reason to dread the ignition of ammunition circulated or circulating on the fighting-decks of ships in action. Numerous instances may be found in naval history (James' 'Naval History,' vol. ii. p. 245,[b] and in many other places) of the explosions of powder on the fighting-decks of ships in action, and of the panic into which those explosions threw the crews, before the agency of live-shells was introduced.

The danger incurred in bringing up and distributing throughout the decks, ammunition and shells for the supply of all the guns of a ship, must hereafter, irrespective of other perils, be greatly increased, and is, in the opinion of many naval officers whom the author has consulted on these matters, perhaps more to be dreaded than the accidental explosion of shells. This dictates the absolute necessity of adopting additional precautions to prevent as far as practicable such fearful accidents; and assuredly there can be none so effectual as to forbid, as in the United States' service, any accumulation of shells or of inflam-

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[a] There are only seven ships of three decks afloat in the French navy, and none of more than 120 guns. The 100-gun ship on three decks is to be suppressed, and no three-decked ships are being built. The disadvantage of ships of three decks, as having a ballistic force not much more considerable than that of a 90-gun ship, the expense of their construction, and the large surface they present to the enemy's projectiles, are strongly urged by the French authorities.—'L'Enquête Parlementaire.'

[b] "In the action between the 'Ambuscade' and the 'Baionnaise,' an explosion of some cartridges took place on board the British frigate, which, besides the panic it created, badly wounded every man at the adjoining gun, and occasioned so much confusion that she was immediately boarded, and, after a very short struggle, captured."—James' 'Naval History,' vol. ii. p. 245.

mable or combustible bodies on the fighting-decks of ships, which may be exposed to the chances of being ignited or exploded by shells or shot striking them.[a] Paixhans observes ('La Nouvelle Force Maritime,' p. 18):—"C'est là surtout qu'il devait y avoir opposition, parce que l'objection principale consistait à dire, qu'il sera dangereux d'employer, à la fois, beaucoup de projectiles chargés, au milieu d'un équipage nombreux." But far from listening to the proposition that this accumulation should be forbidden or reduced, it has by a late regulation been greatly increased (Art. 283, Note).

Lieutenant Jeffers, of the United States' Navy, says, in his treatise on the 'Theory and Practice of Naval Gunnery,' New York, 1850, p. 174, that "No accumulation of shells in the batteries should be allowed, since, if struck by a shot they will explode, and cause great damage; for the shock occasioned by the stroke of a shot on iron develops a heat so great, that the pieces cannot be held in the hand, and their blue colour indicates that the temperature has been raised to about 600°, the point at which powder ignites. If a loaded shell be struck by a shot, the heat developed may ignite the charge, and cause a most disastrous explosion"—an awful fact, which has since been fully established.

317. It is enjoined in our regulations for conducting shell-firing, that the greatest possible care should be taken to expose shells as little as possible to the chance of being struck by shot; for which reasons the shells which are placed on the fighting-decks for the service of the guns are directed to be stowed on shelves behind the beams, because in that position they can only be hit by shot coming in at right angles to the keel! (Art. 287, and the 'Regulations for Shell-firing'). Should a shell be struck, though it might not explode with full force, yet the ignition of the charge, which is the immediate result, must produce, as Lieutenant Jeffers says, the most disastrous results. Can it be detrimental to state these facts and opinions? Are they known to the officers of the British Navy? Is it not right

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[a] See the letter of General Paixhans above. The 'Times,' with its usual vigilance, has thrown out the subject of that letter for consideration; and certainly it most nearly concerns us, who have such immense ships as the "Duke of Wellington," "Prince Albert," &c.

that these warnings should be given? To conceal from ships' companies, and from the country, any danger which seamen must face,—in the new and peculiar system of warfare in which they are engaged, but have not yet experienced, and in which the people of this country, of every class, are so deeply concerned, with a view to prevent seamen from being panic-stricken when the case occurs on service, and to avoid alarming the country, by suppressing the truth,—will assuredly produce effects the very reverse of that intended, and inevitably give ground for the outbreak of panic, at a moment when it is most to be feared—*in action*. Prepare British seamen for what they have to expect, and must face, and they will meet it like brave men. To conceal danger from them is to treat them like children whose nerves are not to be depended upon; and when the truth, which had been concealed or suppressed, is practically disclosed, the very mystery that has been attempted will magnify the danger, and surprise the men into a panic which it will not be easy then to allay. This will act disadvantageously, not only immediately on the ship's company actually serving, but on the people of this country in general, who appear to be kept, by this policy of concealment, totally ignorant of the true character of the new system of naval warfare, and for which they likewise should be prepared.

It is no doubt wise, prudent, and even necessary, to conceal the destructive effects which may be produced on a foe, by the discovery and introduction into the service of any new weapon of war, so to reserve to ourselves the initiative, and the exclusive use of the new arm (although the French did not so with respect to the Paixhans system, nor can anything of a practical description be kept secret in these times); but when the subject of experiment is to ascertain how far the new weapon or system may be used with safety to ourselves, or the reverse, the results should be divulged to the profession at large, to enable them to understand the nature and extent of the danger, and if, upon a full consideration of the facts of the case, it should be decided that the danger is unavoidable and must be encountered, brave men will meet it with the advantage of being well prepared to face it.

Had the facts which are now fully proven, here and elsewhere, been established and as well known before the shell system was carried to its present dangerous extent, it is impossible that it should have been permitted to go so far, at least without a positive prohibition against placing live-shells anywhere on the fighting-decks of ships in action. Let not the reader imagine that this is the first announcement of danger to the users! It was first declared before a select committee of the House of Commons in 1849,[a] as the then First Lord of the Admiralty well knows, in answer to some questions propounded by Sir James Graham, namely, that "in order to conduct with safety the dangerous service of shell-firing on board ships, which has of course greatly increased the chances of a ship being set fire to in a general action," it was necessary to send every filled shell on board in a wooden box, and to provide stores and implements (metal screw-fuzes) for shell-firing. This fearful announcement greatly strengthened the apprehensions entertained by the author and by many British officers and seamen, of the perils incidental to shell-firing—perils which it is neither possible nor prudent to attempt to deny.

318. The dangers incidental to shell-firing having thus been declared by authority several years ago, but the causes and amount of the danger never having been fully examined and ascertained, the author, rather tardily perhaps than otherwise, proposes to examine in what the danger consists;—whether "sending shells on board in separate boxes, with the expensive *implements*" above alluded to, which the select committee were led to believe would be found effectual safeguards against the accidental explosions of shells, have proved so—what is the amount of danger to the users—what the chances of accidental explosions taking place—the effects produced by the bursting

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[a] "Question 5075.—The change of the armament introduced a variety of expenses, which have added annually to the Ordnance vote; amongst them are the stores necessary for firing shells horizontally, and the implements necessary for conducting *that dangerous service* safely on board ship. We are obliged to send every filled shell on board in a wooden box. Of course *this employment of shells has greatly increased the chances of a ship being set fire to in a general action.*

"It has been necessary to substitute leather boxes for that purpose, having a cap fitting so tightly that, in the event of the powder-boy being killed, the box might roll about the deck without a chance of the powder being ignited by the bursting of shells near it."—'Second Report on Army and Ordnance Expenditure,' 1849, p. 325.

of a shell on the fighting-decks of a ship, its consequences,—and whether by any, and what means, those dangers might be obviated, abated, or avoided.

The danger of the entire explosion of a ship—and particularly of a large ship—by the accidental ignition of her own ammunition, or by the explosion of her own projectiles, having been publicly declared and widely circulated, on the authority of the great originator of the system of horizontal shell-firing (which we have imitated in principle, and far surpassed in degree), as a warning of danger to his countrymen, to which no doubt they will listen, and endeavour as much as possible to avoid—inclines the author to think that General Paixhans' opinion and advice demand the most serious consideration from all who are interested in the British Naval Service. The multiplicity and accumulations of incendiary and explosive projectiles on the fighting-decks of our ships, the system of shell-firing from all natures and descriptions of ordnance, and the inordinate magnitudes of ships, not only exceed what General Paixhans proposed in his original work ('La Nouvelle Force Maritime'), but even surpass the extent to which subsequent French naval administrations have assumed the responsibility of transgressing his proposition; and, consequently, we are more likely than they, or any other naval power, to incur the risk of such a catastrophe as that which General Paixhans has darkly foreshadowed.

319. The author has stated in the third edition of this work (page 270 and the Note), that M. Paixhans' original proposition was to apply the canon-obusier to a small extent only in the naval service. The commission appointed by the Minister of Marine, to witness and report upon the experiments of 1821, approved of Colonel Paixhans' new and powerful canon-obusier of 80, and reported that it was well adapted to become the armament of small vessels (as a pivot-gun), but that the introduction of shell-firing into the naval service would require the utmost precautions to prevent the many fearful accidents which might arise from the use of live-shells on board a ship, and therefore recommended that, *if* introduced into ships of the line, it should be in very limited numbers.

In 1824, the Minister of Marine, unwilling to carry into effect, on his sole responsibility, the recommendation of the Commission of 1821, nominated another, the members of which were to revise its Report, and to state their own opinion and decision.[a] Both reports were then referred to the Comité Consultatif de la Marine, with a series of questions upon them; to these the Comité replied, upon the subject of danger,[b] that no possible precaution could altogether suffice to prevent effectually the most dangerous consequences if the use of *canons à bombes* and live shells should be extended generally to every deck of a ship; but, being of opinion[c] that, if the number of those guns were limited to two, or at most four, placed only on the lower deck, and near to the shell-room, the dangers would be comparatively small, the Comité consented to this limited arrangement. Upon the question of magnitude of vessels, they stated that, as large ships in which great numbers of men, guns, shells, and quantities of ammunition were concentrated, would be exposed, in proportion to their size, to the chances of a *déflagration général*, or *une explosion entière*, therefore the Comité recommended that comparatively small vessels should be introduced in place of large ones. The reader will have perceived that the adoption of a contrary measure in France has produced General Paixhans' severe condemnation of the error. These limitations and regulations for the safe custody of shells, were (as may be seen by referring to Section No. 16 of General Paixhans' work, page 85,[d] where the danger which shell-armed vessels will incur from the explosion of their own shells is pointed out) framed

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[a] Rapport fait sur les premières expériences de Brest, en Janvier, 1824, par une commission composée des chefs supérieurs de la marine, du génie maritime et de l'artillerie.—*Paixhans*, p. 41.

Signé de MM. le Vice-Amiral Comte de Gourdon, commandant la marine à Brest; De Kerlerec, major-général de la marine; Geoffroi, directeur des constructions navales; D'Herli, directeur du port; Godebert, directeur de l'artillerie; Lemaraut, Lahalle, Coffrey et Touffet, capitaines de vaisseau; Simon, sous-directeur des constructions; Gérodias, sous-directeur de l'artillerie; Gicquet des Touches, sous-directeur du port; Lettré, De Rossy, Couhitte, et Demaré, capitaines de frégate.—*Paixhans*, p. 44.

[b] Avis du Comité Consultatif de la Marine; Nouvelles expériences ordonnées, plus étendues que les précédentes.—*Paixhans*, p. 47.

[c] Rapport fait sur les secondes expériences de Brest, en Septembre et Octobre 1824, par une commission composée des chefs supérieurs de la marine, du génie maritime et de l'artillerie.—*Paixhans*, p. 57.

Signé de MM. le Contre-Amiral Bergeret, président de la commission; le Colonel Godebert, directeur de l'artillerie navale; Lassale, Russel, et Béhic, capitaines de vaisseau; Simon, sous-directeur des constructions navales; Gérodias, sous-directeur de l'artillerie navale; Longueville et Pasquier, capitaines de frégates.—*Paixhans*, p. 59.

[d] Observations sur le danger que pourront courir nos vaisseaux par les bombes qu'ils emploieront eux-mêmes.—*Paixhans*, p. 84.

expressly to prevent the recurrence of such awful catastrophes as those which occurred on board the "Theseus" (Art. 285, Note), which produced a prodigious sensation at the time, though she was no longer a French ship: such also as the explosion which took place in a French ship at Aboukir; the burning of the "Formidable," which took fire in the poop in the combat off the island of Groix, in 1795, from the explosion of shells, by which she was disabled and obliged to surrender, with the loss of 220 men out of a crew of 666; and lastly, the blowing-up of a French ordnance store-ship, containing quantities of live-shells. All these accidents were ascribed to want of prudence in the safe custody and stowing of shells, and particularly to exposing them on deck, "*autour des canons;*" which accidents, a strict observance of the foregoing regulations and precautions, it is asserted, would have effectually prevented: relying on the efficacy of those regulations, we adopted them; but they have since been either rescinded or violated, both in the French and in the British service, and thereby the dangers said to have been extinguished are reproduced and reactivated.

The Academy of Sciences was consulted on the whole of those proceedings, and reported their concurrence in the views taken by the Commissions and Comités Consultatifs, to which the professional questions had been referred.[a]

By decree of 1838, in conformity with the Reports and recommendations of the Commissions and Comités Consultatifs, as stated in the previous pages, the introduction of canons-obusiers into line-of-battle ships was limited to, at most, four; these to be placed on the lower deck, and near to the shell-room; and the like limitation was long observed in our service, with respect to the analogous and equivalent pieces of ordnance, the 8-inch shell-guns. But since 1838, successive French naval administrations, regardless of the limitations prescribed by the commissions of 1821, 1824—in defiance of the injunctions of the Comité Consultatif, and of the decision of the Minister of Marine,

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[a] Rapport fait à l'Académie des Sciences et approuvé par elle le 10 Mai, 1824.—*Paixhans*, p. 45.

Signé de MM. le Baron Vane, ancien inspecteur général des constructions navales; De Rosse, contre-amiral; De Roni; Marquis de La Place; le Maréchal Duc de Raguse, rapporteur; et Baron Fourier, secrétaire perpétuel de l'Académie pour les Sciences Mathématiques.—*Paixhans*, p. 46.

by whom those recommendations were approved and confirmed, have sanctioned the great augmentations decreed by the regulations of 1848, 1849, and subsequently, in the number of canons-obusiers assigned for the armament of the French navy.[a] These augmentations, with the increased magnitude of ships, and other extensions which General Paixhans disowns having had any share in promoting, and against which he now remonstrates, we on this side of the water have far exceeded. See Armament of the British Navy, as regulated in July, 1848, Appendix C, 4th Edition, compared with what it is now (1860), Appendix E.

It was not the author's intention to open, or even to touch upon, this delicate subject on the present occasion, farther than he has already done in the third edition of this work (Article 246 et seq. of that edition), but the whole of this question having been opened by the distinguished originator of the shell system; and concurring entirely, as the author does, with him as to the great perils which he apprehends from such an extension of the armament and magnitude of ships, he has been induced to express himself strongly, in the hope that the threatened danger may be diminished by attention in high quarters to the advice or General Paixhans, and the suggestions which the author has long since ventured respectfully to offer.

With respect to the remark of General Paixhans, in his recent paper, that the more the weapons of war are rendered powerful, the less are battles destructive of human life, the author wishes to observe that, however this may be true of the number of men killed or wounded in actual conflict, it is not so of incendiary warfare, whether practised against ships or towns: it was not so at Sinope, and will not be so in like circumstances hereafter. The loss of life which will take place when incendiary projectiles are employed cannot but be far greater than on any occasion in ancient warfare. War may be made sufficiently costly to deter nations from entering into it, unless when forced to do so by

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[a] It will be perceived, on referring to the regulation for the armament of the French navy (Appendix C, 4th Edition), that this limitation was strictly observed in the decrees of 1824, 1838; relaxed in that of 1848; further relaxed by the decree of 1849, and subsequently still more so by extending shell-firing to 30 and 36 pounder guns as well as canons-obusiers.

circumstances similar to those in which this nation was lately placed; but it may be rendered effectual without being entirely merciless. The great Nelson prayed that humanity, after victory, might be the predominant characteristic of British seamen.

320. If General Paixhans be right, in stating that the danger of a ship being blown up increases in proportion to the number of explosive projectiles and the quantity of inflammable matter which may be accumulated on, or in circulation throughout, her fighting-decks, the author cannot be wrong in asserting that the danger will be lessened in proportion as the causes are diminished, and consequently that the danger must disappear when no such cause is present. This being so, it must follow, when a ship has no live-shells stowed on her fighting-decks (*mines*, in fact, ready laid to her enemy's hands, and ever ready to be sprung by the blow of a solid shot or the explosion of a shell), and is so armed, in the main, as to be able to drive into and through her opponent the greatest number possible of solid shot, in the least time, from guns double-shotted, at distances beyond the reach of shell-guns similarly charged; that such a ship, all else being equal, must carry the day over any vessel armed with much heavier, and therefore, in proportion, fewer pieces of ordnance for shell-firing: the latter vessel must, moreover, have vast numbers of live-shells stowed on her decks; she will, therefore, have to contend with the rapid inpourings of her enemy's solid shot, and at the same time be exposed to the treacherous effects of her own projectiles.

Upon a full and very serious consideration of the danger, admitted by General Paixhans in his original work, and the limitations under which only his system was adopted (as stated in the preceding article), the author cannot forbear to express his opinion that no shells should be permitted on the fighting-decks of a ship under any circumstances. The reason for placing complements of shells on the fighting-decks of ships was, to enable them to keep up quick shell-firing when in close action with ships. But it is seldom the case that in such actions there is not time to bring shells up as quickly as necessary; and in action against fortresses, forts, and land-defences faced with hard-stone walls, neither quick shell-firing nor any shell-firing will be required from the broadside-batteries of ships (see Art.

355, et seq.), though howitzer or horizontal shell-firing from the pivot-guns of steamers, against troops, or for enfilading, or for incendiary purposes, and mortar-shells from bomb-ships, will always be important adjuncts in the attack of fortresses and arsenals.

321. It appears from what is stated in the proceedings of, and the evidence taken before the French Parliamentary Committee (*l'Enquête Parlementaire*) that French naval officers are becoming very sensible of the fact, that they have overloaded their vessels with armaments which exceed, in the aggregate, the just proportion which should be maintained between the total weight of metal and other material forming the armament, and the displacement of the ship; and consequently affecting prejudicially her stability and speed. That they have augmented the weight of armament for these ships, to extents disproportioned to the "développements relatifs de leur carène." That they have not only overloaded their ships with too much weight of metal in the aggregate, but have introduced ordnance of such surpassing weight, individually, as to have reduced the number of guns beneath that which ships should carry, in relation to their tonnage. That displacing a superior number of guns, (30-pounders No. 1), by a smaller number of *canons-obusiers*, far from adding to the real battle-power of a ship, detracts from it. The number of hits or impacts, all else being equal, will be proportionally greater when the armament consists of 30-pounder guns, than when *canons-obusiers* are used instead of those; that 30-pounder shot have force sufficient to penetrate the side of any ship, even when two shots are fired; that firing two shots from *canons-obusiers* of 80 is interdicted; that the principal and most decisive battle-power in close action, is the faculty of pouring into an enemy's ship a superior number of solid shot in the least possible time; that the use of solid shot should therefore be the rule, shell-firing the exception; that a single man cannot easily, and quickly, put into a gun a projectile larger or heavier than at most a 36-pounder; and that the time required for loading heavier guns, even with increased gun-crews, becomes greater in proportion as the weight and magnitude of a projectile increase: these disadvantages are exclusive of the objections to all chambered guns in quick firing. De la

Gravière declares: "C'est à cette supériorité dans le tir que nous eussions dû attribuer les pluspart de nos reverses depuis 1793: c'est à cette grêle de boulets, comme l'écrivait Nelson, que l'Angleterre devait alors l'empire absolu des mers, qu'il devait lui-même la victoire d'Aboukir, et qu'il allait devoir celle de Trafalgar. . . . . . Ils jonchaient nos ponts de cadavres." (Vol. ii. pp. 175, 176.) And in another place he adds: "Aujourd'hui même, en effet, où la science pyrotechnique a fait d'immenses progrès, on peut se demander encore si les boulets creux méritent bien réellement l'effrayante réputation qu'on leur a faite, et si le tir plus rapide et plus sûr des projectiles pleins n'est point toujours celui dont l'efficacité demeure le mieux établie." (Vol. i. p. 99.)

These views and opinions coincide so much with what the author had previously stated in the former edition of this work, and has now more expressly enunciated in the foregoing article, that he may be excused for thus availing himself of the important weight of opinions coming from so experienced and enlightened a body of men of science and experience, on the other side of the Channel, concurrently with those of many persons at home. But, before quitting this part of his subject, he is anxious to state explicitly, that though perhaps it may be generally regretted that shell-firing should ever have been thought of for the naval service, yet, having been introduced in other navies, it is no longer a question whether or not we should adopt it likewise. The author is far from thinking that it ought to be abolished in our service so long as it is retained in others. No doubt the burning of the Turkish squadron at Sinope is an awful proof of the destructive effects of the Paixhans shell-practice, and may well be brought against any proposition for the rejection of that practice; but the author does not propose to relinquish or to enfeeble that system: he affirms it in principle, but condemns the excesses to which we have carried it. Its originator disowns the excesses, and the author, agreeing with him, condemns them, from a thorough convictio [illegible] rs to which they give rise.

322. If the armament of the [illegible] judicious combination of shell-gr [illegible] fined to the use of th [illegible]

our ships would be deprived of none of their real battle-power, by restoring to solid-shot guns the exclusive use of their own missiles. The shell-power of a ship would, by such a wise combination, suffice for a special use of shells; there would be no need to place any shells on the fighting-decks, and there would be no difficulty in providing ample space for stowing them in shell-rooms; whilst by restoring to solid-shot guns the use of projectiles suited to their very natures, the danger of placing multiplicities of shells on the fighting-deck for their use, would be entirely avoided. "If it were proposed," observes the Comité Consultatif de la Marine, pp. 49, 50, "to give hollow projectiles to a hundred pieces of ordnance on board a ship, the precautions to be taken would be numerous, and the danger would be difficult to avoid; but it is proposed to have only four or six *canons à bombes*, which, being placed on the lower deck, can be supplied with their shells by conveying these last a short distance only; and, though powerful guns, being few, they will require but a moderate quantity of ammunition."[a] Yet we have vastly multiplied the number of shell-guns, and thus we persist in braving the dangers against which these warnings are pronounced, and have hurried on the French to do the like. The difficulty of providing safe stowage for many hundreds of shells, in some cases, in shell-rooms whose heights are limited, by the necessity of keeping their tops or crowns sufficiently below the water-line, renders it necessary to add to their length, and hence has arisen, in a great degree, the costly lengthening of ships, to enable them to stow their vast complements of shells. The real battle-power that would be restored to ships, by this emancipation of solid-shot guns from the obligation to use shells, consists in the superior range, accuracy, and penetrating force of solid-shot guns, in their superiority for firing double-shot (Arts. 261, 272), and in the greater number of guns which vessels so armed would carry in relation to their tonnage; and the reader, pur-

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[a] "S'il s'agissait," observes the Comité Consultatif de la Marine, pp. 49, 50, "de donner des projectiles creux à cent bouches à feu du haut en bas d'un vaisseau, les précautions seraient infinies et le danger difficile à éviter; mais il ne s'agit ici que de quatre ou six canons à bombes, qui, étant placés dans la batterie basse, recevront leurs projectiles, sans longs trajets, et qui, ayant une très-grande puissance, n'auront qu'un approvisionnement peu nombreux."

suing the argument briefly stated in the third edition of this work (Arts. 246 to 248 of that edition), and given at greater length above, will not fail to arrive at a just conclusion.

323. It is a great step in the right direction, and is quite conformable to what has been stated above in this work (Art. 258, and Note), that in arming the "Royal Sovereign," the number of shell-guns on the lower deck has been reduced to ten, the other guns on that deck being 32-pounders of 56 and 58 cwt., the charges for which are 10 lbs.; also that the number of shell-guns on the middle deck is limited to six, the other guns on that deck being 32-pounders of 50 cwt., with charges of 8 lbs. It must be observed, however, that the 32-pounders of 42 cwt., charge 6 lbs., and 32-pounders of 25 cwt., charge 4 lbs., on the middle and upper decks, are very insufficient ordnance either for distant firing or for close action: in the former case, from want of extent of range except at high elevations; and, in the latter case, from want of penetrating power, as well as from their incapacity of being double-shotted.

Exaggerated statements concerning the gunnery power which the British Navy has acquired by the construction and armament of large ships of war, have been made in the periodicals which advocated such constructions. It has been asserted, for example, that the "Royal Sovereign" may at every discharge throw 4736 pounds' weight of iron with certainty against any battery half a mile distant from her; and, that at 3000 yards every shot fired from her would take effect upon a frigate: but, assuredly, neither the 32-pounders of 25 cwt. nor those of 42 cwt. could effectively take part in such feats. Had this ship been a two-decker, the expense of construction would have been far less, and the smaller number of comparatively inefficient guns would have been more than compensated by arming the decks throughout with guns as powerful as those which she now carries on her lower decks only.

The number of shots that were found sticking in the sides of line-of-battle ships after actions in the war between 1793 and 1814 has since been used as an argument against the efficiency of solid shot, and in favour of shells: but Simmons, in his excellent work on the effects of heavy ordnance, pp. 69, 70, attributes this most justly to the custom of double and treble shotting t so general; and the author has shown in Art. 262 that this arose in some cases from carrying a little too far the well-known fact that by reducing the charge to what is just sufficient to produce penetration through the side of a ship, the ravaging and splintering effects are increased: these errors will probably exist no longer; but, however this may be, if solid shots have not power to penetrate under the circumstances, still less could shells or hollow shots do so.

324. When it is unavoidably necessary to fill shells on board ship, the metal fuze should be carefully brushed and luted before it is put in; the shell should be filled by means of a funnel, taking care to insert its orifice below the screw in the tap of the shell, so that no grains of powder may get into the thread. To guard the more effectually against this accident, the female screw in the tap of the shell should likewise be carefully brushed out before the fuze is introduced, and a *washer* of parchment or some other material should be placed under the collar or head of the fuze, that there may be no contact between the metals of the fuze and the shell.

All sea-service shells are fixed to wooden bottoms by straps or bands of tin, or snaked by yarns to grommets of rope, to prevent the shell from turning in setting home; the latter is the more certain expedient, on account of the tin straps being liable to be broken, or injured by damp.

325. Fuzes should be frequently examined to see that their caps have not become so corroded as to be immoveable, but it must be remarked that this can be safely done only by putting the shell whose fuze is to be so examined into a gun previously loaded with a few ounces of powder—the range to the front, right and left, being clear. The cap may then be screwed off safely with the instrument proposed by Captain Nott, a brass wrench supplied for that purpose; the same instrument is used for fixing the fuze in, and withdrawing it from the shell; the men who turn the instrument keeping well within it and the shell; and, in the event of the fuze igniting, the shell would be blown out of the gun.

The examination of percussion-fuzes will be still more perilous, but at the same time more necessary; for the deteriorating effects produced by vicissitudes of climate and temperature, and by sea-damp on the chemical compounds contained in those shells when long stowed in a ship, have not yet been ascertained. To tamper with such explosive bodies, by opening, examining, renewing, and replacing them on board ship, should not be permitted on any account;[a] and there only remains to be tried the effect of firing them against rocks or other resisting masses. This may not always be convenient or possible, and at best will only show whether or not the shells fired have been efficient: it will not show that all those in the ship's store-rooms will prove so thereafter; and failures not unfrequently occur, even with new made percussion-fuzes.

326. In the experiments of 1853, several 8-inch shells were found to have struck the object without exploding; some stuck in the side of the hulk; others passed through the wood, which was unsound, the shock not having been sufficient to produce the explosion. An 8 or 10 inch shell passed through the near-side, and struck an iron bolt on the opposite side, yet did not explode, the percussion-fuze being found entire. Thus those projectiles failed as shells, and did not even succeed as shots. Had those shells which stuck in the sides or lodged in the body of the hulk been fitted with time-fuzes, the effect of their explosion would have been the greatest possible. Many of Moorsom's fuzes were picked up entire and uninjured amongst numerous splinters of shells after the experiments had been made. The old hulk the "York" was no doubt very much riddled and ravaged by these experiments; but she was not burnt, which she must have been by even one such shell as that mentioned, or by one or two of the shells, having time-fuzes, which were planted in the "Prince George" in the experiments of 1838.

327. It is now of vast importance to the naval service of this country that a series of experiments should be undertaken in order to establish, if possible, the following points:—1st. What are the effects produced on the sides of a ship by firing against them shells with different degrees of velocity?—for example, at

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[a] "An awful explosion took place in the laboratory at Rochefort, in 1851, in preparing the implements for shell-firing, in which a maître-d'artificiers and several men were killed; and a similar accident at Mauvillon.
seamen-gunners perished."—'L'Enquête Parlementaire,' vol.

short ranges, with full charges; at medium ranges and with medium charges; and at long ranges with reduced charges. 2ndly. At what time, and where, would the bursting take place? 3rdly. At what ranges and with what velocities would the shell explode by the concussion without penetrating at all into the timber? and must the blow be very slight to have this effect; that is, to render the shell harmless? The following facts may be considered as affording answers to some of the above inquiries; and may be of use in regulating the charges of powder in shell-firing against ships. At 1250 yards, 10 lbs. of powder drove an 8-inch shell through one side and lodged it in the further side of a line-of-battle ship at the lower deck; with 8 lbs. of powder an 8-inch shell perforated the first side and rebounded from the other. At 900 yards, with charges of 8 and 10 lbs. of powder, 8-inch shells passed through the first side and lodged in the second. At 600 yards, with charges of 7 and 8 lbs. of powder, 8-inch shells just perforated both sides and then dropped. At 600 yards, an 8-inch shell, with a charge of 5 lbs. of powder, passed through the first and lodged in the second side. At 300 yards, with charges of 7 and 8 lbs. of powder, 8-inch shells perforated both sides and buried themselves in the butt. With hollow shot, plugged, of 56 lbs., and a charge of 10 lbs. of powder, at 1250 yards, the shot passed through the first side and buried itself in the second. With 12 lb. charges (now abandoned) shells frequently burst in a gun, or at its muzzle.

In May, 1853, at the request of the Special Committee of Artillery Officers, six 32-pounder shells, and six 8-inch shells, all fitted with Freeburn's concussion-fuzes, were fired from the "Excellent" at the "York" hulk, at 1200 yards' distance, when the following results were obtained:—Every shell struck the hulk: of these 10 burst immediately; one struck an iron knee and broke, and one did not burst. There was no premature explosion; the trial was therefore very satisfactory, and it was recommended that some fuzes of the same kind should be made at the Royal Laboratory, in order to be preserved there as patterns for future constructions.

328. It has hitherto been generally supposed that the frequent bursting of shells in or near the muzzles of guns, when

impelled by large charges,[a] arose, in common shells, from the dislocation of the composition contained in the fuze, and particularly in short-time fuses; and with respect to Shrapnel shells, in which it is most essential that large charges should be used, the premature explosions which frequently take place were supposed to be due to the same cause. It was to determine this point that a committee was appointed to make experiments and report upon those failures. The committee recommended that the service-charges for spherical case-shot should be considerably reduced; this measure, having been approved and adopted, has, by so much, deprived that description of shell-firing of the essential cause of its efficiency. But it was surmised by many, and firmly believed by the author, that those premature explosions neither arose from dislocations of the short column of composition in the fuze, nor from the friction of the bullets on the bursting-charge contained in the shell, in the interstices between the balls; for it has been recently proved that shells without fuzes, the taps stopped with iron plugs, explode at or near the muzzle of the gun when fired with large charges; and the friction of the bullets on the powder (which is effectually prevented in Captain Boxer's fuzes) can scarcely be the cause of the explosion, because friction cannot have had time to produce the heat required to ignite the bursting-charge on the shell issuing from the gun, although it might do so in the course of, and near the end of its flight, from the grinding of the powder by the balls. It may therefore be surmised that the explosion of the shell at the instant of firing can arise from no other cause than that gunpowder is explosive by percussion, and that the bursting-charge is exploded by the shock of discharge, just as when a loaded shell is struck by a shot it is exploded, not by a spark elicited on the previous breaking of the shell, but, as already stated, by the ignition of its contents contemporaneously with, or instantaneously after, it is broken by the blow.

329. The fact, incontestably, is that gunpowder is, in a considerable and dangerous degree, explosive by perc

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[a] "In firing Shrapnel shells from heavy 32-pound
charge of 6 lbs. is not to be exceeded, and is the
used with these guns; with a greater charge the
burst in the gun from the concussion on firing."—

cussion, compression, and friction, and though not instantaneously, yet gradually, by even a small degree of heat. To one or other of these latent dangers in gunpowder, and the more easily ignited compounds for fuze-primings, &c., may be ascribed the unaccountable explosions which so frequently occur in the powder-mill, the laboratory, the firework-manufactory, and in ships, as well as the frequent explosions of ammunition in tumbrels and on the field-waggons, and of which no good account has been given, because in general all the persons near and about are killed. A very terrific case of this description occurred at Portsmouth, in 1851, where a large concourse of naval and military officers and many other persons assembled, at the Fire Barn, to witness the trials of a 10-inch shell, filled with a slow-burning composition, which, on being ignited by its fuze, should emit a dense smoke or vapour, having moreover suffocating effects. But instead of burning slowly, the composition, as soon as ignited, exploded the shell, scattered its splinters with great force in every direction, and, besides the casualties it occasioned to the bystanders, had well-nigh put an end to the valuable life of a gallant and distinguished general officer, one of the author's most valued friends.[a] After the most careful investigation, this accident has never been accounted for, and remains one of numerous instances of the treacherous character of all such artifices.

It was proved by Le Roi that gunpowder is explosive by percussion, for this chemist found that a few grains strewed on an iron anvil, and struck by an iron hammer, exploded. Jeffers, in the work above quoted, says (p. 174), that gunpowder likewise explodes by the collision of iron on brass, brass against brass, copper against copper, though less readily; likewise by the shock of bronze on copper, iron on marble, iron on lead, and lead on lead. The latter was abundantly proved in an experiment made by Professor Faraday, who is in possession of a large fragment of a shell containing a mass of lead formed by the bullets it had contained, which were transformed, by the shock of impact, into a mass of prisms; this was made use of to try whether the action of lead on lead would ignite gunpowder; for this purpose a small quantity was placed in the hollow of the

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[a] Major-General Simpson, Governor of Portsmouth.

shell, which, when struck by a leaden bullet, was ignited. A stone shot, of 770 lbs. weight, entered the lower deck of the "Windsor Castle" in 1807, set fire to some powder, and produced a terrible explosion, by which 46 men were killed and wounded, and such a panic was created that some men jumped overboard and were drowned. Why, then, might not the blow of a 32-lb. shot, fired with a full service-charge, and striking a shell at rest, explode the shell by percussion? But whether the shell be broken and its contents ignited thereupon, or whether it be exploded by its charge on receiving the blow, this at least we know, that such an ignition of powder may produce, as it did at Sinope, the most disastrous effects in a ship in action.

330. The expense of shell-equipment and shell-firing, to the extent to which it has been carried in the British navy, is enormous. The cost of every 8-inch shell shipped in its box, including the fuze, is 11*s.* 6*d.* Every 8-inch shell fired costs 17*s.* 4¾*d.*[a] The cost of the fuze for a 10-inch shell is the same as that for an 8-inch, but the expense of the shell itself is greater than that of an 8-inch, in proportion to the greater weight of the larger shell. Fully admitting the advantages of pivot-guns to steamers and other vessels, and of a limited number of shell-guns for special shell-firing, there is nothing to object to the expense, though large, of guns, carriages, slides, and appurtenances of the former,[b] nor to the supply of 8-inch shells for a limited number of shell-guns. But with respect to the vast expense of arming whole decks of line-of-battle and other ships with shell-guns, and of shell-firing from all natures and descriptions of ordnance, great and growing objections are made, and making their

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[a] Cost per Round of 8-inch Naval Shells fired.

	s.	*d.*
Shell	5	4½
Metal fuze and its cap, about	5	0
Charge, 10 lbs. powder at 7*d.*	5	10
Bursting-powder, 2 lbs.	1	2
Box	1	11
Total, including the box	19	3½

Moorsom's fuzes cost about 6*s.* each; boxes, 6-inch, 1*s.* 6*d.*

[b] The expense of the gun, carriage, slide, and appurtenances

of a 68-pounder gun			£225
Ditto	ditto	of a 10-inch gun	176
Ditto	ditto	of an 8-inch gun	172

way. The vast expense of our shell system consists not only in providing great numbers of new shell-guns, shells, fuzes, &c., but, moreover, of constructing ships and vessels of vastly increased and enormous magnitudes, capable of carrying such heavy armaments and of providing stowage in their interior for the greatly increased complements of shells. For this the relation formerly existing between the displacement of ships and the number of guns they are to carry (Arts. 257-260) has been greatly altered, in the construction of new ships, and in remodelling those formerly built. If General Paixhans, the great originator of the shell system, be right, and unless the author and many experienced first-rate naval officers be egregiously mistaken, fresh expense of no small amount will have to be incurred merely to undo much that has been already done.

The author can scarcely doubt that he will be considered by the reader to have established, in the preceding pages, a case of very great peril, deserving the most serious consideration:—this, at least, is so strongly impressed upon him in the course of the laborious, protracted, and most anxious attention which he has given to this important subject, that he feels it impossible to repress the avowal of his apprehension, now that he is called upon by the demand for his work to resume his labours. Thus he disburthens his mind of the load he would have to bear, and clears his conscience of the responsibility which, in certain cases, he might incur, did he conceal the convictions of his own mind. The reader will pronounce whether, in his judgment, a case of peril to the profession and to the country has, or has not, been established in these pages; and, if the former, whether by any, and what means, the danger may be prevented, abated, or avoided.

SECTION IX.—ON MILITARY ROCKETS.

331. A rocket for military purposes consists of an inflammable composition contained in a cylindrical case of stout paper or of iron, the head, or anterior part, having usually the form of a cone, but, occasionally, that of a hemisphere or paraboloid. The composition for the cylindrical part consists of nitre, sulphur and charcoal, in the following proportions:—Nitre, 4 lbs. 4 oz.; sulphur, 12 oz.; and charcoal, 2 lbs. When the rocket is used

merely for making signals, the head, which is then conical, is filled with a composition for producing, at the explosion, the stars of light which constitute the signal.

A rod of wood is attached, at one end, to the base, the neck or choke of the rocket;[a] its length being equal to about 60 times the diameter of the cylindrical part of the rocket, and its thickness equal to about half that diameter. Signal rockets weigh from half a pound to 2 lbs.: the diameter of a 1-lb. rocket is $1\frac{2}{3}$ inch; the length of the cylindrical part is $12\frac{2}{3}$ inches, and of the conical part $3\frac{1}{3}$ inches.

The composition is driven into the rocket-case till its density is equal to about twice that of gunpowder; but, in the interior, about the axis of the case, is left a void space of a conical form, its base coinciding with the neck of the rocket; and, in this neck several apertures are formed for the admission of air: at one of these, in which is left a piece of *quick match*, the fire is applied to the composition. The rocket, when about to be fired, is fitted in a tube, which is attached, in a given position, to a rest; when, on applying the match, the whole surface of the conical space is put in a state of slow combustion and the rocket is propelled: the combustion continues till the composition is entirely consumed; the elastic gas generated by the combustion escaping through the apertures.

332. The propelling power is produced by the expansion of the gas generated in the burning composition: the force thus originated causes a pressure, outwards, against the sides and ends of the rocket; but the apertures in the neck allowing the gas to escape there (being resisted only by the pressure of the atmosphere at the apertures), the pressure against that end is consequently less than that which is exerted by the gas against the head, or anterior part of the rocket; and the difference between the pressures at the opposite ends is a resultant force acting against the head during all the time that the composition is burning; this constitutes, therefore, a pressive force by which the rocket moves onwards with a motion continually accelerated

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[a] At first the rod was attached to one side of the rocket; but
great irregularities in the flight, and the late Sir William Congre
in the direction of the axis of the rocket: this disposition in a gr
remedied the evil without interfering with the escape of the gas

till the resistance of the air against the head becomes equal to that force, or till the composition is burnt out, when the rocket falls to the ground. This action of the gas is quite analogous to that which produces the recoil of a suspended gun, when fired without shot or wadding.

333. The rod serves to guide the rocket steadily in its flight, the lateral resistance of the air about it preventing, in some measure, its vibrations. In a 1-lb. rocket, before combustion begins, the common centre of gravity of the rocket and rod is about 2 feet from the head of the former, and about 7 feet from the opposite extremity of the latter; and then the resistance of the air, in checking the vibrations of the rocket from accidental causes, acts with considerable effect, like a power applied at the end of the longer arm of a lever; but, in proportion as the composition is burnt out, the centre of gravity approaches the middle of the length of the whole missile; the resistance of the air is then less able to counteract the accidental deviations of the rocket itself; the head at the same time begins to droop, and at length the whole comes obliquely to the ground. It has happened, even, when the angle of elevation was small, that the weight of the rocket preponderated so far over that of the rod as to cause the missile to come to the ground in a direction tending towards the spot whence it was fired.

Signal rockets, whose diameters vary from 1 to 2 inches, will ascend vertically to a height of 500 or 600 yards; and those whose diameters vary from 2 to 3 inches, to a height of 1200 yards. A 12-pounder rocket fired at an elevation of 16°; and a 6-pounder rocket, at an elevation of 14½°, range about 1200 yards. The distances at which the explosions of rockets have been seen vary from 40 to 50 miles.

334. The use of rockets was first introduced into the military service by Sir William Congreve. This scientific officer caused them to be made to serve as shells or carcasses; and their weights, for these purposes, are 3, 6, 12, 24 and 32 pounds. When fired against timber or earth they penetrate to considerable depths. A 12-pounder rocket, after a range of 1260 yards, has entered to the depth of 22 feet into earth.

Every shell-rocket is fitted with a fuze, screwed into the base of the shell. The fuze is as long as the size of the shell will admit of, so as to leave sufficient space between the end of it and the inner surface of the shell, for putting in the bursting-powder; and the end of the fuze is cupped, to serve as a guide in the insertion of the boring-bit. There is a hole in the end or apex of the shell, secured by a screw metal-plug, for putting in the bursting-powder, and for boring, according to the different ranges at which it may be required to burst the shell. The following table shows the dimensions of the parts of the rocket which relate to the fuze:—

Nature of Rocket.	Distance from the surface of the Shell to the end of the Fuze, in Inches and Tenths.	Length of the Fuze.	Distance from the surface of the Shell to the top of the Cone in the interior of the Rocket, in Inches and Tenths.	Diameter of Fuze-Composition, in Tenths of an Inch.	Diameter of Fuze-hole, in Tenths of an Inch.	Diameter of Plug-hole, in Tenths of an Inch,	Shell contains, of fine grain Powder, in Ounces.	Thickness of the Rocket-Composition above the Cone.
24-pounder ..	1.6	3.3	9.3	.25	.75	.4	8¾	3.3
12-pounder ..	1.	2.5	7.2	.25	.75	.4	3¼	2.8
6-pounder ..	.9	2.	5.7	.2	.55	.25	1½	1.8
3-pounder ..	.7	1.3	4.	.2	.55	.25	¾	1.5

If the rocket is to be used as a shot-rocket, the only thing to be attended to, is to take care that there is no powder in the shell, and that the plug is secured in the plug-hole.

If the rocket is to be used as a shell-rocket, at the longest range, the plug is to be taken out, and the shell filled, the fuze left at its full length, and the plug replaced.

If at the shortest range, the fuze is to be entirely bored through and the rocket-composition bored into, to within one inch and a half of the top of the cone, in the 24-pounder rocket, and to within one inch in the 12, 6, and 3 pounder rockets. The distances from the surface of the shell to the top of the cone, and from the surface of the shell to the end of the fuze, and also the length of the fuze, being fixed and known, the place on the boring-bit at which to screw the sto various lengths of fuzes or length of rocket-co r the cone, is easily determined; these the brass scales for each nature rocket-composition available for boring into, and the lengths of fuze, are also set off, and subdivided into tenths of an inch.[a]

335. The very vague observations on shell-rocket practice given in the subjoined Note, are sufficient to show the great uncertainty of that practice against troops in the field; and to this uncertainty must be added the liability of the sticks to be broken on grazing the ground, when fired at low angles.

The forward motion of a rocket, besides being impeded by the resistance of the air at the head, is further impeded by the action of gravity when the missile is fired at an elevation. Again, in firing across the wind, the action of the air upon the

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[a] The following rules concerning the lengths of rocket-fuzes, the ranges and elevations, may be useful, though they have not been confirmed by an extensive course of practice :—

For 24-pounder rockets; if the whole length of the fuze is left in the shell of the 24-pounder rocket, it may be expected to burst at about 3700 yards, elevation 47 degrees.

If the whole of the fuze-composition be bored out, and the rocket-composition left entire, the shell may be expected to burst at about 2000 yards, elevation 27 degrees.

If the rocket-composition be bored into, to within 1.5 inch of the top of the cone, the shell may be expected to burst at about 700 yards, elevation 17 degrees.

For 12-pounder rockets; if the whole length of fuze be left in the shell of the 12-pounder rocket, it may be expected to burst at about 3000 yards, elevation 40 degrees.

If the whole of the fuze-composition be bored out, and the rocket-composition left entire, the shell may be expected to burst at about 1500 yards, elevation 20 degrees.

If the rocket-composition be bored into, to within one inch of the top of the cone, the shell may be expected to burst at about 420 yards, elevation 10 degrees.

For 6-pounder rockets; if the whole length of fuze be left in the shell of the 6-pounder rocket, it may be expected to burst at about 2300 yards, elevation 37 degrees.

If the whole of the fuze-composition be bored out, and the rocket-composition be left entire, the shell may be expected to burst at about 1100 yards, elevation 15 degrees.

If the rocket-composition be bored into within one inch of the top of the cone, the shell may be expected to burst at about 420 yards, elevation 10 degrees.

For 3-pounder rockets; if the whole length of the fuze be left in the shell of the 3-pounder rocket, it may be expected to burst at about 1800 yards, elevation 25 degrees.

If the whole of the fuze-composition be bored out, and the rocket-composition be left entire, the shell may be expected to burst at about 850 yards, elevation 12 degrees.

If the rocket-composition be bored into within one inch of the top of the cone, the shell may be expected to burst at about 420 yards, elevation 8 degrees.

stick causes the rocket to come up more to the wind instead of being driven bodily to leeward, and the stronger the current of air is, the more the rocket points towards the quarter from whence the wind comes. When the rocket is fired against the wind the range is considerably shortened, and when fired with the wind it is lengthened. Thus, in firing across the wind, some allowance must be made for its effects, and the rocket must be pointed by so much to leeward of the object; in firing against the wind, greater elevation than that which the distance requires must be given, and in firing with the wind, less elevation must be given: but the amount of these allowances can only be assumed approximatively according to an estimate of the strength of the wind; and therefore the practice must be uncertain.

336. The author has seen sufficient of rocket-practice on service to convince him of the uncertainty and inefficiency of that weapon in firing at small objects. When used against large towns, which can scarcely be missed, in order to set fire to habitations and other structures formed of combustible materials, rockets may answer well as incendiary weapons; but they are far more formidable to private dwellings and their unfortunate inmates than destructive of military defences and the lodgments of the troops. If a rocket strike the roof of a house it will there stick and set it on fire; but it has not penetrating power to produce any serious effect on the defences of a place.[a] Flushing was set on fire in many places, at the bombardment of that town in 1809, but no mark was left of the rockets having done any material injury either to the defences or the defenders. Rockets may be used with considerable advantage against cavalry, from the scaring effects of that blazing projectile upon horses: they may also be employed efficaciously against squares or masses of infantry, and in dislodging an enemy from villages or towns, which could not otherwise be approached by infantry alone. At the battle of Leipsic, in 1813, the British rocket-troop

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[a] It must be remarked that what is called a shot-rocket is one whos
is not loaded with powder, and which has the top plugged. It is t
only a thin hollow shot, having consequently comparatively small pen
power, and which, like other hollow shot, would break to pieces on
any very hard material.

under the command of Captain Bogue, is said to have rendered essential service; and at the passage of the Adour some discharges of rockets fired across the river checked a French column that was advancing to attack the lodgment which had been effected on the right bank of the river by a body of 600 British troops; but it appears upon the whole that the effects produced by these first uses of this apparently fearful weapon were rather moral than real. Rockets may also be fired from ships against troops or towns with considerable effect as incendiary projectiles; and were used as such by the French in 1844, against the cities of Tangier and Suerah; they have also been found very useful for incendiary purposes in Algiers. The portability of rockets, when great numbers are to be conveyed in countries impracticable for wheel-carriages, renders them very desirable weapons with troops in the field, and even with the artillery of an army, to be used on special occasions, as when guns cannot be brought up.

337. Sir William Congreve enthusiastically believed that his rockets would entirely supersede the use of artillery in the land-service, and many exaggerated opinions were once entertained of the efficiency of that weapon; but these have long since sobered down to the idea, now very generally prevalent, that they are only substitutes for field-guns, when these cannot be brought up; they may easily be carried by men or drawn by horses, and may commence firing upon an enemy before artillery could be brought into position. The most efficient use, however, that can be made of rockets is, as an incendiary projectile, to set fire to towns or single buildings; but it may be doubted whether the rocket system is not carried too far for field-service in the organization of rocket-troops. These consist of mounted men, as in the horse-artillery, with a number of carriages for transporting the rockets and their appurtenances. The carriages cannot be brought up unless the country in which they are to act is practicable for them; and if so, would it not be better that a troop consisting of so many men, carriages, and horses, should have guns rather than rockets? According to the present organization of rocket-troops, these very uncertain weapons are made substitutes for artillery which the same number of carriages might transport and the same number of

men might serve. M. Charpentier, in his 'Essai d'Artillerie,' p. 199, makes the following very just observation respecting extreme opinions on the value of rockets:—" Quelques militaires regardent les fusées de guerre comme des projectiles insignifiants. D'autres, s'exagérant leur puissance destructive, en font une sorte d'invention infernale, dont ils voudraient, dans des vues philanthropiques, voir l'usage interdit. Il y a erreur de part et d'autre. Les fusées incendiaires peuvent avoir un effet très-utile dans certaines circonstances de la guerre, ne fut-ce que pour porter la démoralisation chez l'ennemi." [a]

Thus in the affair at the Adour, in 1812, the French soldiers were certainly very much scared, but not much hurt; one of them, who was made prisoner, had the skirts of his coat set on fire by a rocket, and on surrendering exclaimed in great consternation—" Sacré Dieu! j'ai vingt ans de service et je n'ai jamais vu des armes à feu comme celles-là." But, continues M. Charpentier, if rockets are powerless against the strong materials of ships of war, they may be used with great efficacy against places on a sea-coast, to protect landings, and against crowds there assembled; and, accordingly, they should be plentifully supplied to steam-ships, which, having small draught of water, may approach close to an enemy's coast, and by using these incendiary projectiles compensate advantageously for the small number of guns to which their armament must be limited. Thus large proportions of rockets are issued to steam-ships in the French navy, and even to other vessels.

338. But rockets are dangerous inmates in ships: there is no space to stow them in shell-rooms or magazines, nor would it be proper to place them there. A terrific exemplification of the danger of these incendiary bodies, in ships overmuch provided with weapons of this description, is given in the subjoined note.[b]

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[a] "There are military men who consider rockets as weapons of small value; and there are others who, exaggerating their destructive powers, consider them as a sort of *infernal* invention, the employment of which they would, from motives of philanthropy, interdict. Both parties are in error: rockets can be employed with advantage in war only as a means of producing disorder among an enemy's troops."

[b] "A terrible misfortune has occurred [illegible] 'while at sea, and in the passage from Torbay t[illegible] of a gunner, who had in his possession [illegible] exploded. About five o'clock in the mo[illegible]

Rocket firing from ships is a very dangerous practice. The first rush of back-fire before the rocket starts is capable of igniting any combustible body upon which the tongues of the flame act. An expedient, we believe, has been proposed, to protect the ship from this back-fire, but it does not appear to have been successful.

339. When, to all the other aberrations to which a projectile is subject in its flight, we add that the trajectory which a rocket describes is made up of two portions produced by very different causes and governed by different laws, the very great uncertainty of rocket-practice will be obvious. When it first starts from the tube, the velocity is so small that it is not sufficient to prevent the fore part of the rocket from drooping or dipping below the axis of the tube; the actual angle of departure is, therefore, less than that at which the tube is set, and allowance for the error can only be made by a vague estimation. As the rocket proceeds its velocity increases, and is supposed to be greatest at one-third or one-half the range. The common centre of gravity of a rocket and its stick on starting is situated near the propelling power, and the vibrations of the rocket during its flight take place about that point; this point is, however, continually changing its place in proportion as the composition is consumed, and this change causes continual irregularities in the deviations of the rocket during its flight. When the composition is entirely burnt out, the rocket proceeds under new and very different conditions: so that upon the whole it is utterly impossible to lay down the trajectory of a rocket, or to obtain good and sufficient rules for conducting the practice with that arm.

340. A very ingenious method of dispensing with the stick of the rocket has recently been proposed by Mr. Hale. This consists in causing the rocket to rotate on its axis during its

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sion was heard, like a clap of thunder, on board. At the same moment the rappel was beaten, minute-guns were fired, and orders given to get out the boats. The shock was so great that the whole of the lights were extinguished; darkness the most complete prevailed; and the crew ran a risk of being suffocated by the smoke of the powder. Nothing was heard but the cries and moanings of the wounded, the greater part of whom were as if buried under the timbers. Twenty seamen, whose forms had lost all human appearance, were found amongst the ruins. Ten of them died in half an hour after, and it is feared that very few can be saved. The 'Valmy,' damaged completely in her inside, is to put into Brest to be repaired."

flight; and, as in the case of an elongated shot, move steadily with the point foremost. For this purpose, instead of permitting the rush of flame to escape from the bottom orifice in a line with the axis of the tube, by which the flame acts directly against the air, the burning material issues from five orifices made near the neck, obliquely to the axis of the tube; the effect of which is that the body of the rocket is made to rotate while it is also propelled. This is certainly a very ingenious contrivance, which may be expected to produce advantageous results. In the experiments made with these rockets several modes of directing them have been tried. First, by firing them from a small trough formed of wood in two inclined planes. Secondly, from a frame, carrying two portions of rings, which grasp the body of the rocket and retain it in one position till it has acquired, after ignition, sufficient force to overcome the pressure of a spring below it; this force, suddenly releasing the body from the rings, permits the rocket to escape with a velocity sufficient to prevent the usual droop or dip above mentioned. This droop was supposed to be the cause of the failures in some previous experiments which had been made at low angles of elevation without the rings. Thirdly, the rockets were directed by a circular machine consisting of three hoops made of iron bars, between which the rocket was introduced; on being ignited, it proceeded round the circle between the bars with increasing velocity, and escaped at the lower part of the machine with force sufficient to prevent any droop as well as to carry it to a very great distance.

341. These rockets were not recommended by the select committee, on account chiefly of their liability to failure at low angles; but, whatever may be their present defects, they appeared to the committee to be capable, when further improved, of being made very valuable weapons.

Unless the cause of the failure of the Hale-rocket, when used at low angles, can be removed, it will be of little use against troops in the field; and it is in horizontal firing, on plane battle-fields, that rockets are most formidable. In other respects also the success of the Hale-rocket may be doubted: the stick-rocket continues its flight, directed by the stick, after the composition is burnt out; but the Hale-rocket loses its directing power as soon as the composition is consumed, because the rotation then ceases, and nothing can be expected from the rocket, beyond the distance it has reached when the composition ceases to burn.

SECTION X.—ON THE ATTACK OF MARITIME FORTRESSES.

342. The bombardment of a fortified place is more destructive to the non-combating inhabitants, generally very numerous, than to the defenders of the works, who, when not on duty, are lodged in shell-proof barracks; and it produces less effect upon the military works than upon the dwellings of the citizens. In fact, the object of the bombardment is to compel the garrison to surrender, not by the injury which it may sustain, but by the slaughter and misery inflicted on the unoffending inhabitants; and no retrospect can be more afflicting than that which intrudes on the mind of one who, like the author, has witnessed the horrors of a bombardment.

When the very existence of a nation is menaced, when, consequently, self-defence, active as well as passive, is a paramount consideration, the infliction of the greatest possible injury on the aggressor, by any means whatever, becomes justifiable; but, in a war of policy, which should be directed rather against the chief of a state and his forces than against his subjects, a measure, the dreadful consequences of which fall upon these alone, must inevitably engender among them feelings of bitter animosity against the nation by which they have been so cruelly outraged.

343. But, if it be determined that a place, whether it be an inland fortress or a naval arsenal, shall be bombarded, the ordnance used should be of large calibre, and mortars should be employed rather than howitzers. When the object is to crush buildings or destroy shipping, bomb-shells, fired at considerable angles of elevation should be used, in order that the momentum acquired in their descent may be sufficient to penetrate magazines or casemates down to the foundations, and there exploding, set fire to the buildings and create havoc and disorder among the troops; or, should they fall on ships, either pierce through and sink them, or, by exploding, blow them up. Neither per-

cussion nor concussion shells, fired at comparatively small elevations, will serve this purpose; and it may be doubted whether any time-fuzes can withstand the shock of the charge which must be used in firing excentric shells (Art. 192) from a 68-pounder gun, or a 10-inch shell-gun, to obtain a range of 5000 or 6000 yards. But it is known that the fuze of a 13-inch shell will resist the shock produced by the explosion of 20 lbs. of powder in a sea-service mortar, and the fuze of a 10-inch shell will resist the shock produced by 10 lbs. of powder. The effect of the recoil of a 10-inch shell-gun downwards on the deck of a steamer, severely damages the vessel by straining it in every joint; but no distress is caused by the discharge of a 13-inch shell in a mortar-ship, in which the ordnance is placed on a solid mass of material resting on the bottom of the vessel.[a]

344. For the bombardment of a naval arsenal, the 13-inch

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[a] The ranges of the 13-inch and 10-inch sea-service mortars differ very little from each other, the former being 4200 yards, and the latter 3090 yards, the elevations in both cases being 45 degrees (Tables II. and III., Appendix B). The weight of a 13-inch mortar is 101 cwt., that of a 10-inch gun 86 cwt., and of a 68-pr. gun 95 cwt. The weight of a 13-inch shell, empty, is 190 lbs., and that of its bursting-powder 6 lbs. 12 oz.; the weight of a 10-inch shell, empty, is 85 lbs., and that of its bursting-powder 2 lbs. 12 oz. Lastly, the weight of an 8-inch shell, empty, is 41 lbs., and that of its bursting-powder 1 lb. 14 oz. ('Artillerist's Manual.') The practice of these large shells, from their comparatively small initial velocities, with respect to range, time of flight, and velocity in the curve, may be determined with tolerable precision from the parabolic theory (see Art. 49, Note). A range of 4000 yards, or about 2¼ miles, is quite adequate to the bombardment of any arsenal, with its magazines, barracks, dock-yards, and basins: these could scarcely be missed at every discharge, and a few 13-inch shells would suffice to crush the buildings and destroy the shipping.

In 1856 a 13-inch sea-service iron mortar, weighing 103 cwt., which had been cast in the preceding year at the Low Moor Foundry, was experimented on at Spithead, for the purpose of trying its strength, under the direction of Sir Thomas Maitland, and subsequently at Fort Cumberland, by the officers of the Royal Marine Artillery. At the first of these places 160 rounds were fired, and at the other 1249 rounds, all with charges of 50 lbs. of powder. At the last round the mortar burst in a direction, as usual, from the vent to the notch at the muzzle. At Fort Cumberland the first 300 rounds were fired in one day, but the subsequent rounds at greater intervals.

The chamber of the mortar was found to be uninjured, but the part of the bore near the mouth of the chamber and between the dolphins was considerably scored, which was ascribed to a rush of gas towards that part. Metal caps were introduced at the bottom of the chamber, which probably tended to protect it. After about 600 rounds had been fired, the bottom of the vent became rather rough; the rough part was [illegible] an instrument. but after a few more rounds had [illegible]
it was then filled up with zinc, [illegible]

mortar is a most valuable piece of ordnance; and, as its transport by sea is neither so difficult nor so costly as by land, the considerations which prevent, or impede to a great extent, the employment of these, and of 10-inch mortars, in the land-service, are not sufficiently cogent to warrant the disuse of such ordnance in naval expeditions. It appears to the author that a large fleet, fitted out specially for the purpose of bombardment, should be provided with a certain number of bomb-ships. These are very inexpensively furnished, draw little water, and may be towed to their fighting positions by small steam-tugs: an officer and a few marine artillerymen suffice for the service of the mortars: they are also small objects for the enemy to fire at; and, if destroyed, there is comparatively little loss in value, and small risk of life. Seven bomb-ships were attached to the Baltic fleet in 1801, and, from these, at the time of forcing the passage of the Sound, shells were thrown into Cronenberg with considerable effect, while the fleet sustained no injury whatever from the enemy's guns. Admiral Nelson made use of those bomb-ships at the battle of Copenhagen; and to this bombarding power was greatly indebted in bringing those very critical operations to a successful termination. In the British naval service, though bomb-ships no longer exist, 13-inch and 10-inch sea-service mortars are retained (see Table XXIV., Appendix B): from this it appears that horizontal or howitzer shells, fired from the pivot-guns of steam-frigates, are supposed to be efficient substitutes for mortars in bombardments of fortresses and naval arsenals: but this is not so; and therefore to employ large and costly steam-ships in this way is to incur a risk of very great loss in property and life, without the power of accomplishing the peculiar conditions required in bombardments, and which mortar-shells can so much more effectually fulfil.[a]

345. The most recent cases of vertical shell-firing which have occurred since the termination (1815) of the general war, are those carried on by the French. The bombardment by the French squadron of San Juan d'Ulloa in 1838, and of Vera Cruz in 1839, may be taken as proofs of the uncertainty of vertical

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[a] The above paragraph was written before the present gun-boats and floating-batteries were constructed. See Arts. 372, 386.

shell-practice against castles or other small places, as well as of the inability of fleets to contend with fortresses and other powerful land-batteries, unless the ships be very close to them. Whether the attacking ships or squadrons should, under any circumstances, be permitted to approach to such proximity unopposed, are questions which will be surely solved in the negative, whenever it may happen that ships, advancing with such temerity, shall be properly *cannonaded,* as soon as they come within the reach of well-placed, powerful and well-served long-range guns. This not having been done at Algiers and Acre, and we may add Navarino, the daring and success of the operations against those places have tended to create the erroneous notion that land-service batteries cannot under any circumstances withstand the concentrated fire of ships of the line.

346. If, indeed, ships be permitted to approach, with impunity, to measure well their distances from a fortress, and then deliberately open their fire, the torrent of iron which they may throw in must be irresistible and overwhelming, particularly if the batteries are placed *à fleur d'eau,* and consequently commanded by the upper decks of large ships. Batteries placed nearly on a level with the water are far more subject to the fire of ships, and are much less formidable to them, than batteries elevated somewhat above the surface of the sea: these last command the upper deck of a ship by a direct, though depressed fire, which will penetrate obliquely into, and through her sides, and possibly come out below the water-line; whereas shot, even the best directed, from the ship, will, except such as may chance to enter the embrasures, or graze the crest of the parapet, pass over the heads of the defenders in the battery without doing any material harm. Should any guns be mounted *en barbette,* which ought never to be the case in sea-batteries intended for close or flanking defences, they would inevitably be dismounted. No ricochet from a ship can touch a battery in a commanding position; whilst, unless the battery be situated so high that its shot would strike the water under angles exceeding 3° or $3\frac{1}{2}$° (Art. 142; see also Arts. 163-167), shot ricocheting on the water will strike the ship.

In the 'Aide Mém that the
height of a coast or

be from 10 to 15 mètres (yards), because that height will permit the ricochet to take effect as far from the battery as about 200 mètres (yards), and will avoid the effect of the ricochet of shot fired from ships' decks, which are only from 5 to 6 mètres (yards) above the water-line.

It is not easy to assign any general rule for the most advantageous height of a battery above the level of the sea, because that level alters with the tide: the height should also depend on the degree of proximity to which vessels may, from their draught of water, approach to attack. It may be stated in general, that all batteries should have some command over the body fired at. The most favourable situation for a gun battery in the field-service is about one hundredth part of the range above the position of the enemy.[a] But this low command is sufficient only in firing against troops: when the fire of one battery is directed against another, a more considerable command is of great importance. At the siege of Burgos, in 1812, the batteries of the place were 50 feet above the breaching-battery, at the distance of 150 yards only; and their effect was irresistible, the shot plunging on the very platforms of the besiegers' battery.

M. Sar, in his 'Cours d'Etudes Militaires,' pp. 349, 350, 359, *et seq.*, has treated this subject with great perspicuity and intelligence: his words are to the following effect—"The experiments which, at different times, have been made prove that shots *ricochet* more perfectly on water than on land; and, according to Gassendi, all ricochets with elevations of 2, 3, and even 4 degrees, cause large shots to lose very little of their force."—pp. 348, 349.

"A battery of 10 pieces, served by skilful gunners, firing in succession, would soon overpower a ship, whatever might be her force, especially if the guns are of high calibre, or if red-hot shot are projected."—p. 350.

"The shot from ships whose decks are 6, 12, or 18 feet above the water cannot, in ricocheting, [illegible]e up to the battery, while the latter can employ both a direct and a ricocheting fire against the whole body of the ship. On the other hand, only those shots from the ship can take effect which pass 18 inches above the

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[a] 'Practice Cards' by Lieut.-Colonel Burns.

parapet of the battery, since the guns in the latter are only so far exposed, and the gun itself covers the head of the man who points it; all the rest of the service is performed behind the parapet. Thus the ship, for every 18 feet length of gunwale, has no other object to aim at than the muzzle of a gun presenting only about 2 square feet of surface, while the battery has before it an object presenting 2000 square feet of surface, independently of the masts, ropes, and sails."—pp. 350, 351.

347. Land-batteries properly placed, well armed and skilfully served, may open with great effect on an enemy's ships at great distances, and keep up, as the latter approach, a continued and deliberate fire, the effect of which will become still more formidable in proportion as the ships are nearer. This fire the ships cannot return but by their bow-guns, until they shall have taken their position for attack; and during all that time they will have been severely maltreated.

While ships are approaching, under fire of the heavy ordnance with which coast-batteries should ever be armed, a few well-directed shells, having time-fuzes, thrown in at suitable distances, to act against the whole expanse of a ship—masts, sails, and body—can scarcely fail to produce very severe dismantling effects, which will very much interfere with, and impede the operations they have yet to execute, before they can open their fire with any safety or effect; and Shrapnel shells well applied during the operation of furling sails, would be extremely deadly to the crowds of hands then aloft.

348. In the naval attack of Sevastopol, 1854, each sailing-ship was led to its station by a steam-vessel lashed alongside, and this is a more effectual method than towing would be; but the best application of steam-power for battle purposes is evidently that in which the propulsion is inherent in the ship itself. The Prince de Joinville's ships, in his attack of Tangiers, were towed into their positions by steam-traction; but, besides the difficulty of passing a tow-rope from one ship to another, th
is the greatest risk of its breaking or being cut
the steam-vessel itself may be disabled.

349. Lord Exmouth, in the "Queen Charlot
to approach and anchor with impunity within
Mole of Algiers! He then opened his fire, and

a torrent of projectiles as to silence every gun opposed to him, with the loss of only 8 men killed and 131 wounded. But the "Impregnable," which was fired upon at 1200 or 1500 yards' distance, had 50 men killed and 138 wounded, and was greatly damaged in her material: thus the ship engaged at a distance sustained greater loss and damage than that which fought in close action. And it appears that only those ships which were very near the enemy silenced the batteries with which they were engaged.

The British fleet was permitted to approach Acre almost without any opposition; to sound as they advanced, to buoy the positions which the several ships were to take up, and then to open a most destructive fire upon the place, which was very inefficiently returned.

It did not escape the sagacity and vigilance of the Duke of Wellington, in voting the thanks of the House of Lords to the admiral, officers, and seamen engaged in that successful operation, that wrong and perilous impressions might be created as to the ability of fleets to contend with fortresses in general; that the achievement of Acre was an exceptional case, and that it would not be safe or practicable to do the like against fortresses or land-batteries well armed and skilfully defended. Thus His Grace, after expressing his cordial approbation of the services performed by the navy in the Mediterranean, and of those who were engaged in that glorious expedition, goes on to say:—

"He had a little experience in services of this nature, and he thought it his duty to warn their Lordships on this occasion that they must not always expect that ships, however well commanded or gallant their seamen might be, were capable of commonly engaging successfully with stone walls.

"He would repeat that this was a singular instance, in the achievement of which great skill was undoubtedly manifested; but which was also connected with peculiar circumstances, which they could not hope always to occur. It must not, therefore, be expected, as a matter of course, that all such attempts in future must necessarily succeed."[a]

350. The victory of Copenhagen in 1801 was dearly pur-

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[a] 'Hansard's Debates,' vol. lvi. p. 254.

chased—the loss in killed and wounded was far greater, and the ships more severely damaged, than in the great battle of Aboukir, especially in their hulls; most of them had several of their guns rendered useless, whilst the land-batteries were comparatively little damaged.

The "Agamemnon," "Bellona," and "Russell," having run aground, occasioned gaps in the British line, which exposed the van-ships to a greater share of fire from the enemy's land and floating batteries than was intended; on perceiving which the gallant Riou in the "Amazon," with the frigates "Blanche" and "Alcmene," and two sloops, bravely attacked the Crown batteries, but suffered so severely that they were obliged to haul off, by which they were probably saved from destruction. If the Crown Prince of Denmark had refused to listen to Nelson's overtures for a cessation of fire,[a] Nelson could neither have withdrawn his crippled ships nor effected his own retreat, in compliance with the signal of recall, if he had been disposed to obey it; for the Crown batteries, which had driven off the frigates, effectually stopped that outlet. But the British fleet on that occasion was provided with powerful bomb-ships, which had taken position behind Nelson's line, and which continued, throughout the action, to throw their shells into Copenhagen, over the ships in line of battle, and might, if hostilities continued, bombard, and in great part destroy, the city on the morrow. This the Crown Prince well knew, and to save the capital from the horrors of a bombardment, ordered the fire to cease.

The Crown batteries were the great difficulties with which Nelson had to contend: to attack Copenhagen from the south, it was necessary to pass under the fire of those powerful works, in order to get into the King's Channel, an attempt which was at first meditated, but afterwards abandoned for the purpose of avoiding their fire; and the attack was made through the passage to the north of the Middle Ground, the ships entering the Royal Channel by the south. When the crippled state of many of Nelson's ships rendered it advisable to endeavour to withdraw them as soon as possible from the intricate channel in which

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[a] The circumstances under which wax was used instead of a wafer, prove an intention to avoid giving ground for an opinion that the letter was sent off in haste.

they had gallantly fought, but severely suffered, it was clear that the Crown batteries, which had not been directly engaged since the defeat of the frigates under the gallant Riou, and had subsequently been reinforced with fresh men, would effectually prevent the passage of any ships through the outlet which those batteries commanded: but Nelson was happily extricated from this very painful, and perhaps perilous predicament, by the acceptance of his overtures for a cessation of fire, or the result of the battle might have been somewhat different.[a] However this may have been, this, at least, is certain, that it would not be prudent, with fleets only, to repeat such an attempt against fortresses or powerful batteries armed as all now are, and provided with expert gunners and skilful bombardiers.

When Copenhagen was attacked in 1807, with a large military force, combined with a powerful fleet, the place and all its sea defences were first invested on the land side, then besieged, bombarded, and captured; and thus the naval objects of the expedition were accomplished without much difficulty, and with the loss of only 56 killed and 179 wounded in both services. The loss of the Danes in killed and wounded in the naval and military operations, external to the city, was much greater: in the subsequent bombardment, 305 houses were destroyed, many more much injured, and 2000 inhabitants, men, women, and children, perished: not a man was hurt in the attacking batteries, but an armed transport, was blown up by a mortar-shell fired from the Crown batteries, and by which the master of the transport, 2 officers, and 28 men were killed and wounded.[b]

351. At Navarino the combined fleet was permitted to pass under the guns of commanding and powerful batteries; which, had they opened, as they ought, on the ships of a fleet entering in this equivocal if not hostile manner, would have severely crippled these ships before they could have got into position to engage the Turkish fleet.

352. In 1814 a French 80-gun ship, in attacking at anchor a 2-gun battery in the Scheldt, mounting one long 18-pounder gun and one 5½-inch howitzer, at a distance of 600 yards, was

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[a] James' 'Naval History,' vol. iii. p. 74; *De la Gravière*, vol. ii. p. 14, *et seq.*

[b] James' 'Naval History,' vol. iv. p. 290.

beaten off with the loss of 41 men killed and wounded, besides being severely damaged in her hull. The battery lost only 1 man killed and 2 wounded. No doubt the howitzer shells fired from the battery contributed greatly to its success, but shell-firing from a 5½-inch howitzer, at 600 yards, could scarcely have penetrated the side of an 80-gun ship; it must have been chiefly by the solid shot of the long gun that the vessel was so severely damaged as to be in a sinking state. The ship might, it is said, have been sunk or captured had the position of the battery been such as to have given it a more oblique command of the ship.

353. Sir Sidney Smith, in the "Pompee" of 80 guns, with the "Hydra" of 38 guns, and the "Aurora" of 28 guns, cannonaded, at 600 or 700 yards' distance, a 2-gun battery protected by a tower; both battery and tower being placed considerably above the level of the sea. The two frigates remained under weigh, and occasionally fired at the fort, but without silencing it; at length the marines landed in the rear of the battery; and on their approach the serjeant in command of the post immediately surrendered. This shows in principle, though on a small scale, the advantages of a combined attack by land and sea. The "Pompée," having remained stationary at anchor, had 35 men killed and wounded, and received 40 shot in her hull.

In the engagement between the "Loire" frigate and a fort armed with 12 long 18-pounders, the fort being placed in a commanding situation, the disadvantage of an attack by sea was strongly exemplified; the defenders of the fort were so well covered that the frigate's fire, though accurately directed, was comparatively ineffectual; whilst almost every shot from the fort struck and penetrated the frigate, so that in a very few minutes of this unequal warfare, the "Loire" sustained consi able loss (James' 'Naval History,' vol. iv. p. 135).

354. The batteries which the "Christian the Eighth" so discreetly engaged, were placed 18 feet and 12 feet above level of the sea. The first was armed with two 8-inch g (French) and two brass 24-pounder siege-guns; and the sec with four 18-pounders.

The Danish commander in his official Report states finding, after much expenditure of ammunition, the s suffering greatly from the fire of the most elevated battery, while that of the "Christian the Eighth" and other vessels made no material impression upon it, he withdrew from his position and engaged exclusively the lower but weaker battery, mounting four 18-pounders. His ship soon afterwards blew up, having been set on fire by shells and red-hot shot fired from the commanding battery. (See Colonel Stevens' account of that catastrophe.)

355. From all that has been said respecting horizontal shell-firing against ships, it is plain, that the inability of fleets or squadrons to contend with fortresses and land-batteries, if they are properly armed and their guns well served, is much greater now than it was in the cases to which we have referred, in the late war. Nearly half the armament of our ships consists of ordnance neither designed for, adapted to, nor capable of encountering heavy-armed land-batteries. The smashing effects of hollow shot[a] of large diameter, and the ravaging effects of horizontal shells on ships, in close and the closest action, were the objects for which shell-guns have been so largely introduced into the broadside-batteries of our ships. And we must observe that the heavy guns and solid shot, whose battering and penetrating powers were so great, and which formerly stood on the lower decks of our ships, and the main decks of our frigates, have been displaced by ordnance incapable, at any distance, of contending with fortresses (the reader is requested to refer to the table of relative penetrations of solid and hollow shot, Art. 250, p. 244). In fact, the force of our wooden walls, applied against stone walls, is reduced to the number of solid-shot guns which may yet remain on the upper decks.[b] Hollow shot and shells

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[a] Hollow shot ought only to be used (if ever without being loaded) at very limited ranges. At such ranges their velocity is sufficient, their *smashing* effects, from their volume, very great; and they possess that great advantage of being more readily handled than the solid shot of equal weight; but at considerable ranges, solid shot are efficient, where hollow shot would be useless.—*Simmons*, p. 28.

[b] It has been already stated (Art. 217, p. 178) that, since 1838, when the 42-pounder ceased to be a naval gun, the largest solid-shot gun in the British Navy is the 32-pounder, whilst in other navies guns of larger calibre form the armament of the lower decks of line-of-battle ships. Thus it appears that the real battering power of our line-of-battle ships in respect to solid-shot guns is not in general so great as it was during the late war, when many of our ships carried 42-pounders, and, as James states in several places, did good service

break to pieces, and solid shot frequently split, on striking walls of granite or scarps of hard stone.[*]

356. Horizontal shells, which have been shown to be so destructive when fired from ships, against ships, will be very

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with them (the "Britannia" for example, vol. i. p. 262). This reduction in the battering power of our ships is now further, very materially, diminished by displacing solid-shot guns on the lower decks and arming the ships, many wholly, and others chiefly, with 8-inch shell-guns.

The advocates for retaining the 42-pounder in the United States' Navy argue that its superiority to the 32-pounder, in respect of accuracy, penetration, and the magnitude of the fracture it makes, is nearly as 2 to 1; while, for the same weight of battery, the 32-pounder outnumbers the 42-pounder only as 4 to 3: hence the relative values of the 42-pounder and 32-pounder are as 3 to 2. A higher ratio than that of the weights of the two natures of shot.

[*] L'effet des obus contre la maçonnerie est à peu près nul; ils se brisent au moment du choc, ou bien, tirés à de très-petites charges, ils ne produisent que des impressions très-faibles.—'Metz Experiments,' 1834. 'Aide Mémoire,' p. 434. The like results were obtained from the Experiments of 1839 at Fort Monroe.—'United States' Ordnance Manual,' p. 372.

From a summary of experimental practice against a four-foot square wrought-iron plate ⅝-inch thick, fixed against a solid granite-block placed oblique to the line of fire from a 32-pounder of 56 cwt. with solid shot, and charge 10 lbs., in order to ascertain up to what angle it would deflect, it appears that every shot broke or split into pieces. Thus neither hollow nor solid iron round-shot will avail for destroying such a hard material (see the table below). Perhaps 8-inch hollow shot, filled with lead and fired from 68-pounder guns, with charges increased in the ration of the weight of the solid shot of 68 lbs. to that of the hollow shot filled with lead, might produce some impression on granite. The iron or shell would no doubt break, but the lead would not, and, the velocities being equal, the momentum of the blow would be greater than that of a solid 68-lb. shot in the ratio of their respective weights.

Angle of the surface with the line of fire.	Charge.		Deflection of the fragments.
10°	10 lbs.;	shot broke	4½°
12½°	"	"	17½°
15°	"	"	13°
17½°	"	"	30°
20°	"	"	21°
22½°	"	"	18½°
25°	4 lbs.	"	21¼°
27°	10 lbs.;	shot broke into 4 pieces	11°
27°	4 lbs.;	shot broke into 4 pieces, and many small ones	21¼°

Two rounds were fired at an angle of 30°, formed by the line of fire, with the surface of a 5⅝-inch wrought-iron plate, 4 ft. square, fixed against a 4 ft. cube mass of oak, built of squared logs.

30° Charge 10 lbs. The shot broke; some pieces went through the plate, and some deflected.

30° Charge 4lbs. The shot broke; one half went through the plate, and upset the whole mass of oak; the other half deflected in broken pieces.

generally used, with greater relative advantage, and more safety to the users, from *land-batteries*, against ships; whilst shell firing from ships against batteries, and with percussion-shells in particular, will produce little or no effect on the material of which the batteries are formed, whether earth, or blocks of granite, and still less against the *personnel* posted behind parapets which cannot, like timber, be penetrated, ravaged, or set on fire by shells. Solid shot only, with the highest charges, should be employed against a stone casemated battery, and the fire of such shot should be *convergent*. It may be imagined that if sixty 32-pounders (the broadside-battery of a ship of 120 guns) were fired nearly together, at a distance of 400 or 500 yards, the momentum would be sufficient to make a considerable breach in the wall.

In promulgating these opinions, and giving these cautions, upon a matter of such vast, and perhaps immediate importance, the author is naturally desirous of availing himself of the support of any influential and competent judgment expressed in other works which may inspire confidence in his conclusions; and finding in a recent publication—'Report on the National Defences of the United States'—some very remarkable coincidences of that description, he extracts the following:—

"So far as the new projectiles are concerned, these have, relatively to ships, strengthened forts; for hollow shot crumble into fragments, and strike harmless, when directed against stone walls. It takes solid shot, and plenty of them, rapidly discharged and concentrated upon or near one spot, to batter walls and make breaches. On the other hand, a few 8 or 10 inch shells fired from forts at ships, pass through the side of any line-of-battle ship into the main or lower deck, and, there exploding amidst the dense crowds at the batteries, every fragment multiplies itself in countless splinters of wood and iron; or, if a shell enter the orlop-deck among the men passing the powder, or, lower still, strike the water-line, large irregular splinters will be torn out, leaving openings which will defy all shot-plugs. Changing the scene to a steamer, it has been said that, compared with a sailing-ship, a steamer has many more vulnerable and vital points. No! ships armed with hollow-shot ordnance will do well to prefer contending with something similarly constructed. No ship or ships can, at this day, lie under a fort having furnaces for heating shot, in addition to its murderous shells."[a]

The principle laid down in this admirable work on the national defences of the United States is that all assailable points should be guarded by forts, so as to leave the naval forces free. Forts can be made impregnable against any naval force that could be brought against them, and are needed for the protection of our fleets while preparing for hostilities on the ocean. The government and people of the United States view not with favour the substitution of floating batteries for permanent land defences, on account of the perishable nature of the former, and the inefficient state in which they may be when sudden danger menaces. The value which they might have, if in perfect order at the moment of being wanted, ceases as soon as the occasion which called them forth no longer exists; and their speedy decay is certain. To leave the defence of harbours and other permanent establishments to temporary constructions so costly as ships, which are formed of perishable materials, would be to expend enormous sums in a manner which would invite attack by sea. If we rely for our defence on our naval force, no portion of it should be permitted to leave our coasts for the protection of our foreign commerce, in the event of an alarm of war occurring. To employ our active navy, in whole or in part, for defence, instead of strengthening our fortifications and raising new ones, would be to supplant impregnable bulwarks by perishable ones—a fixed security by a changeable one: it would be to expose ourselves to the chances of being suddenly left for a time without adequate defence. In so doing we should resign our sense of security, and our confidence of safety; we should divert our navy from its highest duty, deprive it of its chief honour and its chief claim to the respect and support of the people: we

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[a] Among the various propositions made for the defence of naval arsenals and maritime places in general, floating batteries made of iron so thick as to be shot-proof have been recommended; and, in order to test the value of such constructions, a target, representing the side of an iron floating battery, was formed with seven thicknesses of boiler-iron, well bolted and riveted together. A shot from a heavy gun passed, without difficulty, through the target, and tore out large fragments.—'Report on the National Defences of the United States,' 1852, page 6.

should lose the power of vindicating the national honour and independence, and of asserting the freedom of the seas. The navy is not a defensive, but a protective force.

357. The attack of fortresses and powerful land-batteries with a naval force only, must ever be a hazardous, and perhaps desperate, undertaking. But if skilfully combined with a military force sufficiently strong to make good its landing, to invest the place or the batteries on the land side, to take the defences in reverse, and so open the way to the attack by sea, the object of the attack will in general be successful. But this mode of proceeding can only be applied when the place to be attacked occupies a position, insular or otherwise, of such extent as to admit of being attacked by land as well as by sea.

In combining military and naval operations of this description, the first and main difficulty to be encountered is to effect a landing and establish a lodgment on the enemy's coast, in the face of a large military force, which ought always to make the most determined efforts to oppose a debarkation or prevent a lodgment from being made good; for, as in the assault of a breach, and in forcing the passage of a river, if a solid lodgment be once established on the crest of the one, or on the further side of the other, a fulcrum is obtained which, if skilfully used, and supported with sufficient means, will ensure the success of the enterprise.

A very large army may now be transported with great speed and convenience in a very few large steam-ships to any seat of war, however remote; but to transfer 1000, 1500, or 2000 men from the transports to the shore is a work of considerable time, and requires great numbers of boats, specially constructed, for that purpose. This preparatory operation cannot be attempted or executed under fire from the enemy; and, therefore, the troops intended to force a landing must be embarked in the boats which are to take them to the shore, whilst the transports are anchored at a safe distance. The success of the operation will mainly depend upon the nature of the locality that may be chosen. It should not be too near to the fortress or stronghold to be attacked, because, in this case, the garrisons of the forts or fortresses might safely co-operate with the force in the field, to oppose the landing and attack the lodgment. Nor should the point of debarkation be too distant from the great objective of the expedition, because that would necessitate a long march to invest the place, and much difficulty in getting up the siege-train and stores. How strikingly were these principles exemplified in the miseries suffered by the British army during the invasion of the Crimea in 1854–55, from the inconvenience of the harbour at Balaklava, and the distance from thence to the scene of the operations before Sevastopol (see Appendix C, 'On the Naval Operations in the Black Sea').

If the enemy (exclusive of the force in the garrisons) is not strong in the field, it might be advantageous to endeavour to seize some capacious bay or inlet capable of affording shelter to the numerous ships, vessels, and small craft, and near which a fort might be constructed to serve as an entrepôt and base of operations; but these great objects can rarely be effected immediately: indeed, if the enemy has occupied and strengthened the localities, and if he is, moreover, strong in the field, it would not be prudent to attempt a landing there. In this case some point, deemed apparently by the enemy of minor importance, should be sought for—some promontory, with a nearly level surface, and remote from high lands, having also water about it of sufficient depth to permit the boats to arrive at the beach, and to enable bomb-ships, steamers, and gun-boats to cover the advance of the flotilla containing the troops, support their landing, and protect the lodgment they may form. Having thus obtained a footing, and received such increase of strength as may be deemed necessary, including field-artillery, the whole force should move forward to meet the enemy in the field, and conquer for itself some position which may afford shelter to the fleet, and become a tête de débarquement and base of operations to the invading army. In forcing the passage of a river, the operation is undertaken, if possible, in a sinuosity re-entering with respect to the invaders, and a lodgment is made upon t opposite salient in the enemy's position; the whole interior that position is commanded from the points in the possession the assailants, and consequently the lodgment to be made capable of being supported and protected. ('An Essay on Principles, &c. of Military Bridges,' by Gen. Sir Howard Dou Arts. 157, 159, 3rd edit.). In like manner, in order to a footing on an enemy's coast, a low level promontory or salient should be chosen, because ships on each side of it may perform the same office (commanding the opposite ground) as, in forcing the passage of a river, is performed by the batteries placed at the two salient points which contain between them the re-entering sinuosity. The ships are thus enabled to support the lodgment on the coast and protect the flanks of the troops which have gained the shore. To attempt to force a landing in a bay, reverses these conditions, for the shore of a bay, unless it be very extensive, cannot be held, nor even approached, until both the promontories which contain it are occupied.

358. When the Duke of Wellington, then Sir Arthur Wellesley, invaded Portugal in 1808, it was a favourite object with the ministry that the descent should be made at the mouth of the Tagus. Wellesley decided otherwise, and made choice of a landing-place remote from Lisbon, in order to avoid the danger of a debarkation in face of a large force. He effected his landing at a part deemed by the enemy of minor importance, the mouth of the Mondego River: he moved forward as soon as he could, fought a general action, gained a complete victory, and obtained possession of Lisbon. (*Napier*, 'History of the War in the Peninsula,' Book I., ch. 4.)

359. For great operations of this description any want of mortar-ships, gun-boats having small draught of water, and flat-bottomed boats for landing the troops, would be seriously felt. All the landings of troops in the face of an enemy, in the course of the great war with France, at some of which the author served, were conducted in the following manner. The troops intended for debarkation being placed in the boats out of fire of the shore, were directed by signal to form line abreast on points marked by men-of-war's boats, carrying distinguishing pennants, and containing the naval officers charged with the direction of the several divisions of the flotilla, and the whole was placed under the superintendence and command of a naval officer of rank. When the line was formed, the whole moved forward by signal, rowing easily, the better to keep in line, until within the reach of musketry from the shore, when orders were given to row out. The whole of the operation, from its commencement, was covered by bomb-ships carrying 10 and 13 inch mortars, and these pro-

tected the advance of the troops by firing shells, when necessary, over the line of boats, in order to reach the beach; a like firing, with increased charges, being directed against the enemy's supports in rear of the troops disputing the landing: at the same time gun-boats, drawing little water, placed on the flanks of the operation, scoured the beach upon which the troops were to land. Whilst these operations were being executed, the fleet of line-of-battle ships remained at a distance in reserve, unscathed and ready to take their part in the ulterior operation when the proper time arrived.

When, in 1801, the British army under Sir Ralph Abercrombie arrived in Aboukir Bay, and the weather, at first tempestuous, became calm enough to permit the troops to land, General Abercrombie, who had himself reconnoitred the coast in a small vessel, gave orders for the first division, consisting of 6000 men, to prepare for landing early on the following morning (March 8). The preparations could not be made, however, without attracting the notice of the French; and these disposed themselves, with a numerous force of infantry, cavalry, and artillery, to prevent the invaders, if possible, from gaining the shore. The "Fury" and the "Tartarus" bomb-vessels, with sloops and gun-boats, were appointed to protect the landing of the force, and, though they suffered severely from the fire of the French, the troops succeeded, though with difficulty, and only in detached parties, in making good their landing. The enemy retired, and, on the 21st of the same month, the battle of Alexandria, in which Sir Ralph Abercrombie fell, took place.

360. When the place, fortress, or arsenal to be attacked is covered and protected by isolated points of defence, mutually protecting each other, and when no previous military operation can be made, those points or outposts should be attacked in detail and successively reduced; after which the fleet may arrive at, and attack the main position. This must evidently be a protracted and difficult process even with such means: with ships alone it cannot be effected without severe loss and damage; and it should always be remembered, that many of the attacking ships would be severely injured, probably disabled, in the attempt, whilst the enemy's fleet would remain untouched and in reserve. It would therefore follow, that the attacking fleet must be exposed

to a very disadvantageous action with the enemy in the event of the latter subsequently leaving his place of shelter.

In the Walcheren campaign—ill-fated, unfortunate expedition! yet in this respect instructive—it was at first intended that the fleet, consisting of 10 sail of the line and 11 first-class frigates, should at once force the passage of the West Scheldt, and cannonade Flushing. But Sir Richard Strachan very judiciously determined to remain in the offing until the place should be invested on the land side, and the batteries of attack ready to open. Thus the place, not having been invested on the seaside, became a *tête* to Cadsand, from whence reinforcements to a large amount were sent over to Flushing, until the frigates had forced the passage and intercepted the water-communication between Cadsand and that town. When all was ready, a powerful and irresistible combined attack was made upon the place by the naval and military forces, and it surrendered the next day. Neither of the forces, however considerable, could have succeeded singly in reducing the place. No military force, without the co-operation of the fleet, could have reduced the *tête*, which was capable of being supported to any extent by sea; and the naval forces, without the co-operation of the army, would have been crushed by the artillery of the place, exclusively directed against them.

361. The capture and destruction of Bomarsund, with little loss, and in a very short time, by the skilful manner in which the military and naval forces co-operated with each other in those operations, are satisfactory illustrations—may they prove happy omens!—of the success which, as stated in Art. 357, p. 364, and Art. 362, p. 371,[a] will usually attend all such well-concerted undertakings. The forts were breached, and the fortress reduced to the necessity of surrendering, by a few powerful solid-shot guns landed from the ships of the combined fleet. Shell-guns and hollow shot could not have effected this, whether fired from the land or from ships' batteries. It is no disparagement to the naval forces to assert that they, alone, could not have demolished the defences of Bomarsund in so short a time,

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[a] In the articles to which these figures refer, these results are fully predicated.

and not without much damage to the ships. The firing of shot and shells from the French and English ships, at long ranges, caused no serious injury; but the breaching of the forts, and the skilful establishment of a breaching-battery within 400 yards of the rear of the fortress, rendered all further resistance vain. Major-General Sir Harry Jones states, in his official despatch, that the interior of the place showed that the fire of the ships did such trifling injury, that the governor, with so strong a garrison in a well-casemated work, and without a breach having been formed, ought not to have surrendered; but the batteries, armed with 32-pounder British guns, being ready to open, and the forts destroyed, Bomarsund was no longer defensible. The British admiral exercised a wise discretion in not exposing the ships of the combined fleet to the severe damage they would have sustained by recklessly advancing under the fire of the enemy's seaward batteries; and having conducted with admirable skill the whole fleet through the intricacies of the channels leading to the point of attack, and arranged with his gallant allies and associates the plan of operations, he did right to leave to the land-batteries to do what they so well and skilfully accomplished, and to keep the fleet in reserve, upon the principle that the seaward fronts of such forts being always thicker and stronger than the works, if any, which enclose them in the rear, should never be attacked in front if by any means they can be turned and battered in the reverse. Thus there can be no question that the place was taken by the land attack under Marshal Baraguay d'Hilliers, and the skilful engineers, Major-General Sir Harry Jones and General Niel; and by means so effectual, that, without any other assistance from the naval forces than the loan of a few of their solid-shot guns, and that of investing the place by sea, to prevent succours from being thrown in, Bomarsund must have fallen. Authentic information, for the accuracy of which the author vouches, enables him to state that, in respect to the effects of the solid shot on the granite, with which the walls were faced, the French guns made no impression on the blocks when they were struck perpendicularly in the middle of their faces; nor did the shot fired from the more powerful 32-pounder British guns split the granite when so struck. When, however, the blocks were hit by the latter near the edge, or on a joint of masonry, they were displaced, the joints penetrated, the wall the shaken; and this not being backed with solid masonry, but filled-in with rubble, the mass was thrown down and a practicable breach formed. This successful operation is very generally, but erroneously, stated to have been effected by the fire of the ships, and is even strongly held up as a proof of what ships can do, and ought to attempt, alone, elsewhere. But the results of the experimental firing at the remnant of the fort which, unless the previous firing of the ships during the attack was absolutely harmless, must have been somewhat damaged, and moreover shaken, by the blowing up of the contiguous portions, do not warrant this conclusion, even should the attacking ships be permitted, like the "Edinburgh," to take up, quietly and coolly, positions within 500 yards, and then deliberately commence and continue their firing, without being fired at! (Art. 345, p. 353 at top, and Art. 347.) The firing of the "Edinburgh," at 1060 yards, was unsatisfactory: 390 shot and shells were fired from the largest and most powerful guns in the British navy (viz. from the Lancaster gun of 95 cwt., with an elongated shell of 100 lbs.; from 68-pounders of 95 cwt. and 32-pounders of 56 cwt., solid-shot guns; from 10-inch shell-guns of 84 cwt., with hollow shot of 84 lbs.; from 8-inch shell-guns of 65 and 60 cwt., with hollow shot of 56 lbs.), but did little injury to the work. At 480 yards, 250 shot, shells, and hollow shot were fired: a small breach was formed in the facing of the outer wall, of extremely bad masonry, and considerable damage done to the embrasures and other portions of the wall; but no decisive result was obtained—no practicable breach formed by which the work might be assaulted, taken, and effectually destroyed (Art. 363), although 640 shot and shells (40,000 lbs. of metal) were fired into the place, first at 1060 and then at 480 yards. Several casemates had fallen in, the embrasures not having been made high enough to admit of giving the guns sufficient elevation for very distant firing, in attempting which the key-stones were actually blown out, the casemates ruined, and their guns rendered useless. The Lancaster shells, of which such high expectations were entertained, failed signally in precision of fire, even at 480 yards, and evidently cannot be depended upon, even when fired from a large and steady ship. What then can be expected from those guns and projectiles, at 5000 yards, when fired from the side of a crank Despatch gun-boat? (Art. 371). Shells, whether percussion or time fuzed, and hollow shot, broke on striking the granite (Art. 355, and Art. 356, p. 362); and it was found that percussion-shells could be of no use in such a case (pp. 313, 329, at bottom), whereas time-fuzed shells might produce their effects upon the personnel in the interior of the fort, by entering a casemate through an embrasure, and then exploding. It is of very great importance that the facts of the case should be rightly understood, lest wrong notions should induce the attack of more formidable places which do not admit of military co-operation, with ships alone; and which the author repeats, now more confidently than ever, would be a desperate and perilous experiment.

362. When the fortress or arsenal to be attacked is situated on a coast which may be approached from the open sea in any direction, steam-ships may avoid the danger of a direct attack, end-on or oblique, by approaching the place on either, or perhaps on both sides; and, having gained the proper proximity, clear of raking or diagonal fire, may range quickly up in parallel order, to attack the place in line or lines. So, in steam warfare, ship against ship or fleet against fleet, direct advances upon the broadside-batteries of ships, may, upon the same principle, be avoided, and the enemy be attacked in parallel order, by ranging up to him, if the attacking ships are superior in speed, and forcing him to fight.

But, when the fortress, arsenal, or place to be attacked, is only approachable by a narrow and intricate channel, through which ships can only pass singly, or nearly so, there can be no manœuvring for position. There is is no way of avoiding being met, first by direct, then oblique, and ultimately by raking fire from the batteries that defend the channel; and steam can only perform its office of propulsion into or through the intricacies, and under disadvantageous and hazardous circumstances. Steam-ships might, indeed, run past any advanced or covering batteries at full speed, without being much damaged; but it would be extremely perilous to leave such forts unsilenced in their rear; and, unless the daring enterprise should succeed, like

Nelson's at Copenhagen, to produce a cessation of hostilities, the fleet, or at least any disabled ships, could never get out again.

363. However successful a naval attack of a fortress or arsenal may be, the work of destruction can never be effectually accomplished by ships. The sea-defences may be silenced, guns dismounted, parapets ruined, magazines blown up by mortar-shells, and habitations devastated by the cruel process of bombardment; but no substantial demolition of the defences, or material destruction of public works and property, can be effected unless the damages inflicted by the attacks of ships be followed up and completed, by having actual possession of the captured place for a sufficient time to ruin it entirely. No naval operation, however skilfully planned and gallantly executed, can, alone, reap the fruits of its victory.

In the desultory operations of small active steamers, employed, with their pivot-guns, to shell open towns, roadsteads, harbours, and slender buildings, magazines, stores, &c. &c., or to shell bodies of troops on shore, the attacking vessels should never anchor, but, having given their end-on fire, go off at speed to reload, and prepare to take up the fire in turn with others, whenever they regain a favourable position for a good effect. To hit a steamer running with speed across a line of fire is no easy matter; and, when in the end-on position, she presents but a small target to be hit at a long range.

364. But the attack of such comparatively insignificant places by horizontal or howitzer shell-firing, is a very different affair from the regular attacks of formidable fortresses, naval or military stations, or other defences solidly constructed, and efficiently armed and manned, by the broadside-batteries of line-of-battle ships, or from their bombardment by sea-service mortars which still figure in the list (Table XXIV., Appendix B) of ordnance in use in the Naval service, though, for using them, no bomb-ships exist. There can be no skirmishing with huge line-of-battle ships. When these are employed to attack fortresses, they must do so at anchor, after they shall have attained favourable positions in sufficient proximity. They then become stationary floating batteries, large targets to fire at, and scarcely can be missed. This will assuredly invite retrospect to the defence of

Gibraltar, and the destruction of the Spanish floating-batteries, by red-hot shot.

365. The disuse of mortars in the British navy is founded upon the belief that sea-service howitzers will supersede them in naval bombardments; while mortars are retained in the land-service, as indispensably necessary in sieges and bombardments, for important purposes which cannot be effected without them, whether the attack be made by land or by sea.

We have seen, p. 151, that, in 1851, a range of 4866 yards was obtained with an excentric shell fired from a 10-inch gun at an elevation of 32°; and that in 1852, p. 152, a range of 5860 yards was obtained with an elevation of 32° from a new 10-inch gun of 116 cwt. cast for the purpose of those experiments. But these great elevations are so trying to the gun (at the round next after that which produced the maximum range the gun burst), and so straining to the ship, unless she is so well trussed in her framework as to give her longitudinal strength to bear the pressure of so heavy a gun placed over a fine bow, or at the stern over a clean run, that these high elevations cannot easily and safely be used.[a] These guns may be found useful in "shelling" towns, roadsteads, open batteries, and troops on shore at great distances; but how far they are fit to supersede mortars in the attack and bombardment of large fortresses and arsenals, is another question. In this case small elevation is a disadvantage; there is too much horizontality in the trajectory to produce the crushing effects of bomb-shells. The shell wants that tremendous force which can only be acquired by the descent of mortar-shells fired at the elevations which produce their greatest range (42° or 45°), when they fall with force sufficient to penetrate into any building, and finish their course with the destructive effects of a mine. Shells fired horizontally from any ordnance, however useful in shelling places of minor importance, are not efficient substitutes for mortar-shells for purposes of bombardment. A bomb-ship may, without much exposure, do great damage to an extensive fortress or arsenal, which, being a large object, ought to be struck at every discharge at upwards

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[a] This was amply verified by the bursting of one of these guns at Shoebury Ness, 12th October, 1854.

of 4000 yards, whilst she is a mere speck on the sea at that great distance. (*Ward*, p. 48.) The French mortars did good service in the attack of Bomarsund by land: the powerful effect of the descent of their shells into the forts was particularly noticed. Sir Charles Napier reports (19th Aug.) that they never missed, and contributed largely to the reduction of the place. The fire from mortars destroyed the magazines and arsenals at Sveaborg in 1854,[a] and the French might, with a great probability of gaining the end, have sent some of the *Bombardes*, which they wisely retain in their Naval service, to the attack of Cronstadt and Sevastopol. In the bombardment of Sevastopol mortar-ships would have been of more use than the Despatch gun-boats, by throwing bomb-shells of 100 lbs. weight into the arsenal over the surrounding heights, covering the dockyard from any horizontal firing, and screening the arsenal from being seen.

366. The fortifications which defended the harbour of Sevastopol at the time of the attack made on those works by the allied fleet, October 17th, 1854, were:—on the northern side, Fort Constantine, near the water's edge, on which were mounted 101 guns; the Telegraph battery, mounting 17 guns; and the Wasp battery, 6 guns: both of these works were considerably elevated above the sea-level, and there were, besides, several other batteries of earth which were armed with artillery. On the southern side were,—Fort Alexander, mounting 50 guns, and the Quarantine battery, 51 guns, both of which were near the level of the sea, besides the battery of 54 guns, on high ground.

The British admiral, Sir Edmund Lyons, in the "Agamemnon," supported by the "London" and the "Sanspareil," took up a position opposite to an angle of Fort Constantine, at the distance of 800 yards, while Captain Symonds, of the "Arethusa," disposed his ship, with the "Albion," the "Sphinx," and the "Terrible," opposite the Wasp and the Telegraph batteries; the "Arethusa" being *abeam* of the former battery, which was

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[a] The bombardment of Odessa, in the same year, lasted five hours, and was effected by giving the pieces high elevations, and using Congreve rockets. At the bombardment of Sveaborg shells were fired from mortars at high elevations, at the distance of 2200 yards, conjointly with shot from guns of long range: this bombardment continued during forty-five hours.

on a cliff, 100 feet above the sea-level, at 650 yards' distance. The French line was anchored head and stern, at 1400 yards from the Russian forts on the south side, extending across the entrance of the harbour, and between this and the British line the Turkish fleet was disposed. Each of the sailing ships of war was led to its station by a steamer lashed alongside, to enable it to move independently of the wind. While the British ships were taking up their positions, a shell, supposed to have been thrown from the "Terrible," caused a great explosion in Fort Constantine, by which all its barbette guns were at once silenced. The Wasp battery was also for a time silenced by the "Arethusa," two of its guns being dismounted and the men obliged to retreat to a trench in its rear; that ship had, however, been previously plunged into by the fire of the fort; one shell burst on the main deck, and knocked down two guns' crews; another knocked three cabins into one on the lower deck, and burned a bed which was close to 200 shells; a third blew seven planks out of the bends, so that, had there been much sea, the ship must have sunk; and a fourth burst in the timbers at the water-line. The "Albion" had not fired above two or three rounds, after anchoring, before four or five shells burst on board and set her on fire, in which state she was towed off by the "Firebrand." Captain Symonds is of opinion that, if the explosion in Fort Constantine had not occurred, the British ships would have suffered to a fearful extent.

The French ships made great impression on some of the works opposed to them. The Quarantine Fort was so injured, at the end of an hour from the commencement of the action, that its fire sensibly slackened; but, on the side of the French, there was but a limited supply of ammunition, so that the action was in a degree suspended; and the ships of both fleets having suffered severely, at night they withdrew.

The Russians are said to have lost 1000 or 1200 men, from the fire of the French ships which were opposed to them, while the French had 350 killed and wounded: a very small loss, considering the force against which they had to contend. But the only advantage which resulted from this naval attack was the diversion created in favour of the land armies by occupying during several hours the attention of a considerable portion of the enemy's troops.

With respect to the relative effects produced by ships of war and land-batteries when opposed to each other, the naval attack of the forts which protected the harbour of Sevastopol, just described, is that alone from which any just ideas on the subject can be obtained. We have seen what was the effect of the fire from the northern forts on the British fleet. The southern batteries were armed with 300 pieces of artillery, of which 150 could be directed against the 15 French ships which were opposed to them; consequently each ship had to sustain, on an average, the fire of 10 guns; yet the battle continued till night, and the hail of projectiles from the ships caused great loss among the gunners in the batteries. Admiral Bouet Willaumez states, in his work 'Batailles de Terre et de Mer,' that the ship temporarily commanded by the Capitaine Dompiere d'Hornoy received in its hull 41 shells or shot, some of which were red-hot, and nearly as many in its masts or rigging; the ship was not put *hors de combat*, though the splinters of the shells killed or wounded many of the crew: the shells occasionally set objects on fire, but the flame was easily extinguished; the shot which struck near, or below, the water-line filled up the holes which themselves had made by lodging in the ship's side.

The distance of the "Britannia" from Fort Constantine, as stated by Major-General Brereton in his pamphlet 'The British Fleet in the Black Sea' (p. 31), was about 1600 yards. At that distance the only shot that could be considered efficient were 710 which were fired from the 32-pounders of 56 cwt., with charges of 10 lbs. of powder. Seven hundred rounds fired from the second-class 32-pounders with 8 lbs. of powder produced little effect, and 850 shot from the third-class 32-pounders, with 6 lbs. of powder, were useless. Three hundred and twenty hollow shot fired from 8-inch guns produced no effect, as they broke on striking the wall; and all the shells fired, whether with time-fuzes or Moorsom's fuzes, were wholly inefficient. It may hence be seen how inadequate was the battering power of the British fleet, and the same may be said of the French fleet, to contend with stone walls. Had the armaments of the fleets consisted wholly, or nearly so, of powerful solid-shot guns, the effect of the four hours' cannonading would, in all probability, have been very different. The disappointment which the nation felt at the result of this action was heightened in consequence of an erroneous opinion having been entertained that ships possessed, necessarily, battering powers in proportion to their magnitudes.

367. The Government of this country, roused at length to a sense of the importance of having a numerous flotilla of gun-vessels, of dimensions which would permit them to manœuvre in shallow water, caused a considerable number of such vessels to be constructed during the late war with Russia (1854-5), and it was intended that they should be extensively employed in the Baltic and the Black Seas. One kind of these vessels, which were called *Despatch gun-boats*, were from 180 to 200 feet in length, and from $28\frac{1}{3}$ to $30\frac{1}{2}$ feet in breadth; their draught of water was 11 feet 4 inches, and their burthen 150 tons. They were intended to penetrate into creeks, or move along a shore to which larger vessels could not approach. They are propelled by screws, and their horse-power is 160. Their great length in proportion to their breadth is a serious cause of weakness, as it is very difficult to tie them well together in *midships*, and they are very liable to twisting strains in heavy seas. The guns are mounted on pivot-carriages and slides, in the body of the ship; one abaft, and the other before the funnel. In voyaging, the guns are housed, longitudinally, in the middle of the deck. For action on either side, the slide carrying the gun is made to traverse upon a rear pivot, to take up the fighting-bolt on the side to be engaged, and then turned into the position for broadside action. The ports are sufficiently wide to admit of the guns being traversed upon their fighting-points, to about an angle of 56° before or abaft the beam, forming altogether a sector of 112° on the horizontal plane, upon which the guns may fire; so that there remains a sector of 34° on each side, on which there is no fire, which leaves a dead sector of 68° ahead and astern, upon which the guns cannot be brought to bear, a defect which would not be at all compensated by installing $4\frac{2}{5}$ inch brass howitzers in the bow-ports. The arrangements for turning the guns into their fighting positions appear to be very complicated. To turn the gun into action, on either side, the rear

housing-bolt is first disengaged from the socket, and the traversing platform turned upon its front housing-bolt, to take up a rear turning-point established on the deck, on that side of the middle line of the ship on which she is to be engaged, and so placed as to be equidistant from the front housing-bolt and the fighting point on that side: the former centre being then disengaged, the platform is turned upon the rear point, to take up the fighting-bolt in the centre line of the port, when, the rear point being disengaged, the gun is ready for action. Thus two operations are required to move either gun from its housed position, into that for action, and the same operations, in the reverse, to re-house the gun. To shift the gun from one side of the ship to the other requires therefore four operations; whereas if the rear housing-bolt were placed equidistant from the other and from both fighting-points, the gun might be simply turned into position for action on either side, or wheeled on that centre from one side to the other without difficulty, and in much less time.

368. It is no doubt a serious, and may be a fatal defect in the armament of these vessels, that, whether chasing or chased, they cannot bring their guns to bear upon the enemy's ship but by means of the helm, which would have the effect of losing distance from the vessel pursued, or from that pursuing. Fighting-pivots are indeed established at each of the bow-ports; but besides the difficulty of transporting a gun, which, together with its carriage and slides, weighs 7 or 8 tons, it is the opinion of many experienced naval constructors that the fine and lean bows of these vessels have neither displacement nor longitudinal strength, however well trussed, to bear that weight, far less to resist the shock of an elevated discharge of the gun. Sensible of this, an expedient of a novel and somewhat startling character has been proposed—possibly for serious emergencies which cannot otherwise be met—viz. to establish other fighting-points on the decks, so that the guns may be turned into positions parallel to the keel, and so fire ahead over the bows, or astern over the taffrail, as the case may require. But it is clear that this cannot be done unless the guns are fired at high elevations, especially the gun firing ahead, on account of the rise of the bow of the ship; and consequently this expedient is not available when the

enemy is near. The pivot of the foremost gun being about 60 feet from the bow of the vessel, the blast from the discharge of the gun would sweep over all the fore part of the deck: a shot might pass close over the head-rails, without damage to the ship; but it remains to be seen whether the bulwarks would not be injured or blown down, unless the gun were fired at its highest elevation, and whether there would not be much danger of setting fire to the rigging, hammock-cloths, or sails, though brailed up or furled, by sparks being driven into the foldings or other crevices. The aftermost gun is about 100 feet from the taffrail: fired "over all" astern, its discharge would sweep with equal danger and violence over the after part of the deck—in both cases there must be no men nor ammunition placed in the way of those explosions. How then would it be with the helmsmen? This expedient for enabling the vessels to fire ahead or astern in the line of the keel, cannot be practised, nor would it be prudent to attempt such firing in action. These vessels can therefore only fight in the broadside position—an utter abandonment of the peculiar advantages of steamers. By extreme training of their guns they might fire at angles of 34° with the keel; but they would then expose to the enemy a surface expressed by the area of the broadside, reduced in the ratio of unity to the sine of 34°; or a length of about $89\frac{1}{2}$ feet ($160 \times \sin 34°$); and thus would form a target three and a-half times larger than the area of the transverse section.

369. The Despatch-boats are very beautiful, fine, and speedy-looking craft; but they are greatly overloaded, with respect to their displacement and form, by the enormous weight of their deck-load, which, consisting of two guns, each of 95 cwt., with their massive carriages and slides, cannot be less than 14 tons! With such a top-weight they must roll excessively in any sea; which will interfere much with their speed in voyaging, with their stability in action, and with their safety in a heavy sea. When tried, they will, no doubt, confirm the apprehensions which are very generally entertained, that such heavy armament will detract greatly from the essential quality of a despatch-vessel, and make a very bad gun-boat. Perhaps it may be said that these vessels were not designed for the ordinary service of steamers (which in every case requires that they should be so

armed at their ends as to make what would otherwise be their weak point their strongest), but are intended to use the enormous guns with which they are armed for broadside firing, to batter granite walls at great distances. It were much better to make the experiment against a granite wall, in some actual siege-operations by land, than from the battery of a ship at sea. To hit a wall with any projectile fired at 18° of elevation, at the distance of 5000 yards, is a very remote probability, even when the gun is fired on solid ground; from a ship the practice must be infinitely more at random, when there is any swell; and here we would observe that the deviation to the right, occasioned by the rotation of the projectile in that direction, is largely developed in practice from the Lancaster gun, with elongated shells (the average amount of the deviation is 150 feet at 5000 yards). This ought to be allowed for, in proportion, at any range; but the deviations not being constant, they cannot be accurately estimated. If these vessels were designed, and armed with such heavy ordnance, for battering purposes, they will rather have to serve as stationary floating batteries than as active steamers to shoot flying; and therefore, instead of being built for speed, they should have been formed for stability and steadiness. The alternate recoils and running-up of guns of such vast weight, on the sides of vessels of their size and form, must occasion a rolling motion which will never cease, however still the water. The motion may be insensible to the eye, and yet such as to destroy entirely the accuracy of practice, in which deviations of half a degree in the elevation will make a vast difference in the range. A skilful seaman-gunner knows well that a rolling motion is more disturbing to good gunnery than a pitching motion; that the former does not affect the length of range from a pivot-gun at bow or stern, though if there is much of that motion it may occasion lateral deviations; that very small rolling motions have great influence on the range in broadside firing; and that a swell abeam, or a cross sea, produces very little pitching, but a great deal of rolling motion.

The aberrations in gunnery practice arising from the floating motions of a ship, affect vertical and horizontal shell-firing very differently. If the shell of a mortar whose greatest range is at 42° of elevation, depart from the muzzle at any greater or smaller angle, the range is shorter in both cases, and equally so if the error, plus or minus, be equal; but small differences of elevation are of very little moment in a range of 4200 yards, and the shell would scarcely miss the area on which it is intended to fall; for its horizontal velocity, never very great, is nearly exhausted, and the velocity of descent is very great; but in horizontal shell-firing, errors of the same amount taking place above or below the angle of elevation at which it is intended to fire, produce very great differences in the range—there is so much horizontal velocity that the shot passes over large spaces in very short times; there is very little vertical velocity and less chance of the howitzer-shell falling within a given area than a mortar-shell, both being subject to the same amount of disturbance in the intended elevation.

As gun-boats these vessels are universally considered as too narrow and crank to carry their heavy deck-loads. So much of their volume is taken up by the engine that there does not remain sufficient available capacity for the stowage of provisions and stores. Their draught of water is much too great; and, in general, all the ships and vessels we sent to the Baltic in the late war with Russia were disadvantageous in these respects. Ships drawing from 24 to 27 feet of water have no business in such shallow waters; while there was not a sufficient number of small ships to enter creeks or inlets, or to approach the batteries on the coasts, without getting frequently aground. No doubt it was necessary that there should be a fleet consisting of a sufficient number of line-of-battle ships to prevent the enemy's fleet from coming out, and to beat them, if they endeavoured to disturb the desultory operations of the squadrons of the allied fleets engaged in blockading, and other detached services; but for this, huge vessels of great draught of water would be rather hurtful than serviceable. The ships of a fleet, acting in shallow seas and intricate channels, imperfectly surveyed, should be as much as possible of the same draught of water: if not, and even if one or two draw some feet of water more than the others, the operations of the fleet must be as much impeded by shallow water, if they are to act together, as if all the vessels of the fleet were as deep in the water as a the one or two larger ships.

370. The Russian ships of the line—and the same may be said of those belonging to Denmark and Sweden—do not exceed in draught of water 23 English feet; that of our ships is from 25 to 27 feet, and in some still more. England should always be provided with ships suited for service in all seas. Our old 74-gun ships were just the class of line-of-battle ships required for service in the Baltic, but they are now extinct.[a]

371. Some experiments were carried on at Portsmouth, August 22, 1854, with Mr. Lancaster's guns on board of a despatch-boat; and, on this occasion, the gun maintained the character given of it in Art. 197 for length of range; but the practice, always uncertain at such distances, was extremely wild and random, from the motion of the vessel. Two shells broke soon after leaving the gun, thus affording additional proof that even wrought-iron shells cannot be depended upon; and, unless this serious defect can be effectually remedied, it must be considered a great objection to the adoption of the gun; for, considering the enormous cost of the shell and the vast expense of the system, one lost opportunity of obtaining the full effect of a discharge, from the breaking of the shell in or near the gun,—of which so many instances have recently occurred,—might be productive of the severest disappointments in action. How this defect is to be remedied, appears to be a very difficult and doubtful matter. But however this may be, the difficulty has not been overcome, as the late experiments show; and the despatch gun-boats, constructed expressly to demolish the enemy's defences in the Baltic and Black Seas, with elongated shells of 100 lbs. weight, fired from Lancaster's elliptical guns, were actually sent to their destinations, provided, it appears,

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[a] The gallant and distinguished Vice-Admiral who commanded the combined fleet in the Baltic felt then the full force of what he wrote in 1849 (see p. 192 of his late publication). After extolling the old 74's, and condemning their extinction, he goes on to say,—"We seem to have quite forgotten that there are such seas as the North Sea and Baltic, where small ships of two or three decks, with a light draught of water, are indispensable. There are also many places where the like qualification is necessary; and I well recollect that, during the siege of Cadiz, we were obliged to look up all our old 64's, with a light draught of water, so that they might lie clear of the enemy's shells. Another thing we seem to have forgotten—that all the work of the war was done by the 74's, and that the large ships did not stand the blockade so well as the small ones."

with only 25 of their own peculiar oval shells, on the much-vaunted efficiency of which the whole of the Lancaster system depends, but largely supplied with 68-pounder round shot, with which it is said the Lancaster guns make good practice! It was not for this that the enormous expense of the Lancaster system has been incurred, or can be justified; and if there be any truth in all that has been said, written, and done, upon the subject of windage, the principles upon which it is regulated, its annular uniformity, the important condition of a perfectly cylindrical bore, and the rigorous condemnation of any gun in which the smallest irregularity in the surface of the bore can be detected, by the nicest instruments, it is utterly impossible that the anomaly of firing spherical projectiles from guns having elliptical spiral bores can be precise; and this incongruity is therefore repugnant to science, and absolutely fatal to the Lancaster system, as applied to guns.

There never yet was a gun-boat without a powerful gun at the prow, or which could not fire in the direction of her keel. It was therefore a great mistake to call these vessels *Despatch gun-boats:* they are *steam-vessels* armed and fitted in a novel and peculiar manner, for experiment; and much is it to be wished that the experiment, so far unsatisfactory, may in the end be successful. But believing, for the reasons stated, that these vessels will not altogether realise the expectations which the public in general are led to entertain of their services as *gun-boats,* the author deems it his duty thus fully and frankly to state the facts and reasons which have led him to this conclusion.

372. The smaller class of vessels recently fitted out as gun-boats are in length 100 feet; extreme breadth, 22 feet; depth of hold, 7 feet 10 inches; tonnage, 212; engines, two of 30 horse-power each; draught of water at load-line, 6 feet 6 inches; armament, two 68-pounders of 95 cwt. These vessels are lugger-rigged, without bowsprit; they are sufficiently full at each end and abundantly strong to bear that heavy gun, at either or both ends, for action. In voyaging, the guns are housed in
of the vessel, and may either be turned into act
side or at either end, for which ports are
at the stern. The only blemish is the fit

and objectionable project (Art. 368) of firing the guns from the body of the vessel " over all," ahead or astern; and arming them with Lancaster guns instead of 68-pounders, before efficient projectiles congenial to the principles of his system shall have been produced, and at such a moderate cost as would justify a general use of them, but which, confessedly, is not the case at present.

SECTION XI.—ON THE ARMAMENT OF COAST-BATTERIES.

373. With respect to the armament of coast-batteries: wherever a battery is so placed as to command long sea-ranges, and, if properly armed, to open its fire upon an enemy at great distances; or, from the nature of the sinuosities of a coast, to be in a position to enfilade an enemy's fleet or squadron advancing to the point of attack which that battery is established to defend; there assuredly should be placed exclusively, guns possessing, in the highest degree, power of range, accuracy, and penetrating force, powerful 32-pounders, 56-pounders (Monk's), and 68-pounder guns. To these will now be added the new breech-loading cannons of Armstrong and Whitworth.

In batteries which do not command long sea-ranges, which are not in enfilading positions with respect to an advancing force, and are so situated in the scheme of defence, as to serve for the flanking defence of collateral works, or whose seaward range is only open to distances at which shell-firing may be used with effect, there shell-guns, or other howitzers, or 68-pounder carronades, may with advantage be placed.

374. To place in *fixed* batteries chambered 8-inch guns, in lieu of unchambered solid-shot guns, on account of the difference of weight, since neither displacement, transport by sea, nor conveyance by land enters there into the question, were a grievous error, which, much we fear, may have been committed, particularly with respect to 8-inch shell-guns of 50 and 52 cwt.—a very inferior class of that tribe—seeing that more than one-third of the ordnance appropriated to the armament of our coast defences are shell-guns, and that so large a proportion can scarcely be required for shell-firing only.

Extent of range, with the least elevation, the greatest accuracy at long ranges, and penetrating force, are pre-eminently required of guns appropriated to batteries, wherever they command long sea-ranges, or are in enfilading positions.

No law of gunnery is more clearly demonstrated and irrefutable than this—that elevation is, inversely, the exponent of accuracy. No scientific or experienced artillerist will dispute this, and no practitioner of the science can deny it, until he shall first have demonstrated that this well-established law is untrue, and shall cause it to be erased from the codes in which Robins, Hutton, and all professors of the science of gunnery have stereotyped it for our guidance.[a]

"The gun that makes the greatest range with the least elevation, and consequently with the greatest horizontality in the flight of its shot, is, assuredly, the most accurate in its practice, and the most destructive in its effects. Sea-service howitzers do not possess this property in so great a degree as solid-shot guns; for the former require higher elevations to attain the same ranges, and accuracy and effect are sacrificed accordingly." (*Monk.*)[b]

375. That greater degree of horizontality in the trajectory of a projectile, which is produced by superior velocity, is still more important in the armament of coast-batteries, whose sphere of action is over the horizontal surface of the sea, and not over the uneven surface of land; because there is, throughout the range, more of parallelism between the plane of operation and the flight of the projectile, in proportion as the trajectory partakes of horizontality, that is, in proportion as the gun possesses the power of throwing its shot to the greatest distance with the least elevation. The probability of striking an object, and, if missing it, the chance of hitting some other body on the battle-plain, either with cannon, rifles, or common muskets, depends more on the angle under which the projectiles strike or graze the ground than that at which they were projected (Art. 274). Sci shows, as stated in Article 63, that hollow shots, being

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[a] The uncertainty of striking objects increases considerably with the i of range, for it requires corresponding increase of elevation.—*Straith*, ' cation,' vol. ii. p. 227.

[b] The accuracy of the solid shot will be much greater, both on acc its greater velocity, and because the hollow shot, to obtain the same must have greater elevation.—*Simmons*, pp. 26, 27.

capable than solid shots of retaining their initial velocity, graze at angles with the ground which exceed those of their departure in a much greater degree than in a solid shot fired with the same initial velocity. It shows also, that the deviation of the hollow shot increases in proportion to the length of the range, and is greatest at its termination.

376. In practice on shore, or in still water in harbour, the relative superiority of solid-shot guns may be somewhat obscured by extreme skill and nicety in target-firing, to hit a point at a well-ascertained distance, in slow and deliberate school-practice; but in battle, on the open sea, where the firing is rapid, the ship in motion, the enemy not stationary, and the distance not accurately known, and ever varying, the practice cannot be precise; and it must ever be considered that hitting an object under those circumstances is rather a matter of probability than of certainty; and that probability will be greater or less, according as the elevation is less or greater.

Irrespective of the superiority of the range of an unchambered gun, firing solid shot, over a chambered shell-gun of the same calibre, firing hollow shot, at the same elevation; or the advantage of obtaining the same range with equal elevation; it must be observed that the penetrating power of the solid shot is a matter of immense importance in coast-batteries.

The relative penetrating powers of shot fired from the undermentioned heavy ordnance, proposed for the armament of coast defences, are tabulated as on opposite page by Straith ('Fortification,' vol. ii. p. 226), chiefly from the work by Captain Simmons, entitled, 'A Discussion on the Present Armament of the Navy.' The penetrations are calculated by a formula equivalent to the equation for p in Art. 82. Two columns are added from Captain Simmons' work (p. 24) to show the velocities of the 32-lb. solid shot, and the 48-lb. hollow shot, at the further extremities of the different ranges.

The superior penetrating powers of solid shot fired from 32, 42, and 56 pounder guns, compared with that of the hollow shot fired from the best of the 8-inch shell-guns, at the distances stated in the first column, are quite sufficient to establish the great inferiority of the 8-inch shell-gun to solid-shot guns in this important respect.

Range in Yards.	24-pounder iron gun, of 42 cwt., 7 ft. 6 in. long; charge, 8 lbs.	Velocities, in feet per second.	32-pounder iron gun, of 55½ cwt., medium windage .203; charge, one-third of shot.	42-pounder iron gun, medium windage .203; charge, one-third of shot.	56-pounder iron gun, 11 ft. long, 98 cwt.; charge, 16 lbs. solid shot, medium windage .125.	Velocities, in feet per second.	8-inch or 68-pounder sea-service howitzer, 48 lb. hollow shot, charge 12 lbs. windage .125.
	Relative Penetrating Force.		Relative Penetrating Force.	Relative Penetrating Force.	Relative Penetrating Force.		Relative Penetrating Force.
500	60.104	1200	68.302	85.921	104.126	1092	51.136
800	39.055	1001	47.527	66.846	74.158	877	32.983
1000	29.829	883	36.982	46.583	59.596	765	25.096
1200	23.027	783	29.080	37.076	48.304	672	19.365
1500	20.252	661	20.724	26.699	35.679	562	13.544
2000	9.559	515	12.873	16.305	22.396	436	8.152
2500	6.231	418	8.287	10.714	14.869	358	5.494
3000		354	5.944			310	4.121

Shell-guns should therefore only be placed in branches of coast batteries, forts, or fortresses which have not ranges open to them on the sea beyond the limits at which shell-firing ceases to be efficient. The hits of shells are never so frequent as of shot, and beyond 1200 or 1300 yards shell-firing becomes extremely uncertain, and should therefore give place to guns that can best fire solid shot. In some recent experiments made at Portsmouth, out of 100 rounds of shells fired at a large hulk, distant 1200 yards, not less than 15 per cent. missed. No solid shot from a 32-pounder would have failed to hit at that distance.

Unchambered solid-shot guns may, after having efficiently cannonaded an enemy when distant, take up shell-firing when he comes within the limits at which it is efficient; but shell-guns cannot open with much effect, either with hollow shot or shells, upon the enemy, in very distant firing, and not with more effect than unchambered guns, when shell-firing commences. They
cannot fire red-hot shot, a defect which should exclude
from use in coast batteries, except as howitzers.

Simmons, in his excellent work above quoted,
examination of the relative merits of solid and
therefore of unchambered and chambered gun
even be feared that, in introducing hollow
shot, if persevered in during war, very de
ensue" (p. 40). The author unhesitating
opinion, and considers that it will be unfor
service chambered guns are preferred to unc

guns, in the armament of any of our coast-batteries, which require the superior power of solid-shot guns for long seaward ranges.

377. In consequence of the bursting of guns at Gibraltar, and more recently at Malta, in firing hot shot, the charges have been reduced to three-quarters of their present amount. The author does not see how this is to prevent such accidents; but, for other reasons, the reduction of charge is advantageous. Wood is more rapidly and certainly set on fire by hot shots, when these penetrate but little, than when they lodge at great depths, because in the latter case the crushed fibres of the timber, by their elasticity, close upon the shot, and more or less contract the orifice; and the communication with the external air is not sufficiently free to excite combustion. The penetrating power of a red-hot shot is greater than that of a cold shot, fired with the same charge; because, by the expansion of the hot shot, the windage is diminished. Great care must therefore be taken so to regulate the charge, according to the distance and dimensions of the body fired at, as to be sure of causing the hot shot to lodge.

378. A very important error in classification and nomenclature, and one calculated to convey wrong notions to the uninitiated, and even to mislead those who should know better, is frequently observable even in official documents, in which the 8-inch shell-guns are called 56-pounders, and sometimes 68-pounders; but when it is stated that the so-called 56-pounder is a chambered gun, the weight of whose hollow shot is 56 lbs., and that no shell-gun, with one exception, can fire solid shot of 68 lbs., also that none do fire solid shot, the error of not calling things by their right names will be made manifest.[a] From this error in nomenclature our 8-inch shell-gun, called a 56-pounder, led the French to believe (see 'L'Enquête Parlementaire,' vol. ii. p. 414, and Notes thereon by the author, pp. 14 to 16) that we had introduced a 56-pounder unchambered solid-shot gun into our naval service,[b] and this was actually the reason

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[a] Thus Guildford battery at Dover is erroneously believed to be armed with 56-pounder solid-shot guns, whereas the ordnance improperly placed there are 8-inch shell-guns which only fire hollow shot of that weight. Assuredly that battery should be armed with 68-pounder guns.

[b] The armament of the main deck of the "Indefatigable" is stated in a document of authentic character to consist of 28 *56-pounders*, but they are really 8-inch shell-guns.

why the French introduced their 50-pounder as an equivalent gun! This they have now withdrawn from the broadside-batteries of their ships to give place to a greater number of 30-pounders, No. 1.

Simmons, throughout his able and very useful work, calls shell-guns *sea-service howitzers.* So are they denominated by Straith, vol. ii. p. 226. General Millar brought them forward by that title; and by that name they were then, and still are, designated by Monk. In French, and all other foreign treatises, they are called simply *howitzers.*

The author has throughout this work called shell-guns *chambered guns,* since, by the introduction of shell-firing from all natures and descriptions of naval ordnance, the former distinction has ceased. But, without some such explicative, that description of ordnance cannot be correctly and scientifically named and classed; for *guns,* simply, they are not. Chambered guns are contradistinguished from *un*-chambered guns by definitions which cannot be mistaken, and must not be violated. Mortars, howitzers, and shell-guns are designated in terms of their calibres, expressed in inches and decimals; unchambered ordnance for solid shot are contradistinguished by being denominated in terms of the weight of their solid shot, by pounds and decimals or pounds and ounces.

379. Lest erroneous notions should be entertained by the student from the use which has been made in the preceding articles of the term command, the author wishes here to observe that it is not an uncommon error to suppose that the advantages of *command* depend entirely on the height of a work or battery above the object against which its fire is directed, as if a shot would produce, practically, a greater effect against a work situated on a level below that on which the gun is mounted than it would against a work on a higher level. Such is not the case in any appreciable degree, and a work is not effectively commanded unless it can be fired into. But the prevention of this depends not so much upon the relative heights of the ground as upon the positions of the planes of site, or rather of defilade, by which the *reliefs* of the parapets are determined, so th [illegible] plane passing through their crests and the enemy's [illegible] be parallel, or nearly so, to the terreplein of the [illegible]

though such terreplein may be considerably lower than the ground on which the enemy's battery is constructed, it can no more be seen from the guns in the latter than if the work and battery were raised on the same horizontal plane.

On the other hand, when the parapets of two works have equal heights above a horizontal plane passing through both, the terreplein of either of them would be commanded by the other if it should have a rise towards the rear; even when two works are formed on the face of a slope, the upper one may be commanded by the lower, should its terreplein have a greater inclination to the horizon than the ground on which both works are constructed.

The reason why a difference in the vertical heights of works gives scarcely any appreciable advantage to the higher work, and causes as little disadvantage to the lower, in respect of range, is, that all modern improvements in the construction and uses of artillery, having been introduced to render firing more direct, and consequently more accurate; it follows that, within the comparatively short ranges at which artillery can be so used, whatever be the relative heights of the battery and the object fired at, there is little difference in the form of the trajectory of the shot, whether the gun and object be on an oblique or on a horizontal plane, and there is no significant difference in the elevation required for guns of equal powers of range, whether the firing take place from below upwards, or the reverse.

380. It was foreseen that numerous gun-boats would be required to act with the naval force which, in 1854, was sent to the Black Sea, as no expedition intended to act in shallow waters was ever undertaken without being accompanied by such craft. Numerous gun-boats, each armed with a powerful gun, formed part of the equipage for the naval force sent to Walcheren in 1809, and were found extremely useful on all occasions in shallow inland waters. The day after the landing of the troops, a gallant and efficient attack was made by those boats on the fort of Jer Veer, then invested on the land side, which ended in the place being taken.

After the action at Copenhagen, in 1807, the Danes lost nearly all their line-of-battle ships and frigates, but they still possessed some stout brigs of war, and a great number of well-armed gun-boats; and, during the calms which frequently prevail in the Danish waters, the latter were particularly destructive to the British cruisers and convoys.

On the 4th of June, 1808, during a calm in the Great Belt, the "Tickler" gun-brig, commanded by Lieutenant Skinner, was attacked by 4 Danish gun-boats, and, after a conflict of four hours, in which the commander was killed, she was obliged to surrender. A few days afterwards, the bomb-vessel "Thunderer," Captain Caulfield, and the gun-brig "Turbulent," Lieutenant Wood, with a convoy of 70 vessels, were attacked by 25 Danish gun-boats, when the "Turbulent" was captured, with 10 or 12 of the merchant-ships: and on the 2nd of August, the gun-brig "Tigress," Lieutenant Greenswood, was taken by 16 Danish gun-vessels. On the 25th of October, in the same year, the British 64-gun ship "Africa," with a homeward-bound convoy of 137 sail, was attacked by a Danish flotilla, consisting of 25 large gun and mortar boats, and 7 armed launches; nearly all the convoy escaped, but the "Africa" was severely damaged; and, had the daylight continued two hours longer, she must have surrendered or sunk.—James' 'Naval History,' vol. v. pp. 74-76.

On the 7th of July, 1809, a British squadron of 4 ships, under Captain Thomas Byam Martin, while cruising off the coast of Finland, discovered a Russian flotilla of 8 gun-boats, and a fleet of merchant-vessels, at anchor under Porcoln Point. The position which these had taken was one of extraordinary strength, being between two rocks, which served as covers to their wings, and from whence a destructive fire of grape could be poured upon any boats that should approach them. Notwithstanding this, the boats of the ships, 17 in number, advanced close up to the gun-vessels without firing a musket, and, boarding them, carried all before them: 6 of the vessels were taken, 1 sunk, and 1 escaped; 12 merchant-vessels also, laden with powder and provisions for the Russian army, were taken. On the 25th of the same month, 17 boats from a British squadron, under Captain Dudley Pater, attacked 4 Russian gun-boats, and, after a sanguinary contest, succeeded in capturing 3 of th [illegible] pp. 180-182.

The Russians have in the Baltic numerous gun-boats, which, keeping in comparatively shallow water, among the islands, where no large ship can approach them, are ready at every moment to issue forth and seriously annoy the most formidable fleet of line-of-battle ships on the coast.

The Secretary of the American Navy, in his Annual Report to the Senate, 1856, recommends to his Government the building of sloops of war capable, from their small draught of water, of approaching the coasts of the country: he considers that such vessels, armed with 15 or 20 guns each, would annoy an enemy at sea, and defend harbours which are inaccessible to larger vessels.

SECTION XII.—ON THE APPLICATION OF METALLIC DEFENCES TO THE SIDES OF FLOATING AND THE FACES OF LAND BATTERIES.

381. The project of covering ships with iron plates, in order to render them proof against artillery, was suggested, many years since, by Colonel, the late General, Paixhans, in his work entitled 'Nouvelle Force Maritime,' No. 10. The Comité Consultatif de la Marine, at that time, having caused the weight of an iron covering, and the capability of ships to bear the load, to be calculated, found that such armour could not be applied to line-of-battle ships of the lowest class, to frigates, nor to smaller vessels. With respect to ships with three decks, the Comité stated in its Report, that the great displacement of these would enable them to bear the requisite weight, provided the quantity of artillery on the upper decks were diminished; and observed, that the expense was estimated at 600,000 francs (25,000*l.*) for each ship. This inquiry led, however, to no attempt in France to *cuirasse* ships of war, and the project was at that time abandoned, apparently as impracticable.

A proposal for constructing floating-batteries of iron, so thick as to be shot-proof, was entertained by the Government of the United States, in or before the year 1852, and the feasibility of the proposition was made the object of an experiment: the result of this being unfavourable, the project fell to the ground.

The idea of cuirassing ships of war was reproduced in France in 1854, as appears by an article in the 'Moniteur,' by the present Emperor of the French, Napoleon III., who then proposed the construction of floating-batteries, or ships protected on the exterior by thick plates of iron. The ships so covered were to be employed in the attack of maritime fortresses; and in 1856 M. Grivel, Lieutenant de Vaisseau, published in a second edition of a pamphlet entitled 'Attaques et Bombardamens Maritimes' 1857, speaking of the vulnerability of the sides of wooden ships, observes, "When the means shall be found of covering ships of war with an impenetrable cuirass, an equilibrium between land and sea batteries will be established"; and he adds, that the floating batteries will be able, by their power of being moved at pleasure, and by the concentration of their fire, to silence any land-batteries of masonry.

382. We have not been unmindful of the intimation contained in the preceding Article, nor of the purpose for which that expedient is designed; and experiments, sanctioned by the Government, have accordingly long been carrying on to ascertain how far floating-batteries may be made effectually shot and shell proof, by covering their sides with plates of adequate thickness; and whether coast-batteries might be made impenetrable to shot by similar means.

383. In examining closely the subject of iron defences, the author proposes first to state the facts which have been established, and the results obtained from those experiments, for the accuracy of which he may vouch; and then to investigate the whole subject of metallic defences with a view to inquire—

1st. Whether ships constructed wholly or nearly so of iron, are fit for any of the purposes or contingencies of war.

2nd. Whether ships constructed of timber can, with due regard to the conditions on which flotation, stability, manageability, and safety depend, be covered with plates of ponderous, rigid, and brittle material of adequate thickness to resist the penetration and withstand the impulse of the powerful ordnance still in use, and the more potent guns and precise projectiles which are now being introduced.

3rd. Whether iron is a better material for the formation or facing of land-batteries, and for lining embrasures, than earth and sods.

384. The reader will find in Arts. 167 (p. 120) to 175 (p. 132) inclusive, statements of the experiments made in France at Gavre and Metz in 1834, to try the efficiency of slabs of cast iron to resist the impacts of shot, and at Portsmouth in the years 1838, 1840, and 1851, against targets resembling portions of the sides of iron ships, such as the 'Simoon,' formed of plates $\frac{5}{8}$ of an inch thick; several such ships having been constructed, and others contracted for, apparently under the impression that ships made wholly of iron of that thickness, and lined with solution of caoutchouc and sawdust, might be made shot and shell proof, a delusion which the experiments not only dispelled, but further proved (Art. 169) that the expedients of lining the targets representing ships' sides on the inside with compositions of caoutchouc and sawdust, cork, and other elastic substances, were unavailing, and rather made the matter worse. The results obtained from these experiments produced the immediate condemnation of iron ships of that scantling; those which had been finished were sold, and the construction of others stopped (Arts. 176, 177).

385. Experiments have since been made at Portsmouth in September and October 1854, to try the capability of wrought-iron slabs $4\frac{1}{2}$ inches thick to resist the impacts of solid and hollow shot against a target representing a section of a frigate covered with iron plates of that thickness. The guns employed were 32-pounder and 68-pounder solid-shot guns, and 8-inch and 10-inch shell-guns firing hollow shots. At 400 yards, the 32-lb. solid shot, and the 10-inch and 8-inch hollow shot, merely indented the target to the depths respectively of $1\frac{1}{2}$, $2\frac{1}{2}$, and 1 in.; but the 68-lb. solid shot, being fired with 16 lbs. of powder, penetrated the plates. These were always split at the bolt-holes, which were about 1 ft. asunder; and, in consequence, it was recommended that they should be bored as far apart as possible. The conclusion drawn from the experiments was, that $4\frac{1}{2}$ in. iron plates, applied as a covering to ships, would give protection, during an action, against 8-inch and 10-inch hollow shot, and against 32-lb. solid shot, but very little against solid shot of 68 lbs.

The project of covering ships with plates of iron has recently been adopted in this country: it was, at first, intended to cover with slabs of iron 4½ in. thick, only the bows of steamers, it being supposed that, in the use of their bow pivot-guns, the heads merely of the vessels would be presented to the enemy. The weight of an iron covering 4½ in. thick, applied to the bows of a screw-propelled ship of 1074 tons, the covering extending 36 ft. from the head along each bow, and from the deck to 2 ft. below the load-water line, is found to be 10 tons nearly; and this would surely be an enormous burthen, in addition to that which already loads the bows of a steam-vessel.

386. During the war with Russia three floating batteries, the "Erebus," the "Terrible," and the "Thunderer," were constructed in this country, their sides covered with iron plates 4 in. thick, each of about 1460 tons. It was intended to make the decks proof against shot or shell, by covering them likewise with slabs of iron, but it was found that their displacement was insufficient to carry such a top weight, in addition to that placed on the sides, and strong oak-beams were substituted in forming the decks. The weight of the iron plates covering the sides of those floating batteries was upwards of 350 tons, which, together with that of the heavy armament required for these vessels, rendered it scarcely possible to satisfy the necessary conditions of buoyancy and stability. With such an immense top weight, a great counteracting weight of ballast is requisite, but for this there is neither sufficient displacement nor depth of hold; and as the meta-centre must be very near the centre of gravity, so the equilibrium and stability of such vessels cannot but be greatly endangered.

387. The success which attended the attack on the fortress of
Kinburn in 1854, by the floating-batteries of the French fle
in the Black Sea, is sometimes adduced as an instance in
of the capability of such vessels to resist the impacts of sho
artillery on land; but, on examining the circumstances
which the operations were carried on, it will be found
fact is by no means established. The ramparts of the
constituting the fortress were but little elevated above
of the sea, and were armed only with from 60 to 70 gı
were 32-pounders of 75 cwt. each, and these were m

barbette. The attacking vessels were three in number; they were covered with wrought-iron plates 3 in. thick, and each was armed with sixteen 50-pounder French naval guns. The ships were stationed at distances varying from 700 to 800 yards, and the firing was kept up during several hours before the place surrendered.

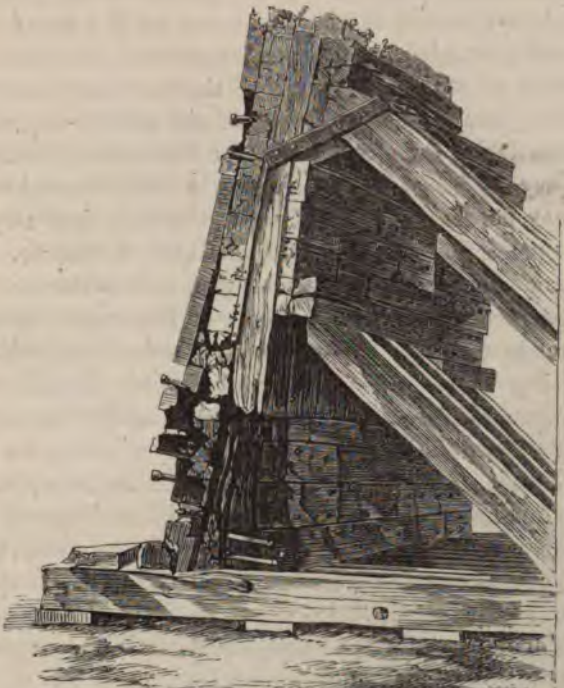
Now it is evident that the Russian guns were of comparatively small calibre, and therefore they could not be expected to produce great effects on iron-covered ships at such distances, yet their shot is said to have deeply indented the plates; and there being no merlons to protect them, it is not surprising that more than half their number were dismounted, and that nearly all the rest were disabled, so that they could not have been again fired. If there were no casualties on board the floating batteries, this can only be taken as a proof of bad gunnery on the part of the Russian artillerymen, who, apparently, could not throw a shot in the ships through any of the ports. Had heavier ordnance been mounted on elevated sites, as were those of the "Telegraph" and "Wasp" batteries at Sevastopol, the French vessels would have been inevitably torn to pieces by its plunging fire.

388. Experiments were carried on at Woolwich in 1856, against a target formed of timber and planks, representing a portion of the side of a ship, covered with plates of iron 12 ft. long, 2 ft. wide, 4 in. thick, and weight about 36 cwt.; a steel plate 2 ft. by 2, and 2 in. thick, was likewise placed on the target for trial. The combined substance of the target was equal to that of the floating-batteries, and weighed 30 tons. This target was subjected, in the first place, to 14 rounds of 68-lb. shot, fired at 600 yards, with a charge of 16 lbs., by which the timbers were much splintered; 10 rounds were then fired at a distance of 400 yards, the result of which was the destruction of the timber-work, and the splintering and breaking of the iron plates, which had been made by the process of rolling. The last shot passed completely through the target, timber and iron included.

A remarkable proof of the percussive force of the shot on the target which, as shown in the figure, was placed on sleepers laid underneath the platform, was exhibited by the fact that at every blow the target, weighing 30 tons, was driven bodily back, to an extent which amounted to several feet at the end of the experiments.

The annexed figure is made from a sketch representing a side and back view of the target or bulkhead constructed on this occasion; and shows the effects, interiorly, of the firing against the face of the target.

Fig. 43.



389. The results of the preceding experiments made at Woolwich in 1856-7, are fully confirmed by what has taken place in the trials made at Portsmouth in 1858, against H.M.S. "Alfred," of 50 guns, covered with plates of wrought iron 4 in. thick, formed of metal of various descriptions, bolted to the timbers by large iron bolts and nuts in the inside of the vessel; the side fired at was shored up on the main deck, and the ports filled in

by strong spars at intervals of about 10 ft., resting against the combings of the hatchways. The firing took place from the "Stork" gunboat. The "Alfred" was placed so as to present her broadside. The plates attached to her sides formed a target 54 ft. long by 18 ft. in height.

390. At 400 yards, 32-lb. cast-iron shot, fired with a charge of 10 lbs. of powder, made merely a few cracks in the plates and started some bolts. At 100 yards, the shot made a round hole in the plate 7 in. in diameter, pieces of the plate being driven into the side of the ship: at one of the rounds a shot struck partly on a hole made by a former shot, and drove pieces of the plate, as well as fragments of the shot, quite through the side, tearing away the inner lining of the ship to the extent of 2½ feet, scattering the pieces about the lower deck, but doing no other injury on board except starting a few bolts and trenails; and it may be concluded that such plates of iron may afford sufficient protection against 32-lb. shot at that distance.

Cast-iron shot from a 68-pounder gun, with a charge of 16 lbs., at the distance of 400 yards, produced little more effect, as it merely made cracks in the plates and started some bolts, but wrought-iron shot of the same calibre, with the like charge, broke out small pieces of the plate and made two cracks, one extending 16 in. the other 8 in., passing by a bolt to the bottom of the plate. The shot broke in pieces, but no injury was done inside. Red-hot shot of the same size, with a charge of 12 lbs., also made cracks in the plates, and started bolts and trenails; and the like effect was produced when empty shells were fired with charges of 16 lbs. In all these cases the wrought-iron shot was doubled up by the impact, and the cast-iron shot, both solid and hollow, was broken in pieces.

At the distance of 200 yards, the effects produced by all the shot were greater: the cast-iron shot and red-hot shot caused cracks in the plates, and shook the woodwork of the ship. The wrought-iron shot, in some of the rounds, broke holes quite through the plates, but all the shot were invariably broken in pieces or doubled up.

At the distance of 100 yards, the effects were more sensible: the cast-iron shot made cracks quite through the plates; the wrought-iron shot fractured the plates, made holes in the ship's side, and caused the timbers of the ship to be much shaken. Even an empty shell made an irregular hole, and started some trenails: the red-hot shot drove some fragments of the plates through the side of the ship and ignited the woodwork; the fire, however, was speedily extinguished. In all cases, as before, the shot was either doubled up or broken in pieces, and either fell into the water or buried itself in the woodwork to the depth of nearly 2 feet.

391. Trials were subsequently made against the same object with Mr. Whitworth's 68-pounder hexagonal shot (described in Art. 242 p. 216), and the following are some of the results. Cast-iron shot, with a charge of 12 lbs., and at the distance of 400 yards, started four bolts and cracked the plates in four places, but did no injury on board. A wrought-iron shot of the same size, and with an equal charge, at the distance of 450 yards, pierced quite through the plates and the ship's side, making a hole 6 in. in diameter, driving the pieces quite through, so that they fell upon the orlop-deck.

A cast-iron shot, with a charge of 10 lbs., and at the distance of 350 yards, cracked the plates, started some trenails, and slightly shook the woodwork inside the ships.

392. At the distance of 100 yards, with a charge of 16 lbs., the cast-iron shot pierced the plate, making an irregular hole 16 in. long and 12 in. broad, burying large pieces in the ship's sides to the depth of 18 in., large cracks were also made in the plate. Inside the ship, a 13-inch diagonal rider was split through; the inner lining of oak, 4½ in. thick, was torn off to the extent of 3 ft.; the timbers were bilged-in 4½ in., and much shattered; several bolt-heads were knocked off, and the splinters scattered about the deck.

393. At 450 yards, with 12 lbs. of powder, the Whit
shot passed through the iron plates and the ship's side,
a round hole in the plate 6 in. in diameter, tearing off
four layers, as if the plate was badly welded, and punc
a piece 5½ in. in diameter; also another irregular
4½ in. by 3½ in.; driving them through the side on to th
deck, they were found about 4 ft. from the hole; the shot
through the side between timbers, and came in contact
the afterpart of the ends of an orlop-beam, which it scored

depth of 4 in., it then grazed the under side of the lower dec and fell inboard, spent, about 2 feet from the hole.

The shot thus passed through 4 in. of iron and the out planking (6 or 7 in. oak), there was no inner lining; the end the shot was much bruised and opened.

The shot was found to be imperfect on loading, being starr at the point. Recoil very moderate as before.

It appears that in loading the gun, on one occasion, the sh jammed in the gun so firmly that it was a work of much dif culty and time to clear the gun. This, however, arose from mechanical imperfection in the conformation of the bore ar shot.

394. At 400 yards, with 12 lbs. of powder, and a cast-irc shot, the Whitworth hexagonal 68-pounder burst with gre violence, some of its fragments cutting away the fore and mai mast, and knocking a large piece out of the funnel. Tl greater part of the gun was blown overboard, leaving pieces the breech only about the carriage, which was much shattered.

395. It is, however, but justice to Mr. Whitworth to stat that the 68-pounder gun used in these experiments was not of h manufacture (see Art. 242), but an unbored block of a Goveri ment gun bored out hexagonally by him, and which he declar was formed of inferior metal. These experiments prove tl great penetrating power of the hexagonal flat-headed shot; an the only question that remains to be decided respecting h system is, whether he can produce a gun which can resist tl strain occasioned by his method of rifling.

396. The 68-lb. solid shot, with a charge of 16 lbs. powder, at 400 yards, directed against that part of the shi which was covered with homogeneous-metal plates 2 in. thic covered with 3-in. planks, African oak, passed through the sid tearing off 3 ft. of two of the planks, and making a hole in tl metal plate 13½ in. by 21 in.; the shot and plate breaking u into very small pieces, spreading about the main deck to tl extent of 22 ft., and making marks on the opposite side to tl depth of half an inch, which sufficiently indicates the destructiv effects which would have been produced on the crew in re service.

397. The effect of a 68-lb. shot, with a charge of 16 lbs

at 400 yards, was then tried against that portion of the ship which was covered with 3-in. steel plates (red); the shot made a round hole 1 ft. in diameter, the pieces of shot and shell were driven into the side, and the woodwork on the main deck much shattered, a large wooden knee being broken, and the side of the ship bilged-in 4½ in. At the second round, under the same circumstances, the shot made an irregular hole 14 in. by 7 in., driving parts into the side, making a crack round the point of impact of about 20 inches in diameter, and another extending from the upper edge of the plate downwards 2 feet in length.

398. The 68-pounder, with a charge of 16lbs., at 400 yards, was then directed against that portion of the ship which was covered with 2-in. steel plates (white). The shot made a hole precisely of the same dimensions as that in the steel plates (red), the shot and plate breaking up as before, and forming a large rent 2 ft. by 14 in. The shelf-piece on the lower deck, formed of stout oak-plank, was cracked, up and down, and the side of the ship bilged-in 1½ in. The fire was then directed against the portion of the ship covered with 2½-in. steel plates, and made a round hole 14 inches in diameter, driving the parts of the plate and shot in to the depth of 2 ft. 2 in., till the shot came in contact with the shelf-piece, and a beam on the lower deck, both of which were started by the concussion.

399. Ships of war intended to be used as floating batteries have been constructed in different ways, with the view of giving them the greatest powers of resistance. In one class of ships (the "Erebus") the main frame consists of strong iron ribs which are lined inside with iron plates nearly ¾ of an in. thick; on the exterior of the ribs is an oak planking 5 or 6 in. thick, and these last are covered with wrought-iron plates 4 in.
Another and apparently a more effectual method
such ships (the "Meteor") is to form the r
10 in. thick, placed about 5 in. asunder,
filled up solid; within these ribs is a plank
at the top, but diminishing gradually to 4
and on the outside of the timbers is an oak
On the exterior are plates of wrought iron 4
bolted to the ship's sides with nuts and screws.

400. The effect of 32-lb. cast-iron spher

with a charge of 10 lbs. of powder, against the "Erebus," w
merely to make some small cracks in the iron covering; but
68-lb. shot, with a charge of 16 lbs., at the same distanc
after two or three rounds, ripped up the inner lining to t
extent of 2 ft., broke off the knee part of a beam to the exte
of 3 ft., and drove the fragments in-board. An iron rib, on ea
side of the line of penetration, was cracked through, and sever
pieces of shot, with many rivets and bolt-heads, were broken
and driven across the deck, while the sides of the ship we
bilged inwards about 1½ in. The shot was broken in pieces
the impact. The effect of the 68-lb. shot was so destructiv
that after the second round it was deemed unnecessary to co
tinue the firing.

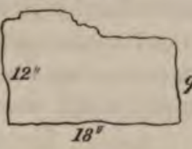
401. With respect to ships constructed according to the secon
of these methods (the "Meteor"), no crack or visible damag
took place when 32-lb. cast-iron shot was fired again
them at 400 yards' distance, with charges of 10 lbs. of powde
A 68-lb. cast-iron round shot, with a charge of 16 lbs., at th
same distance, made cracks in the plates, and started a bo
with some of the inside planking; but wrought-iron shot of th
same nature, with an equal charge, broke off a piece of a pla
15 in. long and 9 in. broad, and drove it inside the ship. Th
inner lining was bilged and shaken, but no bolt-heads we
broken off. The like shot, at the distance of 300 yards onl
drew some bolts and shook the inside planking. A 68-pound
shell, at that distance, with a charge of 12 lbs., did no damage.

402. In February 1860, experiments were made at Portsmout
with the pivot-gun, 68-pounder of 95 cwt., of the "Stork" gu
boat, at a short range, against an iron plate 4 in. thick, 6 f
long, and 4 ft. wide, affixed to the side of the "Old Briton
frigate. The result was, that the third shot broke and smashe
the plate, drove large portions of it through the frigate, an
strewed the deck with numerous fragments of iron and splinte
of timber, more destructive than any shell.

403. In March, 1860, experiments were made against a targ
faced with plates of the manufacture of Messrs. Palmer & Co
each plate being 6 ft. by 3 ft., and 4½ in. thick. They we
bolted on with homogeneous-iron nuts and bolts, each bo
being double-nutted, and fired at with an Armstrong 80-pound

gun, at 400 yards' distance. These plates appear to have stood better than any hitherto tried. But after two previous blows from a conical-headed cast-iron shot, which slightly cracked one of the plates, a hole was punched in it by a homogeneous-iron flat-headed shot, the part punched out being forced into the scantling of timber to a depth of several inches. At the fifth shot, a portion of the plate, of the form shown in the annexed diagram, of the dimensions thereon noted, was driven into the timber, to the depth of 20 inches. The exterior planking, though much shattered, was not splintered. At the eighth shot, the larger half of the plate was broken off, leaving the timber in rear unprotected, but no portion of the shot or plate passed through the scantling, although, by having penetrated to the depth of 20 in. they were very near perforating the side. The five shots first fired struck the target within a radius of 17 in., the individual effects of which, in succession, were noted. Firing only one shot at a time is no very severe or sufficient test of the real-service efficiency of these vessels. Very different would be the effect of a number of shot striking simultaneously, in concentrated continued firing, in action. The battering power of such heavy guns, and the impacts of their solid shot, taking effect upon one particular portion of the ship, would assuredly make a large breach in her side.

Fig. 44.



404. In the attack of maritime fortresses (Art. 346), if the ships are allowed to approach, with impunity, near enough to be able to measure their distance from it, and within effective range (about 400 or 500 yards), to open their fire deliberately, and if the naval operations are combined with a land-attack, the torrent of shot which may be projected against the walls of the fortress will, in general, be irresistible. It was thus that, by a combined attack of the ships and land-batteries, the fortress of Bomarsund was destroyed in 1854 (see Art. 361).

405. The defenceless state of this country, on its sea-coasts, has lately become an object of serious attention on the part of the Government; and batteries or forts have been constructed in various places, in the expectation that they will present efficient obstacles to any attempt, on the part of an enemy, to

effect a landing. As the destruction of some of these will be the first object of the enemy, it becomes of the first importance that they should be made capable of resisting the fire of the heaviest artillery that can be brought against them.

The project of covering ships with thick plates of iron, seems to have led to the idea of protecting, in like manner, the stone faces of land-batteries and forts with massive slabs of iron; and, to try the efficiency of this mode of strengthening the walls of fortresses, was the object of some experiments made in this country in the year 1857.

Fig. 45.

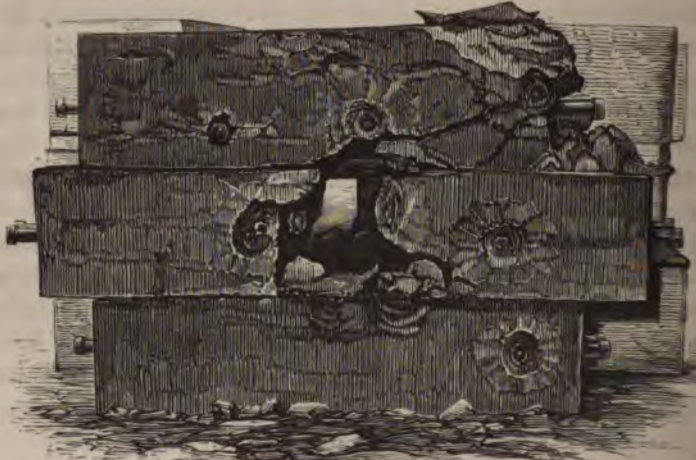


Fig. 46.

406. In the month of September of that year, a Select Committee of the officers of the Royal Artillery, with a number of scientific officers in other branches of Her Majesty's service, assembled in the practice-ground at Woolwich, to witness experiments of this nature.

A target was formed of three cast-iron blocks, each 8 ft. long, 2 ft. high, and 2½ ft. thick, average weight of each block 8 tons. They were placed one above another, a groove being cast on the upper surface of the centre block, 3 in. deep by 14 in. wide, to receive a corresponding projection on the under surface of the block above it. This target was supported in rear by a rectangular mass, consisting of six heavy blocks of granite, each block 4½ × 3 × 2 ft. leaving 4½ ft. of the centre of the target unsupported.

Practice against this target was carried on at 400 yards, with a 68-pounder, 95 cwt. gun, 16 lbs. charge, with cast and wrought iron shot, at the distance of 600 yards: four of the shot were of wrought iron, and the rest of cast iron. The wall was struck ten times, and entirely destroyed. The annexed figures (45 and 46) represent the appearances of the wall, at the front and back, at the conclusion of the experiments.

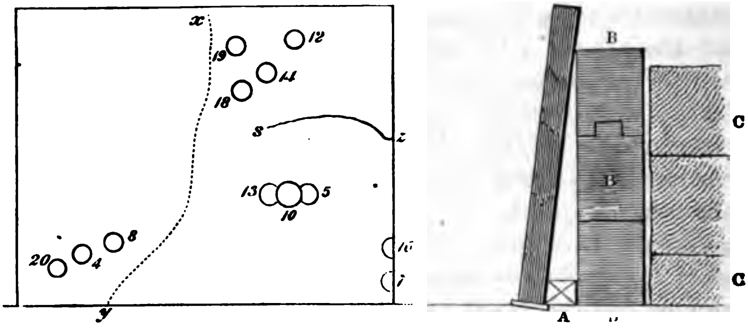
407. The accompanying sketch (fig. 47) is a striking illustration of the marvellous manner in which slabs of iron and blocks of stone were broken up at every blow.

Fig. 47.

408. Another experiment was made against a cast-iron block, 6 ft. by 4 ft. and 2 ft. thick, weight 9 tons 13 cwt., with the same gun and charge as before, and at the same range as the experiment against the three iron blocks. Only one cast-iron shot struck the block, knocking it down, and cracking it through the entire face.

409. In April, 1858, an experiment was made at Woolwich, against a wrought-iron plate 6 ft. square and 8 in. thick, placed in a leaning position, as in the annexed figure, the foot resting on the ground, before a log of wood A, about 10 in. square, and the top of the plate supported by a wall formed of these blocks of cast iron, B B, tongued into one another. Immediately behind these were placed two piles of blocks of solid granite, C C, but the space between the plate and the upright wall left void. Shot of different kinds were fired against the iron plate, from a 68-pounder of 95 cwt., with charges of 16 lbs. of powder, at different distances; and fig. 48 shows the various points of impact. The 1st at a distance of 600 yards, cast-iron shot, caused indentations as at Nos. 4 and 5, which were about 1·3 in. deep; they also produced cracks and slight bulges. behind, besides cracks 6 in. long on the front face and edge: the impact No. 8 increased the former cracks.

Fig. 48.



2nd. *Cast-iron shot,* distance 400 yards. The impact, No. 10, formed a crack as at *z s*; those at Nos. 12 and 13 bent the plate a little, and formed bulges and wide cracks behind.

3rd. *Wrought-iron shot,* distance 600 yards. This shot caused indentations as at Nos. 14, 16, and 18, which were 1·9 in. deep, and broke off large fragments from 2 ft. to 3 ft. square.

4th. *Wrought-iron shot*, distance 400 yards. The impact No. 19 broke off a large fragment; and the part of the plate to the right of the line x y was entirely broken up. The impact No. 20 caused a crack as far as the bottom edge; and the shot glanced off high in the air, falling at a point about 500 yards distant, and at right angles to the range.

410. It results from these experiments, and others given in Arts. 173, 174, 175, that vessels, constructed wholly of iron, cannot be made shot-proof, and are, therefore, entirely unfit for any of the purposes or contingencies of war (see Arts. 176, 177). Of this the figures given in pp. 128, 129, 130, 405, of the effects of shot upon slabs or plates of iron, are abundant proofs. The "Great Eastern" would be shot through and through, by such guns as those used in the experiments, and large fragments of iron driven into the ship, at every perforation, with terrific effect. A few 68-lb. shot, taking effect at or a little below water-line, would drive the crew to the pumps; and although leaks on the inner skin of the ship might be plugged, the outer skin could not be got at.

411. Another remarkable experiment was made on iron defences of another description, viz., the employment of a portcullis made of chain-work: it consists of a chain $\frac{3}{8}$ in. thick, formed into squares of about 1 ft. each way. This chain-work it is proposed to place in front of any barrier constructed of strong timbers, at the entrance of a fortress; and it was expected that the chain-work would resist the explosion of any quantity of gunpowder which might be applied to it, and thus prevent the entrance of an enemy's troops into the place.

Experiments were recently tried on such a piece of chain-work, before a barricaded sallyport at Chatham; on which occasion a bag, containing 60 lbs. of gunpowder, was hung on the chain-work before the barrier. The result of the explosion was that, though the wooden gate was shivered to atoms, and the brick-work of the sallyport loosened, the chain remained perfect. The like experiment was tried, and a third, in which 120 lbs. of powder were employed; and the result was, that, although the brickwork of the sallyport was torn away, only one link of the chain was broken. By the direction of Colonel Sandham, Director of the Royal Engineer Establishment, a 6-pounder field-gun was brought, in order to try the effect of shot on the chain; the consequence was, as might have been expected, the first ball, fired at a distance of 40 yards, broke away so much of the chainwork, that an aperture was formed sufficiently large to permit any number of troops to pass through. The like trial was repeated several times, with similar results. Thus iron proved a bad material for defensive armour in this case likewise.

SECTION XIII.—ON MASONRY DEFENCES STRENGTHENED BY A COMBINATION OF IRON SLABS.

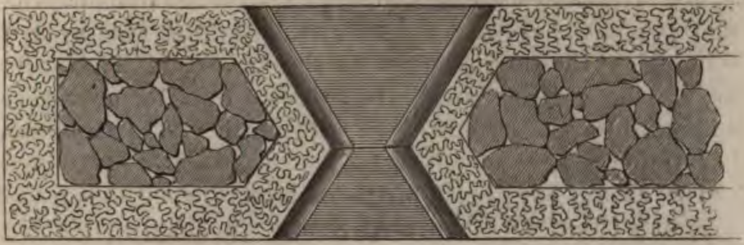
412. Extensive experiments have been made in the United States in 1852 and continued to 1855, against a wall representing a portion of the masonry-works which have been constructed to a considerable extent since 1808 for coast defences; to test the efficacy of plates and slabs of iron to strengthen the outer edges, "flaring surfaces" (cheeks), and throats of casemated embrasures.

413. The objects of these experiments were to ascertain the effects of solid shot, shells, grape and canister shot, from heavy ordnance at 200 yards' distance, upon various materials used in the construction of casemate embrasures; to ascertain whether embrasures might not have a form that would shut out the smaller of these missiles, and resist for a time the heaviest, without lessening the sector of fire, horizontal and vertical, of the casemate gun; to determine whether the throat of the embrasure and also the exterior opening may be lessened; to ascertain whether all smaller missiles might not be prevented from passing through the throat into the battery by shutters consisting of two leaves formed of boiler-iron ½ in. thick, hinged to the vertical throat-irons, and well centred on their respective hinges, to close spontaneously on the discharge of the gun at every round, with some device to keep the shutters from reopening by the rebound.

414. To determine these points, a masonry target, 67 ft. long,

5 ft. thick, and 10 ft. high, containing six gun-embrasures, adapted to casemated batteries, was constructed, of which fig. 49 represents the section and elevation of one casemate.

Fig. 49.

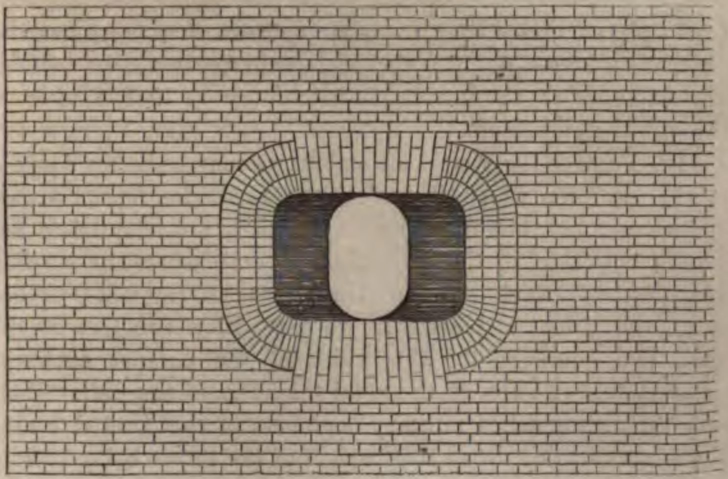


The firing took place at 200 yards; and a screen, formed of rough boards of timber, was placed at the distance of about three feet behind the target, to show the marks of all balls or fragments that might pass through the embrasures.

415. The guns used were 42 and 24-pounders, with service-charges of one-third the weight of the shot; 8-in. and 10-in. shell-guns, firing solid shot of 68 and 128 lbs. respectively, with charges of 10 and 18 lbs. of powder, only one-seventh the weight of the projectile.

The main object of the experiments being to ascertain whether

Fig. 50.



the edges, cheeks, and throats of casemate embrasures might not be effectually strengthened by a combination of iron with the masonry, the author proposes to limit his observations to that important point.

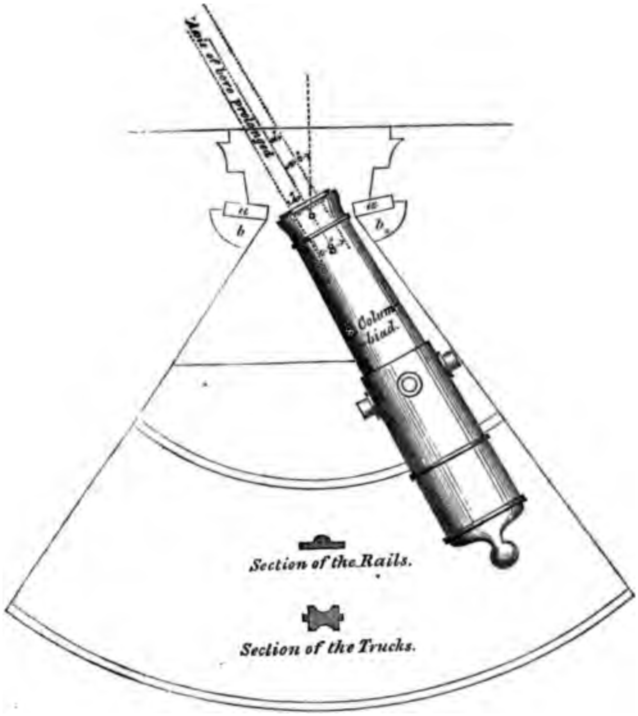
416. The casemate embrasures as shown in the accompanying fig. 50, p. 409, have an exterior opening of 4 ft. wide by 2 ft. 6 in. high at the outside line of the cheeks, and 3 ft. high at the key of the covering arch. The throat, 1 ft. 10 in. wide, is within 2 ft. of the outside of the wall, which at the embrasure is 5 ft. thick.

The cheeks and throat of the embrasure being thus placed so near to the ball when fired from a gun, in the position of extreme training, as to expose them to great damage by the shake occasioned by the blast of the gun.

417. In the American embrasure, the casemate gun must be traversed on a point underneath the muzzle of the gun, in the middle of the throat, where for this purpose the pintle must be established firmly in the stone; and the bar, whether of timber or of iron, on which as a radius to that centre the gun is traversed, must, as well as the pintle, be greatly exposed to destruction by working on the sole of the embrasure exposed to any inroads of shot. If the platform were made to turn upon a point (fig. 51 opposite), but not upon a pintle, underneath the muzzle of the gun, upon iron rails or "racers" laid down in arcs of circles, concentrating upon that point, and grooved tracks placed under the traversing-platform to run upon those circular rails (see fig. 51), the gun would be traversed without any exposure of the traversing-machinery to shot coming in through the embrasure.

418. Perhaps the American embrasure may be better adapted to the case for which it is designed than the funnel-shaped embrasure; but, however this may be, it is not adapted to nor even practicable in the formation of embrasures in earthen parapets 18 ft. thick. In the United States' casemate embrasures, the throat is placed, as we see, within two feet of the wall, and consequently the width of the parapet outwards reduced to two-fifths of the total thickness of the wall. Well may the distinguished military engineers of the United States of the present day dread the dangers of the throat being broken

Fig. 51.



a, a. Section of the jambs of wrought iron. *b, b.* Section of the slabs of cast iron.

through, and the whole opening through the embrasure being exposed to the inroads of shot! Well do those distinguished men see the absolute necessity of endeavouring to remedy the serious defects of those masonry defences which their elder brethren of 1808 introduced fifty-two years ago, by strengthening the throats of the embrasures with enormous slabs of iron! So, if that form of embrasure were attempted in earthen parapets, the throat must be established far in to the mass of the parapet; and, wherever the throat may be placed, the gun must be made to traverse on a point in the middle of the throat, the interior part of the embrasure being shaped like a loophole and the external part an embrasure.

419. Parapets are unavoidably weakened by embrasures of any form: those of the ordinary funnel-shape have the whole thickness of the parapet between their throats and the outward

facing of the work; but embrasures whose throats are placed deep into the thickness of the parapet, would, if that plan could be adopted, be far more liable to be ruined than those of the ordinary funnel-shape: the angular points of the throat would infallibly be broken through, and the whole of the embrasure exposed in great width to the inroads of shot.

420. To strengthen the throats, cheeks, and outer edges of the casemate embrasure, masses of wrought iron 8 in. thick, composed of sixteen plates each ½ in. thick, firmly welded together, backed by slabs of cast iron, forming a frame on the sides, sole, and top of the throat, are firmly bonded into the masonry; the cheeks notched in planes parallel to the face of the wall, or covered with wrought-iron plates.

421. Scrutinizing the experiments reported in the work on casemate embrasures, it does not appear to the author that the expedients proposed by General Totten have been so effectual as to justify the Government of the United States in expending large sums of money in attempts to remedy defects inherent in all masonry defences.

422. By the experiments reported in pages 41 and 42, to test the efficacy of shutters (described in Art. 413), it appears that the hinges on which the shutters turn, were so strained as to bind them against the gorge-plate, and thus prevent them from closing spontaneously by the blast of the gun as was expected. In the experiment 5, table p. 41, one shutter only closed. In round 6, the shutters closed on the discharge of the gun, but rebounded from the cheek of the embrasure, and remained open. In round 7, some moist clay was placed against the exterior edge of the shutters to show whether they actually opened or not, when it appeared that only one of them had closed, but both were found partially open. The thickness of ½-in. boiler-plate not being found sufficient to resist any small missile or large fragment that might strike them, was increased to 1½ inch or 2 inches.

423. Perhaps the very best use to which plates of iron for defensive purposes can be applied, is that proposed by the United States' engineers, to protect by iron shutters (mantlets) the gunners employed in reloading their guns against rifle-shot fired at them through the embrasures, but which it appears did

not close spontaneously by the blast of the gun on its discharge as was expected. Some other agency is therefore required to ensure their closing. Blasts of wind driven through the embrasure, in or out, would defeat the spontaneous action which the blast of the gun was expected to produce. Might not highly elastic but strong gutta-percha ropes fastened to the lower corners of the shutters be attached to the carriage of the gun, so that by its recoil the shutters might be closed, and pushed open when the gun is run up and ready for firing?

424. In experiment, p. 57, it appears that a 42-lb. shot at 200 yards' distance struck the outer plate in the centre, tore out a considerable portion, drove off two or three other pieces against the opposite cheek of the embrasure, jarred the brickwork behind it, cracked the casement from the sole to the roof, and damaged the wall itself above the embrasure on the inside.

425. In the experiment, p. 58, it appears that a 42-lb. shot, fired at 200 yards, struck a block of granite, cracked the stone, loosening the beds entirely through the wall, enlarging the cracks caused by the previous shot; those in the rear of the wall showing a decided effect upon the stones on that face.

426. In page 59 it is stated that a 42-lb. shot fired at the same distance struck the right gorge-plate, tore it from its fastenings, lifted the inner half of the plate entirely from its bed, sending it completely through the embrasure, leaving the other plate in an inclined position out of its place, and the embrasure unserviceable.

427. In page 829, we see that the throat-plates of an embrasure being struck by a 68-lb. solid shot, the cast-iron backing was cracked and pieces driven off.

428. In page 139, it is stated that the shot which struck the granite under an angle that deflected them (which was always the case unless that angle was very acute) were broken into many pieces, all of which passed on. If not deflected, the shot were invariably crushed up into a mass o slightly-cohering fragments and fine particles. In severa instances, grape and canister shot striking the oblique chee of a granite embrasure were broken into numerous fragments, all of which were deflected through the throat of the embrasu into the battery, several having force enough to pass thr

the shutters; very many smaller pieces and spiculæ burying themselves more or less in the wooden screens, with a force that would have caused serious wounds in human flesh.

429. It appears from an inspection of these tables of experiments, that the effects of 42-lb. solid shot, fired with the service-charge of one-third the weight of the projectile, were more destructive than shot fired from 8-in. and 10-in. shell-guns, with charges of 10 lbs. and 18 lbs. of powder, only one-seventh the weight of the shot, as might have been expected from their very small velocity.

430. In the experiments with the 8-in. gun as reported in pp. 77 and 78, it appears that the shot did not pass through the bank of earth 24 ft. thick, situated about 10 ft. from the muzzle of the gun. For what purpose this mound was constructed does not appear.

431. In the experiment, p. 110, with solid shot of 128 lbs. weight, fired from a 10-in. shell-gun, with a charge of 18 lbs. of powder, it appears that the shot broke up on striking, shattered the wall badly in all directions, opening the vertical joints in many places. In the next round, the shot broke as before, shattering the two adjacent stones above, below, and in all directions. In another experiment, the ball penetrated 3½ ft. into the wall, making a crater of 3 ft. 6 in. wide radius.

432. In the conclusion of the report, it is stated that plates of iron will be deeply indented at the points of impact by solid shot; that the masonry behind the plates will be much jarred, and, unless strongly backed, be considerably displaced; and, moreover, that unless the thickness of 3 ft. be well tied into thicker masses immediately adjacent on the sides, above and below, the work will be severely damaged.

433. Thus, as in the case of iron plates backed up with masses of timber, the scantling behind the plates will be found to be seriously damaged, as was the case with the "Trusty" (Art. 242, p. 221), which, when surveyed after the experiments of 1860, was discovered to be so much damaged by the effect of shot, which not only shattered in pieces the wrought-iron plates with which she was covered, but rendered it necessary to repair thoroughly the timberwork before new plates should be placed on her for future trials.

434. In page 138, it is stated that the vibration of the wall was much more energetic in the granite portion of the targets than elsewhere, and that rubble-stones of the inside facing —not always directly behind the point struck—were thrown out by the first motion of the wall, pushed over by the ball; and three or four stones were moved out of their beds, *towards the gun*, so as to project three or four inches from the plane of the wall, being left behind by this first motion, or projected forward by the returning motion of the wall,—stones, moreover, that were well jointed, well bedded in mortar, and of the dimensions of about 3 ft. × 1 ft. 6 in. × 1 ft. 6 in.—while there was also considerable disturbance of all the other stones quite out to the right (the nearest) end, and up to the top of the target. This motion of the granite stones was very slight downward, where the target was supported by the earth, on which it rested; or to the left, where the stones were bonded into a considerable length of brickwork and concrete. The energy of these vibratory movements was very great, as the effects demonstrated; and though the space moved through was no doubt small, it might have been measured, had anything so marked been foreseen and provided for.

435. It must have been from doubts such as these, of the efficacy of the expedient and the cost of executing General Totten's proposition, that the War Department declined to carry it into effect, in the following terms:—"Were it not for the vastly greater cost, the whole scarp might be faced with iron—indeed, might be made of iron only; but, until there shall be much stronger reasons than now exist, or are now anticipated, for believing that well-constructed masonry batteries may be breached by naval broadsides, the cheaper construction may be safely followed; especially as, should such a necessity ever arise, they may be externally plated with iron." If the necessity arise—if there shall hereafter be "stronger reasons than now exist, or are now anticipated," for giving still greater strength to the surrounding wall—the alternative is open to us, as to those who construct the floating-battery (without the objection of weight, so very difficult to overcome in that structure), to coat it (about the embrasures, or further if necessary) with iron plates.

436. A careful perusal of General Totten's work, and an attentive examination of the results of the experiments carried on to test the efficacy of the expedient proposed by him, have left on the author's mind two very deep impressions, he might say convictions: first, as to the inability of masonry walls in general to resist the impacts of solid shot of large calibre; and, secondly, as to the defects of all masonry defences, and to the form proposed to be given by General Totten to the casemate embrasures of his system in particular.

437. It appears to the author that the remedies proposed to strengthen the casemate embrasures is the strongest proof of the original error of having constructed works of this description so as to render it absolutely imperative upon the engineers of the United States to endeavour to remedy defects inherent in masonry defences or to replace them by earthen works. This observation, if followed up, would lead to a very large question on which it would be out of place to enter, but the author may refer to his work lately published on 'Fortification,' in which that question is fully discussed, in examining the controversy which has long been carried on between the French and the German engineers on earthen works against masonry works: the French engineers adhering to the bastion system, with parapets of earth; the German, Prussian, and Austrian engineers abandoning the bastion system, substituting for the defence of the ditches extensive casemated caponnière defences, detaching the escarp from the ramparts, and substituting upright walls, in the manner of Carnot (which the French never adopted), in the middle of the ditch, and many other novelties which had been adopted at Coblentz, Mayence, Rastadt, Ulm, Guimersheim, Verona, Lintz, &c., in all of which masonry defences have been introduced, as the author thinks, most prejudicially, to a very great extent.

438. The very worst combination of materials that can be made in the formation and strengthening of defensive works is that which consists of two hard, rigid, brittle, and splintering materials—stone and iron,—acting and re-acting vehemently upon each other, on the impact of every shot; and which fully explains the causes of the energetic vibrations, concussions, and

displacements, reported in p. 138, of General Totten's work, inserted in Art. 434. The combination of timber and iron is not so bad, on account of the elasticity of the timber, by which the blow is somewhat cushioned. A facing of earth to a stone wall as practised at Sevastopol is a far better cover; but best of all is a parapet of earth—good well-rammed earth—with an escarp wall to the rampart below.

439. With respect to the proposal of applying plates and masonry to the cheeks of embrasures of the ordinary funnel-form, the author considers that neither iron nor stone, nor any other rigid material should be applied to the cheeks of embrasures of earthen parapets; but the merlons should be formed of well-rammed earth, and well-supported by gabions filled with good earth, staked through their centres, and the cheeks formed of good turf. A shot striking there would penetrate into the merlon, and this would be better than that it should glance off an iron plate and be conducted either whole or in fragments into the work, which would be the case if a shot were to strike the iron plate at 25° or any less angle.

440. Reverting to the main question, it is clear that neither iron ships, nor ships covered with slabs of any thickness of metal, that they can carry with safety and due regard to stability, can resist the shock of the heavy ordnance which were brought against them in the preceding experiments; far less will they be invulnerable to the projectiles of the new guns.

441. It will probably be said that, though a ship covered with 4-in. plates of iron may not be proof against the impact of solid shot, it will at least resist the action of shells and hollow shot fired horizontally against them. This is true, and therefore shells should never be used in firing against ships so covered; solid round shot or elongated rifle-shot should be employed, and such shot would inevitably destroy them. Hollow shot is, comparatively, an inefficient projectile, and will soon be discarded from the British navy as it has already been from that of the United States; for, as has been justly observed by Commander Dahlgren ('Treatise on Shells and Shell Guns,' referred to in Art. 274, p. 272), to use a hollow projectile without filling it with gunpowder—which converts a fragile and nearly harmless pro-

jectile into a powerful and efficient weapon—is, in these days, a degree of absurdity which can scarcely be imagined.

All guns, and more especially naval guns, should be capable of firing solid shot which our shell-guns are not, since, even if they were strong enough to do so, their chambers cannot contain charges of powder sufficient to render the solid shot effective. A gun which can only fire hollow shot is, as Commander Dahlgren says, worse than useless if put to fire hollow shot, that is unloaded shells.

442. The French frégates blindées are formed of timbers thick and strong as those of first-rate ships of the line, and their sides covered with steel plates, the thickness of which is said to be 2 or 3 inches. If so, it appears by Articles 397, 398, that steel is the very worst material that can be used for resisting shot, and that steel plates 2 in. thick are easily broken up by 32-lb. shot., or even by shells; and that any of our first-class frigates, if armed on the main-deck with 68-pounder solid-shot guns, would, at any distance within efficient range, tear to pieces a frégate blindée cased with steel plates of that thickness within a very short time. These formidable ships are designed to be substituted for ordinary line-of-battle ships in ocean fleets, and are each armed with 36 heavy guns, 24 of which are 50-pounders converted into rifled guns. The adoption of this scheme by England has been strongly recommended by an able and much lamented naval officer recently deceased (Captain Moorsom), believing apparently that line-of-battle ships cut down to their lower decks, and their sides covered with 4-in. iron plates would not only constitute an effective defence against shells fired horizontally, but even a considerable protection against the heaviest round shot still in use, and going so far as to assert that the fleets of Great Britain should consist of such vessels.

443. A very able and distinguished French officer, M. Richild Grivel, a great admirer and advocate of the Emperor Louis Napoleon's floating-batteries, constructed for the attack of forts and fortresses and other special purposes in inland seas, condemns, in no measured terms, the notion and the practicability of using them in ocean fleets as substitutes for line-of-battle

ships. Admitting fully the advantage of floating-batteries, gunboats, and other vessels of small draft of water, for the special services above stated, he has well said that to dominant fleets of line-of-battle ships for service in the open sea will always belong the sovereignty of the ocean; and that the nation, that would renounce these true representatives of naval power, by constituting their fleets of comparatively small ships, adapted only to services purely special, would be infallibly erased from the category of first-rate naval powers.[a]

444. From the experiments above related (Arts. 385, 388-400), it is evident that plates even of wrought iron 4 in. thick may be pierced through and destroyed by 68-lb. spherical shot,[b] and by the Armstrong and Whitworth elongated shot, if not backed up by a very considerable mass of timber; and that when cracks, or indentations only, are made in the plates, this does not arise from any want of power in the shot to penetrate iron plates of far greater thickness than these (Arts. 401, 402, 403), but from the resistance of the mass of timber forming the body of the ship, by a large surface of which the blow is resisted and penetration prevented, but which so shatters, fractures, and ravages the timber to which the plates are attached, as to render the ship incapable of resisting protracted action unless the carpentry of the ship be made much thicker and stronger than that of those ships which have been already subjected to these severe trials.

445. But to render floating-batteries perfectly shot-proof and capable of contending with coast-batteries, their decks as well as their sides must be covered with shot and shell proof iron plates, so to protect them against the plunging but direct fire of

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[a] "A la flotte de guerre, vaisseaux, frégates et autres bâtiments d'un grand tirant d'eau, appartiendra toujours la souveraineté sur l'océan et dans les eaux profondes. Une nation qui renoncerait à ces premiers représentants de sa force militaire, pour ne plus construire quelles bâtiments de flotille ou de transport, destinés à des usages purement spéciaux, serait infalliment rayée de l'echelle des puissances navales."—'Attaques et Bombardements Maritimes,' par M. Richild Grivel (p. 69).

[b] Supposing the largest battering-ram in use in ancient warfare to have been worked by 500 men, each exerting a force of 70 lbs., the momentum produced by their action, if it were moved at the rate of 1 ft. per second, would be represented by 35,000. The momentum of a 68-pounder shot, moving with a velocity of 1500 ft. per second, estimated in like manner, would be represented by 102,000.

batteries so placed as to have some command above the level of the sea—a condition which none of the floating-batteries hitherto constructed have fulfilled, from their inability to carry such an additional weight of metal.

446. Some interesting experiments have recently been made against iron plates by Sir William Armstrong's new 80-lb. shells, against a target resembling the scantling of a 50-gun frigate, covered with plates of iron of various descriptions, of 1½, 2, 2½, and 3 in. thick, bolted to the timber with wrought-iron screws and nuts. The Armstrong shell, fired with a charge of 10-lbs., pierced the 1½ and 2 in. plates without failure. When fired against the 3-in. plates, one-half only of the number fired penetrated the plates, but not the timber, driving pieces of the plates from 1 ft. to 14 in. into the timber. An 8-in. spherical shell fired with a charge of 16 lbs. against the 2½-in. plates, made only a circular crack round the point of impact. No shell penetrated in an unbroken state, and did not therefore show the effects that a live-shell would have produced by bursting between the decks; or, what is still more destructive, lodging in the side and there bursting.

447. Solid shot of puddled steel, and others of cast iron, fired at the target, penetrated through the 2½ and 3 in. plates, the cast-iron shot doing greater damage to both the plates and timber of the targets, though broken in passing through them, whilst the shot of puddled steel passed unbroken through, both driving off many splinters of plate and wood.

448. Experiments were then made with the Armstrong gun upon the "Trusty" floating-battery, whose sides were 2 ft. thick, covered with wrought-iron plates 4 in. thick, securely bolted on through the timbers, and fastened by nuts.

At 400 yards, with flat-headed cylindrical shot, formed of puddled steel, 80 lbs. weight, and homogeneous-iron shot of 78 lbs., fired with charges of 12 lbs. of powder, none of the cast-iron shot remained unbroken. One shot crushed a plate; two shots broke the plates but did not pierce the timber; one shot only passed through the plates and scantling, but that shot struck close to a previous hole. Two puddled-steel shot were then tried, one of which struck close under a port, drove in a piece of plate 17 in. by 11 in., and scattered splinters of wood and iron over the deck, the other puddled-steel shot struck in the centre of a plate and crushed it, unbroken.

The only shot that really penetrated the plates and timber was formed of homogeneous iron; it struck near the centre of one of the upper plates; smashed off a piece 21 in. by 11 in., and passed through the timber, where it lay partially imbedded. Two cylindrical shot, of 80 lbs. each, went clean through both iron and timber,[a] at a distance of 200 yards, with a charge of 12 lbs. A homogeneous-iron solid shot penetrated nearly a foot into the timber, making a hole in the plate of about its own diameter. A shot of similar form and weight, having struck close to a hole previously made, passed entirely through the side of the ship, driving a fragment of the broken plate deep into the timber on the other side of the ship.

449. The effect of homogeneous-iron shot upon the timbers of the ship differed from that of other shot in this, that the homogeneous shot made more extensive breakage of plates, driving their fragments deep into the wood, from their smaller initial velocity (Arts. 108, 246, 250, 401). All these shots produced great ravaging effects upon the timber behind the plates.

450. Shots were fired through the ports of the "Trusty" so as to strike the other side of the ship without having previously struck. The effect of this was that a piece of 3 ft. long by 2 ft. of a plate, was broken off and driven into the sea after the shot had passed through the timber of that side of the ship. This effect is an important result which had not previously been tried, inasmuch as no opening resembling ports had been made in the targets representing ships' sides; whilst the gun-ports of the ships fired at were filled in. Now, computing by the doctrine of chances the number of shot which struck a surface of given length and height—viz. a section of a ship—how many would pas
any given number of ports of the ordinary dime
be safely affirmed that not less than one-eighth
of shot that took effect upon a target of the l
of the ship would pass through the ten port
and a great many more would pass into a shi
"Alfred," through the twenty-five openings

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[a] Sir William Armstrong's statement to the autho
the effect of the Whitworth flat-headed hexagonal sh
Art. 242, p. 216.

451. This, it must be observed, is a very important circumstance, hitherto unnoticed, as to the effect of horizontal firing from coast-batteries *à fleur d'eau*, at iron-sided floating-batteries; and suggests important practices with cannon of precision, if worked by highly-skilled gunners. But this effect in horizontal firing against such ships, though very important to be noticed, is not to be compared with the far more destructive effect which must be produced upon iron-sided floating-batteries, whose upper decks are penetrable to shot and shells when exposed to a plunging fire from batteries placed on commanding sites of suitable height. When the "Trusty" floating-battery was taken to Chatham to be thoroughly repaired for future trials, the whole of the thick iron plates with which she had been covered were found cracked and broken to pieces, and the timbers much shattered.

452. In the experiments made against the "Undaunted," at Portsmouth, the following results were obtained:—Six wrought-iron 68-lb. shot were fired with a charge of 16 lbs. at 200 yards, the iron plates being 4½ in. thick; four of these shot broke the plates, but did not penetrate the timber; two passed entirely through both plates and timber. Forty-three cast-iron 68-lb. shot were fired against other plates of similar thickness. Of these, four passed through the plates but not the timber. Nine passed through both; but there was only one case of a shot taking good effect after striking an uninjured plate. Thus of the four shots that passed through the plate without penetrating the timber, only one went through a plate that had not been previously weakened.

453. The shot that penetrated entirely through the plates and the timber had all passed through plates previously weakened. No penetration was effected by red-hot 68-lb. shot, with a charge of 10 lbs. The 3 and 2½ in. plates were all penetrated by 68-lb. shot and shells.

454. The following conclusions may safely be made from the preceding experiments:—

1st. That thin plates of wrought iron are proof against any shells, for, though the shells may pass through the plates, they will be in a broken state.

2nd. That being proof against shells will avail little (Art.

441) unless the vessels are likewise proof against solid shot; for shells would of course not be fired against ships proof against them, whereas the destructive effects produced by fragments of shot and of plates, and the great damage done to the scantling of the ship by solid shot appear more like the result of a shell than of a shot.

3rd. That rifled projectiles produce greater effect than spherical projectiles of the same weight at long than at short ranges, on account of the rifled elongated projectiles—the resistance to which is a minimum—retaining more of their initial velocity than spherical projectiles at the same distance.

4th. That the thickness of plates required to resist shot fired from the heaviest nature of guns must not be less than 4½ in.

5th. That, to secure the resistance of the plates and the impenetrability of the sides of a ship, it is indispensable that the plates be strongly backed by masses of the strongest and most resisting timber, as, in all the cases to which reference has just been made, it appears that the plates are easily broken when the support is removed from behind them, by the crushing, fracturing, and damaging effects of the impacts of the shot.

455. Experiments were made in 1848 at Portsmouth (Arts. 163 and 164), against the "Leviathan" to ascertain whether a round shot fired at depression into the water close to a ship would continue its course, and, passing through the water, can maintain force sufficient to penetrate into the ship considerably below the water-line; for this a 32-pounder gun of 56 cwt., with a charge of 10 lbs. was fired at a depression of 7 degrees from a dockyard "lump," 16 yards' distant from the "Leviathan." The shot struck the water 4 feet from the ship's side, rose immediately, passed through the orlop and was found on the lower deck. Another shot, fired under the same circumstances, only indented the wood 18 inches below the water-line. But elongated rifle-shot fired into the water have the faculty of entering and passing through the fluid in the direction of their axes, and, after passing through many feet of water, retain force sufficient to penetrate any ship's side below the water-line. This was proved by firing Whitworth's hexagonal [illegible] circumstances nearly similar to [illegible] against the "Leviathan," when [illegible]

fired from a 24-pounder passed through 33 feet of water, and then penetrated into the ship through 12 or 14 inches of oak-beams and planking. This peculiar faculty of elongated rifle shot may prove very destructive, if not fatal, to a ship close alongside, by a perforation so low that it cannot easily be plugged. But from what has been stated in Arts. 163, 164, and Art. 243, p. 225, this effect can only be produced at short ranges when the elongated shot enters fairly into the water in the direction of its length. And, if the perforation be made through iron sides, it cannot be plugged from within, nor could the parasol-plug (Art. 172) be applied.

456. It is clear, from the result of the preceding experiments, that no perfectly shot-proof ship, capable of resisting a protracted cannonade of 68-pounder solid-shot guns and the new rifled guns, has yet been produced. Those that have been hitherto constructed afford considerable shelter to their crews for a certain time, and may run past any coast-battery with comparative impunity; but in so running past batteries to take a stationary position for the attack of the great objective, whatever it may be, they will have to sustain a protracted cannonade from several coast-batteries armed with the heaviest guns, and which batteries should rather be dispersed on several sites, to concentrate their fire obliquely upon the floating-batteries *à fleur d'eau*, unless the ground admit of placing batteries in commanding positions, which may fire direct but plunging shot and shell upon their unprotected decks. It should therefore be observed as a general rule in the implacement of coast batteries, with a view to defence against floating-batteries whose sides are covered with iron-plates, but whose decks are not proof against shot and shells, that the fire of batteries possessing a suitable command would rip up their decks by a plunging fire with an effect which cannot be reciprocated by the elevated fire of the floating-battery,[a] and with which therefore they are incapable of contending.

457. It having been found by these experiments that ships, such as the "Alfred," "Trusty," "Undaunted," and others, whose sides are not formed of masses of timber sufficiently thick

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[a] See M. Richild Grivel's 'Attaques et Bombardements Maritimes, p. 41.

and strong to resist, throughout a protracted action, the impacts of solid 68-lb. spherical shot and the perforation of the Armstrong and Whitworth elongated rifle-shot, and whose decks as well as their sides are not shot or shell-proof, it has been determined by the Government to construct, for trial, vessels stronger and better fortified in the carpentry of their sides, by which to back up more effectually their iron covering, and whose decks shall likewise be formed of, or covered with, shot-proof iron-plates, and which vessels may be used not only as batteries, but as steam-rams to charge, cut through, and run over any ship with whose side she may come in contact.

458. Two new iron-cased steam-batteries, each of 3668 tons, one being built by Mr. Palmer on the Tyne, the other by Messrs. Westwood and Bailey of Milwall, intended to act as steam-rams proper, both said to be shot-proof, and a gigantic frigate, to be called the "Warrior," are now being constructed in the Thames Shipping Company's yard. The dimensions of the "Warrior" are—length 380 feet (being 100 feet longer than the steam-rams); her breadth 58 feet, tonnage 6177, her two engines of 1200 horse-power, which, with the boilers, will make a total weight of 9050 tons. She has no external keel, but an inner keelson formed of immense slabs of wrought iron; the main-deck is formed of iron cased with wood; the upper-deck will also be so formed. The beams are of wrought iron of immense strength; the skin of the ship is formed of wrought iron, 1¼ in. thick. From 5 feet below the water-line up to the upper deck the sides are formed of a double casing of teak, 18 inches thick. Over these the plates of iron are placed, so that the broadsides of the vessel consist of 20 inches thick of solid teak and 5 inches within and without of the very finest wrought iron. The vessel is subdivided into many portions by water-tight bulkheads. As this vessel is intended to act as a ram, the nose or cutwater, is formed of one immense slab of wrought iron, 30 feet long, 10 inches thick, and weighing about 18 tons. The screw frame is in one piece, of the finest forged iron, and weighing no less than 44 tons. Notwithstanding the vast displacement of the "Warrior," she can only carry coal sufficient for nine days' steaming; she must therefore be provided with full sailing power. To dismantle or dismast her

would therefore be a great object of an enemy, more particularly as the felling of her masts and rigging would infallibly get foul of and disable her screw.

The armament of the "Warrior" on the main-deck is to consist of 36 guns, 15 on each broadside, and 6 revolving guns, all to be Armstrong's long-range guns, for shot of 100 lbs. Some of the plates intended to cover the sides of the "Warrior" were subjected to severe tests, by firing 68-pounder solid shot at them at the distance of 200 yards; but it was found there, as elsewhere, that slabs of iron, of that or any practicable thickness, are quite insufficient to resist concentrated fire of 68-pounder solid-shot guns at short ranges, the plates having been broken and torn apart; what the effect of such a battery will be when the plates are backed up by masses of teak as described, remains to be seen.

459. It may safely be pronounced that the rolling motion of this monstrous flat-bottomed vessel, burthened with so much top weight, will in any swell be destructive of good gunnery, and render abortive the accuracy of the new long-range rifled guns with which she is to be armed, and in the use of which the greatest precision and the nicest instruments in laying the gun are required. By Dynamics, the times of the vibration of floating bodies vary with the depth of the vertical section below the plane of flotation; and nothing but a very deep false keel and bilge-pieces can counteract the tendency of these vessels to follow all the undulations of an agitated fluid. But, to give them false keels would add to their draught of water, and thus prevent their being employed in shallow water. The rolling motion will be far greater even than the undulations of an agitated sea would produce; for the pendulous swing of the top-heavy floating body would not be stopped and reversed until her motion by its momentum had rolled her side deeper into the fluid than what mere undulation of the sea would occasion, before the displacement on the rolling side had become such as to raise that side, and then she would roll equally deep the other way.[a]

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[a] A body is in a position of equilibrium when its centre of gravity and that of the fluid displaced are in the same vertical line. For the pressure of the body downwards is its weight, which may be supposed to be applied at its

460. These vessels, particularly the two smaller, are designed to act as steam-rams for running down and over vessels of any

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centre of gravity; also, the pressure of the fluid upwards is precisely the same as the weight of the displaced fluid downwards, acting in the opposite direction, and the resultant of this pressure upwards must therefore pass through the centre of gravity of the fluid displaced. And, since the body is at rest, the weight of the body downwards and the pressure of the fluid upwards must be opposite and equal; and therefore the two centres of gravity are in the same vertical line.

The equilibrium of any floating body is said to be *stable* when, upon a very slight disturbance, the forces acting upon the body tend to bring it back again to its original position. And the equilibrium is *unstable* when these forces tend to move the body farther from its original position. The equilibrium is *indifferent* when, on a slight disturbance, the forces acting upon the body still balance each other.

Let G be the centre of gravity of a fluid whose surface is A B; let the centre of gravity of the fluid displaced be in the line G C, when the body is in equilibrium; and let H be the centre of gravity of the displacement when the body is moved through a small angle θ. Let the vertical line through H meet C G in M. Now the weight of the floating body acts downwards in the direction G L, and the pressure of the fluid acts upwards in the direction H F; and in the first figure, where M is situated above G, these two forces evidently

Fig. 52.

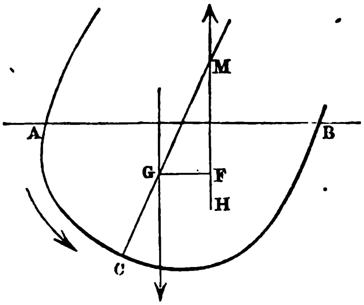
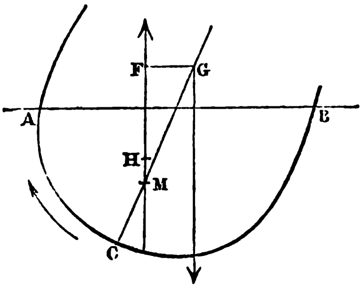


Fig. 53.



size, by the momentum with which they would strike the side of a ship that might permit herself to be so approached, struck,

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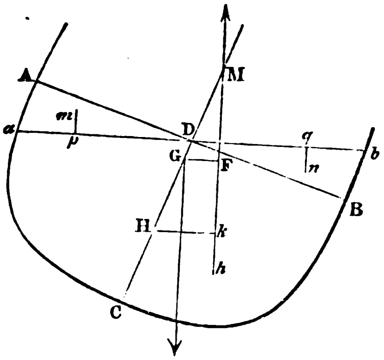
tend to turn the body round in the direction A C B, or to bring the body back to its original position. But if M be below G, as in the second figure, the weight of the body downwards, and the pressure of the fluid upwards tend to turn the body round in the direction B C A, or to move the body farther from its original position; and the equilibrium is therefore unstable. If G and H be in the same vertical line, or M coincides with G, the forces being equal and in opposite directions the body is at rest in every position; and the equilibrium is indifferent. This is the case with a uniform cylinder, or cylindrical shell, floating with its axis horizontally, as it has evidently no tendency to float in one position rather than another. But if the cylinder have a load placed at some distance above it, the body will have a tendency to be overset.

The moment of force which tends to bring the body to its original position, or to move the body farther from it, is the weight of the body W × the arm of the lever F G = W × M G × sin θ, putting the angle G M H = θ. Hence if W and θ be given, the stability of the body is proportional to G M.

The point of intersection, M, of a vertical line passing through H, the centre of gravity of the fluid displaced when the body has been disturbed through a very small angle, and a vertical line passing through G, the centre of gravity of the body when it was at rest, is called the *metacentre* of the body.[*] It appears, from what is shown above, that *the equilibrium of a floating body is stable, unstable, or indifferent, according as the metacentre M is above, below, or coincident with, the centre of gravity of the body.* If we suppose the preceding figure to represent the transverse section of a body floating in a fluid, and that another transverse section, at some distance from this, is equal, or nearly equal, in all respects, to the first section, the intermediate body may be considered as a prism, whose axis is parallel to the surface of the fluid, and whose two ends are equal to the figure A C B. The stability of this prismatic body is readily found as below.

Let A C B be a transverse section of the prismatic body passing through G, its centre of gravity; let A B be the water-line, or the intersection of the plane A C B and the surface of the fluid in a position of equilibrium; *a b* the

Fig. 54.



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[*] The awful rolling of some of the ships of our Channel fleet, on their late voyage from Lisbon, shows that the metacentre is too near the centre of gravity, and thus some of them must have been very near the point of danger.

and run over, and utterly demolish any three-decker, without injury to herself. But great misgivings are entertained, first

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water-line when the body has been disturbed through a small angle θ. Then, since all the transverse sections are equal and similar figures, it is evident that the content of the displacement, or the immersed part, in the first case, is the area $ACB \times l$, and, in the second case, the area $aCb \times l$: l being the length of the prism. And, because these displacements are equal, the area $ACB = aCb$; and therefore the area $ADa = BDb$.

Now, the angle $ADa = \theta$, and the area $ADa = \frac{1}{2} DA \times Da \times \sin\theta = \frac{1}{2} DA^2 . \sin\theta$ ultimately; also the area $BDb = \frac{1}{2} DB^2 . \sin\theta$. And, since these areas are equal, $AD = DB$, or AB is bisected in D. Let H, h, be the centres of gravity of the areas ACB, aCb; and m, n, the centres of gravity of the areas ADa, BDb. Draw mp, nq, perpendicular to ab. Because the area $ADa = BDb$, we may conceive the first area transferred to the position of the second, or the position of the centre of gravity m transferred to n, when the body has been disturbed through the angle θ. Draw Hk parallel and hk perpendicular to ab; put the area $ACB = A$, $AB = 2a$; then the area $ADa = \frac{1}{2} AD^2 \times \sin\theta = \frac{1}{2} a^2 \sin\theta$.

Now, by the property of the centre of gravity,[b]

$$\tfrac{1}{2} a^2 \sin\theta \times pq = A \times Hk$$

and since $Dp = \frac{2}{3} Da$ nearly, $Dq = \frac{2}{3} Db$, therefore $pq = \frac{4}{3} a$.
Hence, if we put $GH = b$, we get

$$Hk = \tfrac{2}{3} . \frac{a^3 \sin\theta}{A}; \text{ and therefore } GF = \left(\frac{2a^3}{3A} - b\right) \sin\theta;$$

and the moment of the force tending to restore the equilibrium is

$$\left(\frac{2a^3}{3A} - b\right) W \sin\theta,$$

W being the weight of the body.

In calculating the stability of ships, the length of the body l is divided into several parts, each equal to λ, and transverse sections drawn through each point of division. Then if λ be taken sufficiently small, each of the solids into which the vessel is divided may practically be considered as a prism; and the preceding calculations therefore can be applied to these solids. Hence, instead of the expression given above,

$$HM = \frac{Hk}{\sin\theta} = \frac{2}{3} . \frac{a^3 . l}{A . l}$$

we shall have, putting $2a$, $2a'$, $2a''$, &c., for the breadths at the different sections,

$$HM = \frac{2\lambda}{3} . \frac{a^3 + a'^3 + a''^3 + \&c.}{\text{whole displacement}}.$$

In the "Warrior," "Great Eastern," and other steam-vessels of very great length, all the transverse vertical sections, except at the head and stern, are nearly similar and equal, and therefore these vessels may be considered as a single prism, with the additions of the bow and stern.

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[b] For if m, m', m'', &c., be a system of bodies whose distances from a given plane are x, x', x'', &c., then if $\bar{x}$ be the distance of the centre of gravity of these bodies from the plane, and $M = m + m' + m'' +$, &c.

$$M\bar{x} = mx + m'x' + m''x'' + \&c.$$

Now, let one of the bodies m be removed to the distance $x + h$ from this plane, and let the distance of the centre of gravity of the system from the plane be now $\bar{x} + k$, we then have

$$M(\bar{x} + k) = m(x + h) + m'x' + m''x'' + \&c.$$

Hence, by subtraction, we get $Mk = mh$.

as to the supposition that any ship, and particularly any steam-propelled ship, would remain so inactive as to permit herself to be so approached and so struck; and, secondly, as to the exemption of the striker from the prodigious shock she must sustain in running butt against the side of a large ship.

The two iron ships which are now being constructed at Millwall and Newcastle-on-Tyne, are more especially designed for running ships down, rather than for fighting them. The author has great misgivings as to the effects which so enormous a shock as that of running *butt* at a large ship would produce upon the ram. Exclusive of the effects that such collision might produce upon the ram-ship, by the fouling of its screw amongst the floating wreck of the vessel so run into, there remains one most important, and, perhaps, vital evil, which has not hitherto been considered. It is, that the momentum of an engine, weighing, with its appurtenances, 800 or 1000 tons—carried forward in a ship moving at the rate of, it is said, fourteen or fifteen knots per hour—being suddenly arrested by the stoppage of the ram when the collision takes place, would cause a shock so enormous, that any ordinary fastenings by which the engine is attached to the ship must be torn asunder, the whole of the internal machinery dislocated, and, by the dispersion of the contents of the furnaces, the ram itself set on fire.

All know the effects produced when ships in motion are suddenly brought to a state of rest by accidental collisions: persons are thrown out of their berths, and everything moveable is thrown forward with prodigious force. And it may be added, that, as the explosion of Armstrong's percussion-shell is effected by the force with which the internal *striker* is thrown forward, when disengaged from its retaining bolt by the force of the impact, so would the whole internal machinery of the steam-ram be thrown forward, overturned, and scattered about, unless retained in its place by fastenings capable of resisting a momentum greater than that of the machinery—including boilers, furnaces, &c.—at the moment of impact.

The author would, therefore, submit that this project should be tried on a real-service scale, by running a floating-battery—well strengthened at the bow, and covered with iron—direct at the broadside of a line-of-battle hulk, brought down to her loadwaterline by being sufficiently loaded. No men should be on board of the hulk; and, during the charge—which should be made at full speed—a couple of men only should be left on board the ram or floating-battery, in order to steer her; a boat being towed astern to enable the men to leave her before the impact takes place. It would be better thus to destroy two ships, in making the experiment, than to leave the project to be tried on actual service, after some expensive ram-ships may have been constructed; which ships may fail to accomplish the purpose for which they have been designed. In the collision, the ram's masts would fall forwards, those of the ship struck, tending towards the blow, would fall over the striker, who, in making her way through quantities of floating fragments of rigging and spars, would infallibly disable her own screw, which, being of the weight of 14 tons, could not be lifted and replaced, and there she would lie like a log, deprived of her motive power, her fuel perhaps nearly exhausted, nothing but a target to be fired at.

461. Nor would it be easy for the ram to attain an opportunity of running into and over the broadside of any ship, well-commanded, in a fleet under steam. It seems to be imagined that the fleet against which steam-rams are so to act are in line-ahead, as if under sail, passively waiting for their iron antagonist, instead of making some countermanœuvre that may dodge or defeat the rush of the ram, and which may easily be done in various ways. The fleet, instead of remaining passive in line-ahead, presenting the broadsides of its ships to be run into by a ram, might turn into line-abreast, and run away from the enemy; but then there would be a pursuit and a protract
cannonade, in which the heavy bow-guns of the ram woul
a great advantage over the comparatively weak poi
retiring ships, raked from stern to stem. But
menaced, the fleet under steam change from lin
line-abreast, or, better still, into double lines of
then to steam, with full power, directly on the
and, when near, turn obliquely or perpendicularl
starboard, they would dodge the ram, which, if of
the "Warrior," could not turn so quickly, just as
is unable to turn as quickly as the hare; and it

author that the inference which is assumed, that a steam-ram may infallibly, if endowed with greater power of speed, run into a ship, is something very much like the operation of laying salt on the sparrow's tail. One thing is at least certain, that no screw-propelled ram-ship could pass through the mass of floating wreck which a collision with any ship would occasion, without the total destruction of her own moving power—the screw. She might sink a ship, but she would effectually disable herself, and become absolutely incapable of fulfilling the purpose for which, at a cost of at least 500,000*l.*, she had been constructed.

462. Let it not be imagined that the results of the experiments made from a one-gun battery—the pivot-gun of a gunboat in very slow firing against targets representing portions of the side of a ship, or against old ships covered with iron plates, with gun-ports filled in and closed with iron-covered lids—are sufficient tests of what the results would be of an action between one of our first-class frigates, armed with 95-cwt. 68-pounder guns on the main-deck, and a floating-battery of the description to which this article relates, the frigate commencing her fire with her whole broadside-battery concentrated upon a part of her enemy's side, and sustaining the battle with the utmost rapidity.

This would, no doubt, prove not only the vulnerability of the floating-battery, by the penetration of single shot, but by the destructive impacts and concussions produced simultaneously, or in quick succession, by a multiplicity of blows, many of the plates would be struck in several places, cracks would extend from one hole to another; the bilging-in, which, as is shown in the preceding experiments, was produced by one shot, would be vastly increased by the impacts of the many; beams would be broken, timbers fractured, beams and shelf-pieces sprung or started; bolts and rivets driven off; seams opened; and one-eighth at least of the shot correctly aimed to hit the hull would enter the ports of the floating battery, dismounting or disabling guns and carriages, the shot taking off many of the crew in crossing the deck, ravaging and penetrating the timbers on that side, and ultimately driving off and into the sea the iron plates on the exterior of that side. Of this we may be perfectly assured, that, when a shot does break through the side of a ship, the effects on the crew, exclusive of those on the material of the vessel, will be far more destructive of the crew than any that could be produced by many shot, and greater (Arts. 402, 403) than even the explosion of any shell.

It is stated in Art. 403, p. 403, in the experiments made at Shoebury Ness on the 1st of March, 1860, that five of the shot fired at the target, struck within a radius of 17 in. In quick concentrated broadside-firing, in action, from a ship's broadside battery, or from a well-armed coast-battery, numerous simultaneous hits would be inflicted on the foe. Five or six heavy shot striking upon any small portion of the side of a ship, would, instead of bilging it in by single shot, as we have seen, drive a great portion of the side in, and make a large breach; and this all the more likely that the shot do not penetrate; for a shot in perforating the side of a ship does not communicate all its motion to the medium through which it is passing, but the impact of a shot does, and that instantaneously; and the amount of five such impacts, acting together, would assuredly make a breach in the side of any ship.

463. As with respect to the preceding descriptions of real-service experiments, ship against ship, so will it be fallacious to assume, from the experiments that have been tried with single guns and slow-firing, against targets representing coast-batteries, that the efficacy of the expedient, reproduced by the Emperor Louis Napoleon, to give to floating-batteries mastery over coast-batteries faced with masonry has been proved. In the first place we trust, that if our coast-batteries should ever be attacked, they will be found to have been formed and faced with a much better material than iron, viz. *earth.* Tested on real service, floating-batteries would have to contend with several coast-batteries, each armed with a considerable number of our most powerful ordnance of the old and new school, either placed, of necessity, if the coast be low, *à fleur d'eau;* or, if the ground admit, established on sites having considerable command above the level of the sea, and rather in separate batteries, from which oblique or concentrated firing may be carried on against the enemy, than by placing the same number of guns in one battery. The gun-batteries placed *à fleur d'eau*, if attacked by floating-batteries, should be aimed with the utmost precision, of which rifled cannon are so capable, at the enemy's ports; when, as

has been shown, in horizontal firing at a ship at short ranges (Art. 450), one-tenth at least of the projectiles so aimed would enter her gun-ports and produce very great internal destruction. If the coast batteries attacked be placed above the level of the sea, on suitable sites, the timber decks of floating batteries would be commanded and ripped up by the plunging but direct fire of shot and shells.[a]

464. It appears to the author that there is little to dread from these unwieldy flat-bottomed, top-weighted, heavy-rolling craft, in the open sea, or on an open coast, against well-placed commanding coast-batteries, strongly armed with new long-range rifled cannon for distant firing, mixed with the smashing effects, at short ranges, of shot or shell from powerful guns which can fire either, and all well served by skilful artillerists.

465. Let us pause in expending millions of money in constructing ships, such monsters as the "Warrior" and others, till the problem of the efficacy of metallic defences be fully worked out: the farther we proceed in that direction, the more will it be found that iron, whether cast or wrought, is the worst material excepting steel that can be used for strengthening either sea or land defences; and that it were better to expend the money in forging in abundance the new engines and bolts of war, than in vain attempts to render ships proof against them. We must not, however, imagine that we have a patent right to the exclusive use of the powerful long-range ordnance which Armstrong and Whitworth have invented. In these times, all the productions of science and art soon become well understood, and the common property of our neighbours as well as of others. The offensive power of those long-range guns, for the destruction of arsenals by bombardment, will rest with whichever of the two powers may have the command of the sea, and this we must ever firmly

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[a] "Les forts et batteries de mer de Sébastobol remplissaient, en un mot, toutes les conditions que le savant général d'artillerie Sir Howard Douglas propose pour les défenses des côtes :—Difficulté d'approche pour les vaisseaux, en raison des bancs et obstacles sous-marins; batteries en terre (forme barbette) pour les terrains élevés; forts en pierre casematés, pour les ouvrages à fleur d'eau ; choix de calibres formidables, canons de grande portée, obusiers et mortiers d'un grand diamètre; concentration d'une masse prépondérante de feux *croisés* et *plongeants*, sur toute la zone navigable, pour les vaisseaux ennemis."

and resolutely maintain. England will never commit any act of unprovoked aggression, but always be well prepared for defence. It does not, however, follow, that, should we be menaced at any time with aggression and invasion, we should act so purely on the defensive as not to avail ourselves of the prodigious power with which the new guns arm us, or forget that the most effectual mode of defending our country is by offensive defence. And so the matter comes to this, that, if we do not maintain absolute dominion on the seas which surround the British Isles, our neighbours will attempt to destroy our arsenals by bombardment with their long-range guns. Whereas if we do maintain firmly that dominion which we have so long held, we may assuredly commence the operations of the war, into which we had been forced, by destroying theirs.

PART IV.

ON THE SERVICE OF GUNS IN ACTION.

SECTION I.—ON THE DETERMINATION OF THE DISTANCES OF OBJECTS AT SEA.

466. IN all cases of gunnery, an accurate knowledge of the distance is of the first importance. When considerable, it is usually estimated very vaguely; but the necessity of knowing it as correctly as possible, at long ranges, is greater than when the trajectory is nearly rectilinear, as in short ranges; elevation being given according to the distance, and inaccuracy increasing with length of range. At considerable distances, also, there is more leisure and opportunity, as well as greater necessity, for determining those distances with precision, while in closer action all that is required is, to be certain that the enemy is within point-blank range. When two vessels are opposed to each other at great distances, the effect will depend almost wholly on the skill of the gunner; and that vessel which has most correctly estimated its distance from its opponent will do most execution, supposing everything else equal. Let those who may be inclined to disregard such niceties refer to our actions with the Americans (which will be more particularly noticed hereafter), and they will perceive that, in our unsuccessful affairs with them, our vessels were in general crippled in distant cannonade before close battle commenced. This is fighting skill against skill, and shows the absolute necessity of attending, minutely, to everything that can contribute to precision of fire at great distances. In such trials the most devoted heroism will avail little, as we have seen, unless trained to precision. It is not proposed that trigonometrical calculation should be used to determine the degree of *proximity* of an enemy who will fairly close for straightforward battle; but, should the opponent prefer to keep off for a time, in order to try the effect of his guns and his skill at long ranges, the importance of what has been recommended with respect to the training of gunners and to the

attainment of an accurate knowledge of the distance at which the fire is to be returned, cannot be disputed; the latter is, indeed, the fundamental requisite for efficiency of practice. If the distance be only vaguely guessed, suppose within two or three hundred yards of the truth, the elevation cannot be right to corresponding extents. The consequent error may indeed be somewhat corrected, when committed, by observing the effect; but *trying the range*, as it is called, is, in such a case, extremely objectionable—discreditable to the system, and consequently injurious in its moral effects.

467. Numerous methods have been proposed for readily estimating distances, and, of these, none appears so simple and obvious as making use of the different angles, subtended, at different distances, by the heights (when known) of the masts of the ship whose distance is desired, the heights and distances being arranged in a table; so that, by simply measuring, with a sextant or quadrant, the angular height of a mast (as is commonly done in line of sailing, or in chasing, to ascertain whether the chace be gaining or losing distance), and entering the column of angles, the corresponding distance may be taken out. Table XVIII., Appendix B, at the end of the work, is one in which the heights of the different parts of French ships of war, and of their masts, above the surface of the water, at load-water-mark, are given, for every rate and class of vessel. From these elements, Tables XIX. and XX., Appendix B, have been formed, in which are given the distances, expressed in English yards and cables' lengths, corresponding to the angles subtended by the heights from the water-line to the truck of the mainmast, and also to the main-topmast cross-trees: the eye of the observe being 20 ft. above the level of the water.

468. It has been ascertained, from authentic documents, t the dimensions of the masts of American ships of war are many cases, exactly the same as those of French ships of co sponding rates, as expressed in the tables; and, in general, th are so nearly alike, that this method may be used to estimate distances with tolerable certainty in acting either against French or American vessels. It is not, indeed, likely that establis dimensions, which are, in general, rigidly observed, wil much from the quantities stated in a table which

formed from official documents; if they should vary in some cases, the difference cannot be so much as would create an error of more than a few yards in the required distance; and the results will always be much nearer the truth than the most practised eye could give: at any rate, the distances found from the table will be sufficiently correct to produce good practice, if all the other essentials be well understood.

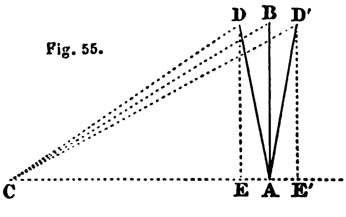
Every man-of-war should be provided with a table showing the angles subtended by the masts of foreign ships of war, with the corresponding distances in English feet or yards.

This method of obtaining distances at sea, simply by the inspection of a table containing the angles subtended by a mast of known height at different distances, as now very generally practised in the service, is preferable to any other when it can be used.

469. Another method which has been recommended consists in taking simultaneously, at the bow and stern of the ship, the horizontal angles between the line joining the places of the observers and lines drawn from those places to some point at the enemy's ship. This method requires either a logarithmic computation, or a double inspection in a table prepared for the purpose; it consequently presents great difficulties when the ships are under weigh, particularly if one is much before or abaft the beam of the other, and is quite inapplicable if one is on the bow or stern of the other: whereas the former method may be used in all positions of the ships, provided the height of a mast of the enemy's ship be known.

470. That method will not, however, serve to obtain the distances of steamers, which either have no masts or have them of no regular height. In this case, the distance may be determined by making use of the ship's own mast as a given height, causing an observer aloft to measure the angle A B C formed by the mast A B, when vertical, and the line of sight B C from the observer to the enemy's ship at C; and then either computing the required distance A C by the formula A B tan A B C. or obtaining it by inspection in a table. If, during the

Fig. 55.



operation, the ship should be on a *heel*, so that the mast has an inclined position as A D or A D′, the angle of heel B A D or B A D′ (as shown by a pendulum suspended from the centre of a graduated arc) must be taken, and either subtracted from the observed angle A D C, or added to A D′ C, according as the *heel* is towards or from the enemy's ship (supposed to be on the beam). The sum is equal to the angle E′ D′ C, and the difference to the angle E D C; and, by trigonometry, A D cos B A D tan E D C = E C, the required distance: but the correction for the heel will rarely be necessary in good fighting weather.

In observing the angle C B A or C D A, since the image of the distant object is that which would be brought by reflexion to coincide with that which is the nearest to the observer (a mark on the *top* or on the deck), the parallax of the instrument would not, in any sensible degree, affect the accuracy of the observed angle.[a]

This, in principle, is nearly the method sometimes practised, of observing with a sextant, at the cross-trees, the angle between the enemy's water-line and a point *vertically* under the observer. If this observation could be always made, it would be indifferent whether the enemy's ship were on the beam, or the bow, or the quarter.

471. An objection to this method is that, when the mast is not in a vertical position at the time of making the observation, it is difficult to have on the deck a point vertically under the observer's eye; and if the observed angle is one between a line, as D C, from the observer to the distant ship and the direction D A of the mast, it would be necessary, when such ship is no
directly on the beam, to introduce a correction to that obs
angle. This correction could be made either by comput
by means of a subsidiary table, provided the angle at

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[a] The parallax of the sextant is the angle subtended, at t
object which is seen by reflexion, by a line joining the observe
point in which the produced ray of light incident on the index g
from that object, intersects the ray from the object seen throug
silvered part of the horizon-glass. This parallax is always g
object seen by reflexion is nearer to the eye, and as the observed
but, at no greater distance than 100 yards, and with an observ
small as 10 degrees, the parallax of a common sextant would n
minutes of a degree.

the mast between the direction of a fore-and-aft line on the deck and that of the enemy's ship be observed at the same time that the angle is observed on the mast. The formula for the correction is, by trigonometry, $\sin h \sin a = \sin C$; in which h is the angle of *heel*, a the angle between the fore-and-aft line and the direction of the enemy's ship, and C the correction.[a] This is subtractive from, or additive to, the angle observed on the mast, according as the heeling of the mast and the enemy's ship are on the same or on contrary sides of the fore-and-aft line.

With respect to the method in which the water-line of an enemy's ship is brought by reflexion to the foot of a plumb-line on deck, it would be, perhaps, impossible to observe the angle with accuracy. But, as the pendulum placed in the main hatchway is useful for other purposes, as in determining the proper instant for firing guns horizontally, or otherwise, so there is nothing to prevent the employment of the instrument for finding the angle of heel in combination with the observation of the angle A D C (fig. 56). An objection has been made to the method of observing such angle from the masthead, when the ship or object is to leeward, on account of the top-gallant sail being in the way; but the top-gallant sail may not be set; if it be, and in the way, it may be clewed up, or the lee-sheet started, and the clew hauled-up during the operation.

472. An able and already distinguished young officer[b] has

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[a] Let A B represent a mast in an inclined position, A E a fore-and-aft line on the deck, and A C the direction of the enemy's ship: let B m be a vertical line let fall from the cross-trees at B to met a horizontal plane passing through A and C, and let B m n be a triangle in a vertical plane passing through B m perpendicularly to A C. Then A B C represents the observed angle, and A B n is the correction which is represented in the text by C; also A B m is represented by h, and E A C, or its equal, A m n, by a.

If A B be represented by unity, we have A m = sin h: and by trigonometry, A m sin A m n = A n; that is, $\sin h \sin a = \sin C$, as in the text. Thus the angle A B n, or C, is found; and being taken from the observed angle A B C, it leaves the angle n B C. Thus A B cos C tan n B C = n C, the required distance.

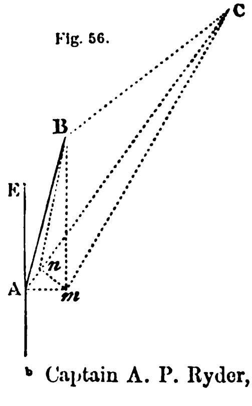

Fig. 56.

[b] Captain A. P. Ryder, R.N.

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lately proposed an ingenious mode of determining the distance of steamers, or of ships the heights of whose masts are not known, by observing from the cross-trees, [top-sail yard, or any other convenient perch, the higher the better, the vertical angle between the visible horizon and the enemy's water-line. The computation, by this method, would be very laborious, requiring logarithms with seven places of decimals, but the proposer has given a double table from which the required distance may be taken by inspection. The chief objection to the method is that the angle subtended, at the observer's eye, between the edge of the horizon and the enemy's water-line is very small, being, at 2630 yards, only 33′ 53″; when land, instead of the sea-horizon, is beyond the enemy's ship, the observation must be made with a sextant fitted with an artificial horizon, and consequently would be liable to great uncertainty.

473. But why might not the following application, in an oblique plane, of Sir E. Belcher's horizontal method, be adopted?

Let two observers, each visible from the other, one at B (suppose at the cross-trees of a mast), see the preceding figure, and the other at A (suppose on the deck) as far forward or aft as possible, take simultaneously (C being the ship or object whose distance is required) the angles C A B, C B A. The length of rope which is made the base A B, being once measured, may be considered as constant; and the required distance A C may be obtained by the usual process. Or, if half the sum of the two observed angles at A and B be taken as one of the angles at the base of the triangle (supposed then to be isosceles), the distance may be found with sufficient precision, on multiplying the half length of the base by the tangent of an angle ec to half that sum. At the distance of 300 yards, the err the most unfavourable case, would not exceed 4 feet; becomes less when the distance is greater. It is easy that a table might be made from which the required dist might be had immediately on inspection.

This method will be better understood by an inspection of annexed plate. The maintop-gallant masthead is supposed be the point marked B in fig. 56, in the preceding note: tl length of the maintop-gallant backstay,[a] to the point to which it leads in the main chains, may be made the base A B; and the length of that rope must be accurately measured: the point C (indicated by the convergence of the lines of observation, A A′ and B B′, produced) being the ship or object whose distance is required, the angles A B C and B A C are taken simultaneously to the water-line of the ship C, by observers placed at the two points. Or, as the lines traced in the plate show, the fore-top-mast or fore-top-gallant-mast stay may, in some cases, be more conveniently used, the observers being placed at the head of the top-mast or top-gallant rigging, and on the jib-boom respectively. The exact lengths of these ropes may easily be verified by actual measurement, as occasion may require.

The distance of steamers not being determinable by the method explained in Art. 467, and the heights of the masts of French sailing ships, though very correctly given in Table XVIII. Appendix B, being subject to alteration from time to time, by variations in the immersion of the ship, and other unknown circumstances; and, seeing that no very accurate account of the heights of masts of other foreign ships of war can be obtained, it is obvious that the method which proceeds upon an accurate knowledge of the height of a vessel's own masts, or length of any convenient rope of its rigging, possesses great advantages over that which depends upon the assumed height of the masts of the vessel to be fired at.

The method proposed by the author (Art. 470) of using the known height of a ship's own mast above the water-line as the

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[a] TABLE showing the Lengths of the Fore and Maintopmast and Top-gallant Stays and Backstays of English Ships of War.

—	Line-of-Battle Ship.		Frigates.				Corvette.		Brig.	
	80 Guns.		50 Guns. 1st Class.		40 Guns. 2nd Class.		18 Guns.		16 Guns.	
	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.
Maintop-mast Backstay ..	136	6	129	8	120	6	84	0	79	6
Maintop-gallant Backstay	167	0	158	6	147	6	105	0	99	6
Foretop-gallant Stay	148	0	147	0	137	0	99	0	100	0

base of the triangle by which the distance of an enemy's ship may be computed, though liable to some difficulties, will be of use on many occasions when other means cannot be resorted to, as when it is required to ascertain the distance of a steamer, or other craft, which has either no masts or such as have not their heights in accordance with a fixed regulation; or, again, when the horizon, from the intervention of the land, cannot be seen. The difficulties alluded to are such as may arise from the ship having so much motion as to render it scarcely practicable to take the angles on the mast and at its foot, as well as the angle of *heel*, simultaneously. In smooth water there can be no difficulty. In inland seas, at anchor, in preparing to attack land-batteries, when it is of importance to determine the distance of the object from the ship, there seems to be no other method of obtaining such distance than by some triangulation in which the base is either the length of the ship, as in Sir Edward Belcher's method, or the height of the ship's own mast, as proposed by the author. In suggesting this last method it is not intended to disparage the very ingenious one proposed by Captain Ryder or that of Sir Edward Belcher, but merely to offer a means which may be employed when circumstances render it applicable; and it may be observed that the difficulties indicated would be equally felt in Sir Edward Belcher's method, which is, besides, applicable only when the object whose distance is required is well on the *beam.*

When the height of the object is not known, the distance may be ascertained by having a line marked on the "knight-heads" at right angles to the keel, and stationing a person at the "Concentrating Director" (fixed as far aft as possible) to keep the object on with the sight; another being stationed forward, to make a signal when the *line* is brought on with the object by the helm: the length between the two observers and the angle by the Director being known, the distance can be ascertained. (See Tables XIX. and XX., Appendix B.)

SECTION II.—ON THE POINTING OF NAVAL ORDNANCE.

474. When, without manœuvring, ships come fairly to close action, the necessity of determining the elevation due to the

distances of the objects does not exist. Superior precision, and rapidity of horizontal fire, will then determine the affair; it is important therefore to consider the best means of laying ordnance readily in horizontal or point-blank positions, whatever be the inclination of the vessel. It very frequently happens that ordnance cannot be pointed accurately by sight, particularly in general actions, on account of the smoke in which the hulls of the contending vessels are usually enveloped. In such cases, therefore, it is necessary to resort to some expedient by which each piece of ordnance may be readily laid, and correctly fired, in a horizontal direction. Various very ingenious contrivances were devised during the late war to regulate generally the position of ordnance for horizontal fire; and the most successful method of doing this was by means of a pendulum, as practised by the gallant Sir Philip Broke in his Majesty's ship "Shannon."

475. This ingenious expedient was also practised by other gallant officers, from the example of its distinguished author; and it is described in a tract by Captain Pechell, entitled 'Observations on the Defective Equipment of Ships' Guns, in a Letter addressed to Vice-Admiral Sir Harry Neale, Bart., G.C.B., dated H.M.S. "Sybille," Dec. 1st, 1825.'[a]

The motion of a large ship, in good engaging weather, is so easy and slow, that anything of a pendulous nature, nicely fitted, on board, will act with considerable accuracy—witness the marine barometer.

Though, at first sight, there may seem to be grave objections to an application of the pendulum for this purpose, on account of the disturbing effects of the vessel's motion, yet experience has proved (see Arts. 476, 477) that the pendulum may, with advantage, be used in regulating the position in which ordnance should be laid, with reference to the angle of heel, so as to

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[a] The author's lamented friend Sir John Pechell, sent him a copy of this tract soon after it was published, in a letter dated Dec. 12, 1826, of which the following is an extract:—"I am sure you will approve of everything that has a tendency to bring gunnery into fashion. You will perceive I have quoted your work, and only wish the Admiralty had long since adopted your system, but it appears they were frightened at the expense; something, however, has been gained by you to begin with, and that is an ample allowance of powder and shot."

produce a fire nearly horizontal. Those, again, who object to the principle of intrusting to captains of guns the care of regulating the pointing by the position of a pendulum, can scarcely be aware of the high degree of efficiency, intelligence, and practical skill, to which, though not in sufficient numbers, the whole corps of seamen gunners has been raised by the Institution described in Part I.

476. The established practice in the British service, with respect to the use of pendulums, is to have one or two of these instruments placed in the square of the hatchway or hatchways in order to denote the inclination of the ship; and general orders, circulated by signal or otherwise, direct the elevation to be given to the lee-guns, or the depression to the weather-guns, according as the ship may be engaged, so that, in either case, her firing may be horizontal. The guns are always kept in horizontal positions, and the sights at point-blank, unless contrary orders are given. The depression chock is always to be used so long as the elevation will admit of it, as the coins are then less liable to start out. This method may be used with advantage when approaching an enemy, by running down from the wind, the guns being prepared for horizontal firing by the best possible estimation of what the heel of the ship may be when brought to the wind.

477. The pendulum is very generally used in the French naval service to indicate the moment when the axis of the gun becomes horizontal; and it is justly considered so important to determine this with the utmost precision, that the indications of the pendulum are compared with, and checked by means of a reflecting instrument, so constructed as to show by the coincidence of the real and reflected horizon, the instant in which the axis of the gun is horizontal. This combination, called L'Horizon Balistique, is mentioned in several works as an important discovery.[a] French writers observe that accuracy in aiming, and certainty in hitting, have now become matters of the utmost importance in an economical as well as in a pro-

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[a] The reader will find a description of these expedients in Colonel Préaux's work, 'Sur le Canonnage à Bord' (p. 100); but no figures are given to show how they are applied.

fessional sense, on account of the enormous expense of the shell-system.

478. However accurately the distance of an object may have been determined, and however well a ship may be furnished with tables and rules for practice, and provided with skilful and experienced gunners, the firing cannot be efficient unless the ordnance be furnished with correct sights.

The only means provided in the ordnance arsenals during the late war for pointing naval ordnance, were the quarter-sights engraved on the sides of the base-rings, in quarter degrees from point-blank to two or three degrees. For close, horizontal fire, guns not provided with proper sights (and some such may yet be required) may be laid by the point-blank quarter-sight, with sufficient accuracy, by simply bringing the notches upon the base-ring and muzzle to bear upon the object aimed at; the elevation will then be correct, and, in close action, the line will be sufficiently true. But when the distance is such as to require any elevation, this method of pointing guns is totally inapplicable to naval service; because, unless the line be correctly taken over the top of the gun at the same time, great errors in horizontal divergence would be produced. In land-service the line may be taken over the top of the piece, and the elevation afterwards regulated by the quarter-sight; but in naval practice these two operations must be executed simultaneously. It is, therefore, a matter of great importance in all naval artillery-practice, to reduce these two operations to one; and this can only be done by means of a tangent-scale fitted to the breech of the gun, either at the side or on the top, and a dispart so placed that the line of sight may be parallel to the axis when the tangent-sight is close down.

In our naval actions of 1812 and 1813 the disadvantages arising from not having any regulated sights or adjustments of this description were severely felt; and, had it not been for the intelligence, ability, and skill of our naval officers, who, by various expedients, supplied this great defect, the consequences might have been very serious. The guns of the United States' frigates were fitted in a manner which enabled them to be fired horizontally, or at any required inclination. In some cases this was accomplished by the dispart, in others by tubes placed on the tops of the guns, and either fixed parallel to the axis or provided with the means of being inclined to it so as to give to the gun the requisite degree of elevation.

479. It was not till after that war that the subject of sights, and scales of elevation, was taken into serious consideration by the proper authorities in this country, when instruments of various descriptions were devised to take the line of direction and give the necessary elevation to the gun at the same time. To effect this, *top-sights* (Congreve's) were first introduced and very generally used. Moveable sights of different heights had been used on board of the "Shannon" and "San Domingo" during the war, the only fixture being a confining sight on the breech, to warn the captain of the gun to keep his eye down to the level of the notch on the base-ring, in line with the other sight. Congreve's sights consisted of tubes of delicate construction, fitted, with mathematical and mechanical nicety, to minute differences of elevation; but it was soon found that instruments of this description standing high upon the top of the gun, would, on service, if attached to guns upon the quarter-deck, forecastle, and gangway, be exposed to damage at every instant by the fall of rigging, &c., from aloft; and, if on the main deck of line-of-battle ships or frigates, by the working of the tacks and sheets in manœuvring. Another serious objection to fixed top-sights standing considerably above the breech, and for which the means then in practice afforded no remedy, was that the lowness of the upper sills of the ports prevented the use of those scales when a ship might be fighting her lee-side under pressure of a smart breeze, her opponent being so distant as to require considerable elevation to be given to the guns.

It appeared also on further trial that whenever there is so great a swell as to occasion much and rapid motion, any close sight having but a small aperture through which to catch a glimpse of the antagonist's ship, as it passed rapidly into and across the field of the tube, was not found so advantageous as an open sight; because the quick motion of a ship giving but a glimpse of the object fired at, without a distinct perception of the approach to coincidence, induced the captain of the gun either to take his eye from the tube, or by keeping his eye too long to it, prevented him from anticipating the right instant, which a skilful and experienced gunner ought to seize.

For these reasons all complicated instruments, as sights, have been abandoned, and the simple tangent-scale, as long used in the land-service, is now universally adopted in the navy.

480. The tangent-scales, with which all naval guns are now fitted, are made of brass. For all 32-pounders, up to 50 cwt., the scales are graduated to 5°. The 56 or 58 cwt. 32-pounder, length 9 ft. 6 in., admits of the tangent-scale being graduated only to 4°. When greater elevations are required than the brass scales can give, a wooden scale[a] of the same form is substituted; this is graduated from 4°, or, as the case may be, from 5°, to 6½°; and, for still greater elevations, a longer scale is put in, which is graduated up to 10°, the greatest elevation which the ports of ships in general admit of. If greater elevation or depression is required than the ports will allow, inclined planes placed, in the former case, under the rear trucks, and in the latter, under the fore trucks, will permit about two or three degrees more, of either, to be given.

The elevation may be increased beyond that at which the gun can come in without its muzzle striking the upper sill of the port, by placing the edge of an inclined plane beneath the after axletree, so that in the recoil of the gun the hinder part of the carriage being forced up the inclined plane, the muzzle is thereby depressed, and comes in without striking.

481. At the time the author first published this work, the elevating-screw was coming rapidly into use in the French naval service for all natures of ordnance; as, by its means, the gun could be easily elevated or depressed by one man, whereas the adjustment by means of the coin required two handspike-men per gun; and in this way the elevation was effected by jerks, whereas with the screw the movement would be uniform and gradual. When great changes of elevation are required, it is true that there is some loss of time by the slow process of the screw, and for this and other reasons it is objected to in our service; but, formerly, the great advantage of the screw over

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[a] It has been found that brass is not suitable for tangent-scales of great length, as they invariably droop if made of that material.

the coin, particularly in rapid firing, was, that by the very ingenious mode of preventing the screw from turning, the elevation of the gun was not altered by the firing; whereas, in the other mode of adjustment, the coins were displaced by the shock of the discharge, so that, after being fired, the gun had to be restored to its previous position, the distance and charge being supposed to remain the same. This objection to the coin does not now exist, as it is secured from shifting its position when the gun is fired, by the use of coin lanyards: while, in regard to the elevating-screw, it must be allowed that there are two serious objections to its use, viz., that it might become so strained or bent by the concussion of firing as to become unserviceable, or it might be bent or broken by shot so as to become jammed and very difficult of removal.

The following table contains the extreme elevations and depressions of guns, which can be given, without injuring the ports, on each deck of different ships of war in the British navy :—

Deck.	Nature of Gun.	Elevation.		Depression.		
	"PRINCESS CHARLOTTE."	°	'	°	'	
Lower .	. .	10	0	5	30	
Middle .	. .	9	0	5	0	
Main .	. .	9	30	7	30	
Upper .	. .	9	30	7	30	
	"ILLUSTRIOUS."					
Lower .	32-prs. (9 ft. 6 in. long) . .	12	0	5	0	
	68-prs. (9 ft. 0 in. „) . .	10	0	6	0	
Main .	32-prs. (9 ft. 0 in. „) . .	12	0	8	0	
Upper .	32-prs. (8 ft.), forecastle . .	9	0	7	0	
	32-prs. Carronades	12	0	8	0	
	"EXCELLENT."					
Lower .	32-prs. (9 ft. 6. in.), without inclined planes	10	0	5	30	Height of port, 2 ft. 9½ in.
	Ditto, with inclined planes. .	13	30	8	30	Ditto of axis above the deck, 3 ft. 4 in.
Middle .	32-prs. 50 cwt. (9 ft. long), without inclined planes . .	10	30	5	45	Height of axis above the deck, 3 ft. 1½ in.
	Ditto, with inclined planes . .	12	0	8	30	
Main .	32-prs. 41 cwt. (8 ft.), without inclined planes	13	0	5	30	Height of axis above the deck, 3 ft.
	Ditto, with inclined planes . .	14	0	7	30	

Table of extreme Elevations and Depressions of Guns in the British Navy—*contd.*

Deck.	Nature of Gun.	Elevation.	Depression.
	"ASIA."		
Lower .	32-prs. (9 ft. 6 in.), without inclined planes	10 0	4 30
	Ditto, with inclined planes (with toggle)[a]	15 30	6 30
	8-in. Guns, 65 cwt. (9 ft.) without inclined planes . .	12 0	2 15
	Ditto, with inclined planes (with toggle)	16 0	4 45
Main .	32-prs. (7 ft. 6 in.), bored up Guns, without inclined planes	15 0	7 0
	Ditto, with inclined planes (with toggle)	16 0	10 30
	8-in. Gun, without inclined planes	7 30	6 0
	Ditto, with inclined planes (with toggle)	12 30	7 30
Upper .	Carronades	10 0	8 30
	Ditto (amount which the screws will allow)	11 30	8 30

Although for extreme elevations and depressions the inclined planes may be used, yet it must be observed that, beyond the elevation which the ports admit of, the sight can no longer be taken by the tangent-scale, nor by any other top-sight. A gun can then only be laid by lowering the breech to an extent regulated by a wooden graduated scale, of which one end is placed upon the carriage, and the elevation is determined relatively with a mark or quarter-sight on the base-ring of the gun in the horizontal plane passing through its axis.[b] Graduated coins are found to answer extremely well, and are more readily used.

482. The following rules for concentrating, or directing the

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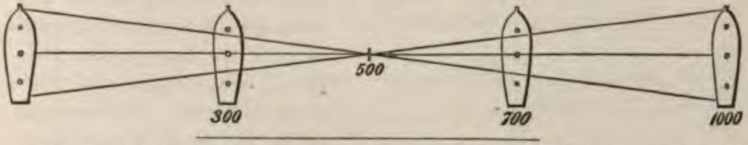
[a] The toggle and tripping-line, which we describe for the information of the general reader, is an expedient by means of which a greater degree of depression may be given to a gun than the height of the lower port-sill admits of, without being struck by the muzzle of the gun in its recoil, as in fighting the weather-side in strong breezes. This is effected by placing a wooden pin (*toggle*) vertically under the breech of the gun, and having one end of a tripping-line fastened to the centre of the toggle, and the other end tied to the breeching-bolt in the side of the ship, so that at the commencement of the recoil the toggle is tripped from its place, when, by the preponderance of the breech, the muzzle is raised sufficiently to come in clear of the port-sill.

[b] For dimensions of the ports of French ships of war, see table opposite page.

fire of several guns towards a given point, are extracted from the Gunnery Instructions Book :[a]—

The guns are trained in the direction of the object by bringing them on with lines, hooked to the centre of each port, and held immediately under marks made on the beams or deck over head, for the several bearings of abeam 1½ and 3 points before and abaft the beam, and laid by marked coin according to the heel of the ship and the distance of the object—the direction being given by aid of an instrument from upper-deck. The midship gun is used as the directing gun, and the angles of training should be ascertained for the above bearings at a constant distance of 500 yards; for though the calculations are made for this distance, yet this method of laying the

Fig. 57.



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[a] The reader is referred to a very interesting publication, entitled, 'Remarks on the Means of Directing the Fire of Ships' Broadsides in Converging Directions,' by Commander Arthur Jerningham, R.N., for some able and elaborate propositions on this subject.

DIMENSIONS of the Ports, in English measures, for different natures of Ordnance, on board of French Ships of War.

SHIPS of the OLD MODEL.

	Natures of Guns.										Carronades.					
	36.		24.		18.		12.		8.		36.		24.		18.	
	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.
Width . .	3	3.4	3	2.2	2	10.8	2	7.2	2	3.5	3	3.4	3	2.	2	10.2
Height . .	3	2.	2	10.8	2	7.2	2	4.7	2	1.6	3	3.4	3	3.4	3	2.
Height of lower sill above the deck . .	2	3.5	2	1.6	1	10.4	1	6.1	1	4.9	1	4.9	1	2.9	1	2.1

SHIPS of the NEW MODEL.

	Canons-Obusiers.						Guns.						Carronades.	
	80, No. 1.		80, No. 2.		16.		30, Long.		30, Short.		12.		30.	
	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.
Width . .	3	3.4	3	2.5	2	11.4	3	3.4	3	2.5	2	7.2	3	2.2
Height . .	3	2.	2	11.4	2	7.2	3	2.	2	11.4	2	4.7	2	[illegible]
Height of lower sill above the deck . .	2	2.8	2	0.	1	8.6	2	2.8	2	0.	1	[illegible]	[illegible]	[illegible]

guns is intended for all ranges within 1000 yards, at which distance, if the guns are properly laid, both as regards elevation and direction, the shot will be at the same distance from each other as on leaving the guns. (Fig. 57, previous page.)

To Calculate the Angles for Concentrating on the Beam.

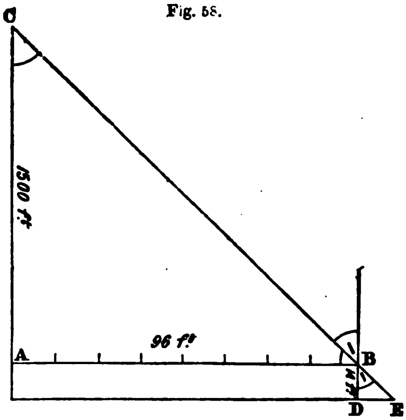


Fig. 58.

Let A be the midship gun trained right abeam, B the foremost one, C the object at a constant distance of 500 yards. Let the distance from A to B, supposed known, equal 96 ft., and the distance from the centre of port inboard be taken as 14 ft., being the same for all the guns. Then the angle C can be easily found, for $\frac{AB}{AC}$ = tan C, the angle of training for the foremost gun. Again, in triangle B D E, we have D E = B D · tan C, the length of the tangent to be set off over head, from the point opposite the centre of the port. For the intermediate guns, divide the length D E by the number of guns *before* the midship one, which will give the length of the tangent for the gun next to the midship one; twice this will be the length for the next gun, and so on:—Thus, if D E = 10·7 inches, and the number of guns before A be 8, we have $\frac{10 \cdot 7}{8}$ = 1·3 inches, or the length for the gun next to A; 2·6 inches = the length for the next gun, and so on. The same measurements answering for the guns abaft A.

To Calculate the Angles for Concentrating 3 *points abaft the Beam.*

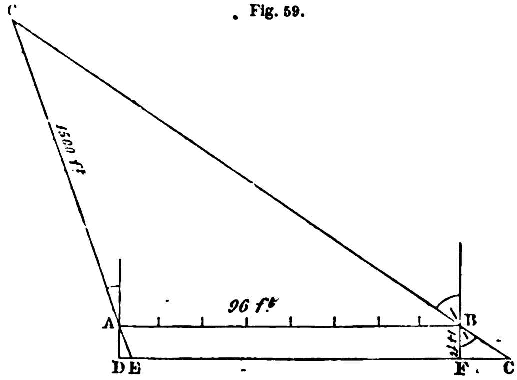


Fig. 59.

Let A be the midship gun trained 3 points abaft the beam, B the foremost one, C the object distant 500 yards. Let the distance from A to B, supposed known, equal 96 feet, and the distance from the centre of the port inboard equal 14 feet as before. Then

from the expression, $$\frac{A\,C + A\,B}{A\,C - A\,B} = \frac{\text{Tan } \frac{1}{2}\,(B + C)}{\text{Tan } \frac{1}{2}\,(B - C)}$$
the angle B can easily be found, which, taken from 90°, will give the angle of training for the foremost gun. Again, in triangles A D E, B F G, we have D E = A D · tan, A and F G = F B · tan B, which are the required lengths of the tangents to be set off overhead from the opposite the centres of these ports. For the intermediate guns, divide the difference between the two lengths D E and F G by the number of guns *before* the midship one, and *add* this common difference to the length D E for the gun next before the midship one, and so on to each gun in succession. Thus, let F G = 10 ft. 5 in., and D E = 9 ft. 4 in., the difference = 1 ft. 1 in.; let the number of guns before A be 8, then we have $\frac{13}{8}$ = 1·6 inches, the common difference for each gun; therefore 9 ft. 5·6 in. = the length for the gun before A; 9 ft. 7·2 in. = the length for the next gun, and so on.

The measurements for the corresponding guns abaft the midship one will be found by *subtracting* the common difference from D E, and so on from each gun in succession.

The calculation of the angles for 3 points before the beam, or for 1½ points before and abaft the beam, is performed in the same manner.

To Mark the Beams overhead after the Angles are calculated.

Having a line parallel to the keel, overhead, at any convenient distance in rear of the guns, measure the assumed distance 14 ft. from the centre of board inboard, and place a perfectly straight-edged batten there, parallel to the keel line; then transfer the centre of the port to the batten by stretching a line taut across from the centre of two opposite *upper* port-sills; or, with any length of line as radius, from the centre of the port describe an arc cutting the batten before and abaft the centre; half the distance between these marks will give the point corresponding to the centre of the port. From this centre, measure off on the batten, to the right and left, the lengths of the tangents for the different bearings, as calculated above; and then transfer these points to the beams or deck immediately over the batten, taking care to paint them in such a manner that the marks for one gun may not be mistaken for those of an adjacent gun: the batten is then removed.

NOTE.—The hook to which the line is attached should be driven in at the centre, and flush, within two or three inches of the outer pa[illegible]nd the 14 ft. measurement used in the calculation of the [illegible] having an eye spliced in the outer end, t[illegible] be held by No. 1 at the time of laying t[illegible]

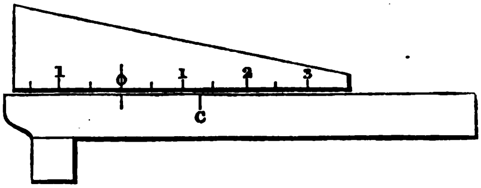
Instructions for the use of Moorsom's Director (New Pattern) for Firing a Concentrated Broadside.

1st. The instrument should be placed at the gangway nearly over the midship gun, or in the most convenient position, on battens parallel to the keel, and horizontal when the ship is upright. The arc is marked in degrees and points; and, at the several bearings of concentration, raised knobs are placed underneath as a guide by night. The large inner sight is graduated in degrees from the centre as a tangent-sight, with the distance between the outer and inner sight as a radius, so that it may be set to any degree of elevation or depression according to the heel of the ship, or, if *rolling*, to that particular degree of the *roll* at which it may be desirable to deliver the broadside.

2nd. The *small* depression-sight is marked in degrees in the same manner; so that it may be set to the angle of depression due to the height of the Director above the guns on the *lowest* deck, for the different distances, as shown in the table; and these angles should be painted on the board, so as to be always at hand when required.

3rd. The beds should also be marked for the angle of depression at 500 yards, due to the height of the guns on each deck above those on the *lowest* deck as in fig. 60: and this mark C, should be considered as the P. B. mark in laying the guns for all distances within 500 yards; the broadside will thus be concentrated at this distance on the *lowest gun-deck* of the enemy: but for all distances beyond 500 yards, the proper P. B. mark should be used.

Fig. 60.



4th. The instrument, having been adjusted to the required bearing, the *small* depresion-sight is set to the angle of depression due to the distance, and then the sliding bar raised, or lowered, till the sights are on with the *lowest* gun-deck of the enemy, when the *heel* will be denoted by the *upper edge* of the sliding bar; the same orders are then given as already explained in 3rd Instruction, and the signal or order to fire should be given when the guns are laid and the object is brought on with the sights.

NOTE.—The director may be used with advantage whenever target-practice is going on from a ship at sea, as it will show at once whether the guns will bear upon the object at any particular time or not, and also for ascertaining the distance of an object.

ANGLES OF DEPRESSION FOR DIFFERENT HEIGHTS AND DISTANCES.

Height.	200 yds.	300 yds.	400 yds.	500 yds.	600 yds.	800 yds.	1000 yds.	Height.
Feet.	Angle of Depression.	Angle of Depression.	Angle of Depression.	Angle of Depression.	Angle of Depression.	Angle of Depression.	Angle of Depression.	Feet.
	° ′	° ′	° ′	° ′	° ′	° ′	° ′	
6	0 34	0 23	0 17	0 14	0 12	0 9	0 7	6
12	1 9	0 46	0 34	0 28	0 23	0 17	0 14	12
18	1 43	1 9	0 52	0 41	0 34	0 26	0 21	18
24	2 18	1 32	1 9	0 55	0 46	0 34	0 28	24
30	2 52	1 55	1 26	1 9	0 57	0 43	0 34	30
36	3 26	2 18	1 43	1 23	1 9	0 52	0 41	36
42	4 0	2 40	2 0	1 36	1 20	1 0	0 48	42

483. When a vessel heels much, or there is any motion, the concentrated fire of a ship's batteries must be given simultaneously in broadsides, or by divisions, either of which methods is objectionable, and should be avoided as much as possible. Firing by volleys, in the naval service in particular, is extremely objectionable, and is rarely as efficacious as the independent and deliberate firing of one or two well-directed and well-served guns.

Perhaps, as stated in Colonel Stevens's interesting pamphlet,[a] it may be doubted whether the somewhat complicated system of concentration may not be carried too far, and whether it is likely to prove as efficient as the independent and quick firing of guns conducted in the ordinary manner. The moral, as well as the material, effect would probably be greater if the same

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[a] It was stated, by more than one eye-witness, in several public prints published at the time, that the "Christian the Eighth" fired by salvos of broadsides, or by divisions of guns, and that these salvos, as indeed evidently was the case, mostly missed the battery, taking effect on or at the base of the redoubt to the eastward. The author is informed that the mode pursued was to fire the salvos by a single word of command, as volleys of infantry *were formerly* in the British service. Thus the moment to fire was not confided to the captain of each gun, its proper director.

In reflecting on the failure of these salvos, the author regards it as a useful warning against the practice of discharging whole broadsides, or divisions of guns, at a given instant, by a word or signal of command, which fatally interferes with the perception of the British seaman, instructed as he now is in the use of the sights with which his gun is equipped.

To the captain of the gun should be confided the important trust of the trigger-line, and with it the duty to fire when, his eye being brought down to the horizontal plane of the sights, he judges that they coincide with the object.—'Account of the Destruction of the Danish
VIII.,' by Colonel Stevens, Royal Marin

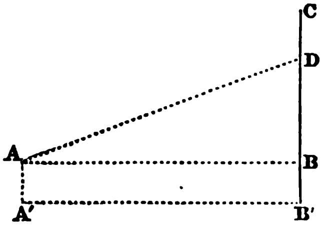
number of guns were fired independently, according to the skill and judgment of well-trained captains of guns, who, each seizing the favourable moment, might spread destruction throughout the enemy's ship.

484. Naval officers and gunners should be well skilled in every available expedient for immediate substitution in all the uncertain and contingent operations of gunnery on service; it may therefore be useful to explain a method of obtaining the elevation required for striking a ship at a given distance, which may be easily practised should other means fail, as by the breaking, or want of a tangent-scale, or some other contingency, and which may, moreover, be generally useful.

The method of pointing ordnance by tangent-practice, in the manner to be explained, was suggested to the author by Sir Philip Broke; and it forms the basis of the French principle for regulating elevation, which, however, by a complicated use of the line-of-metal sight, is extremely objectionable.

The elevation given to a piece of ordnance, at any range beyond point-blank, is intended to allow for the space through which the projectile falls by the action of gravity in the time of flight. Now the vertical space through which the projected body, in its flight, descends below the line of aim, is equal to the tangent of the angle of elevation multiplied by the range or horizontal distance of the object from the gun. Thus, suppose a gun to be at A, at a known height A A above the level of the water, and at a known distance A B from a vertical object B'C, as a ship's mast upon which is a distinct mark D (suppose the main-top), whose height B'D above the level of the water is known. Then if, from the experimented or computed ranges of shot fired from a particular nature of ordnance, there be taken the corresponding elevations; and (BB' being equal to AA') with the ranges and elevations, the heights B'D be computed trigonometrically by the formula

Fig. 61.



$$A\,B \tan B\,A\,D + B'B = B'D;$$

To face page 457

a table of such heights, with the corresponding distances A B (the names of the marks D being also expressed), may be formed; from which, by inspection, there may be taken the designation of the point to be aimed at, in order that the shot may strike the object at the water-line, the dispart sight being used so that the line of aim may be parallel to the axis of the bore of the gun. In this manner Table XXII., Appendix B, was formed for an 8-inch and a 32-pounder gun; the points to be aimed at being on the hull or masts of French ships of two classes.

The ships B and C, represented in the annexed plate, are supposed to be of 82 guns, and the distance from the ship A to the ship B is found to be 630 yards. This requires that A, in firing at a ship B of that class with 8-inch guns (charges 10 lbs.), should aim at a point about midway between the water-line and the main-top (see Table XXII., Appendix B). The distance from the ship A to the ship C, supposed to be 1078 yards, requires that, with the same gun and charges, the aim should be taken to one foot below the main-topmast cross-trees, or to points equally high on the other masts. The masts being thus the aim for the line, as well as for the elevation, will, with this description of practice, be more likely to be wounded or felled, either by shot which penetrate the side of the ship with adequate force, or by shot which may chance to be too high to hit the hull.

485. Since, in the table, the angles of elevation are given, as well as the points to be aimed at, the guns may be elevated, according to the distance of the object, by the quarter-sights or tangent-scales if preferred.

The designations of the parts to be aimed at, in ships of three decks, are not given, because, in firing at such great bodies, so great a degree of precision is not required as in firing against single-decked or two-decked ships; and the tables arranged for the one may be used for the others with small allowances for the differences of height.

SECTION III.—ON LOCKS AND TUBES F

486. The general introduction of fl
naval service resulted from the effi

of 98 guns, on a celebrated occasion, that ship having been previously fully equipped with gun-locks by her captain, the late Sir Charles Douglas, who commanded her from April, 1778, till November, 1781, when he was removed into the "Formidable," as Captain of the Fleet, in which ship he likewise introduced these and other improvements in naval artillery.

The equipment of the "Duke" with flint-locks to all her guns was effected in a manner so characteristic of the ardour and energy of that enlightened and scientific officer, that the author trusts he may be excused for adverting to it in a brief statement of facts, which will, perhaps, be deemed somewhat interesting by the professional reader.

On Sir Charles Douglas's appointment to the "Duke," he brought before the Admiralty and the Ordnance several propositions for improving, facilitating, and quickening the service of naval ordnance. The cartridges were at that time all made of paper, which required the operation of worming guns after every discharge, on account of the lower end of a paper-cartridge remaining generally at the bottom of the bore in a state of ignition. To obviate this, Sir Charles Douglas proposed that the cartridges should be made of flannel. He recommended, and urged repeatedly, the full equipment of his ship with flint-locks, by which the use of the slow-match and the powder-horn for priming might more or less be discontinued; and as tin tubes would manifestly be dangerous and highly objectionable on the fighting-decks of a ship, he recommended that quill-tubes should be substituted for them.

487. Neither of these propositions was immediately or fully adopted; paper-cartridges, the match, and the priming-horn continued for some years in general use. It appears by official documents[a] that no locks were supplied during 1778 to the "Duke" at Plymouth, where she was commissioned in April of that year; but in the following year she was furnished at Portsmouth with two locks for 24-pounders, four locks for 12-pounders, and two for 6-pounders; total eight locks.[b] Yet the "Duke" was fully equipped with gun-locks in the celebrated victory of

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[a] Report of the Ordnance Storekeeper, Devonport, 5th Dec. 1850

[b] Report of Mr. G. Stacey, Chief Clerk, Tower, 7th Dec., 1850

the 12th of April, 1782, to which that ship and the other three deckers, the "Formidable" and the "Namur," so greatly contributed. By what means then had the "Duke," in the previous years, been completed with these important implements? By Sir Charles Douglas, out of his own funds and by his own energies: he bought a sufficient number of common musket-locks, which, being let into pieces of wood, as into the stock of a musket, might then be fastened with iron-wire to the guns. He purchased flannels sufficient to make bottoms for paper-cartridges, goose-quills for tubes, and the ingredients necessary to fill and prime them.

On Sir Charles Douglas's appointment to be Captain of the Fleet, he was succeeded in the command of the "Duke" by Captain, afterwards Lord Gardner; and, in the battle of the ensuing year,[a] the quick and efficient firing of that ship was so conspicuous and powerful as to enable the gallant Gardner to widen the gap which his leaders had made in the enemy's line, and so open the way for Rodney to pass to a memorable victory. That glorious day settled the question of the locks, by bearing down all further opposition to the introduction of improvements which the prejudices of the time deemed useless and unnecessary refinements; but, that battle having likewise put an end to the maritime part of the war, no measures for the supply of locks to naval ordnance appear to have been taken till 1790, when "brass locks" of a new pattern were provided, and continued in general use throughout the late war. These no doubt contributed greatly to the efficiency of our practice, to the accuracy and rapidity of which all French authors attribute the superiority of our gunnery in the actions and battles of the early part of the war, the French not having adopted locks till 1800.

488. The flint-locks of the pattern of 1790 remained in general use till 1818, when the double-flinted lock, likewise adopted by the French, of the author's invention, a drawing of which was given in the former editions of this work, was ordered for general use in the navy.

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[a] An analytical and tactical account of that celebrated and remarkable battle, 12th of April, 1782, will be found in the author's work entitled, 'Naval Evolutions,' in which the manœuvre by which that great victory was gained is fully described. Boone, 1832.

Having thus been the means of introducing improved cannon-locks into the naval service, and strongly convinced of the very great importance of applying locks to all land-service artillery, whether field, siege, or garrison, the author addressed to the Master-General and Board of Ordnance (in 1817), a recommendation to that effect in the same paper in which he proposed the improved double-flinted locks for general adoption in the navy. But the Board of Ordnance not having come to any decision on that proposition, in conveying to the author their approval of the other (in a letter to the author, dated Jan. 16, 1818), he resolved to endeavour to procure support in the prosecution of his plan by consulting officers of greater experience and authority, and, in the event of their judgment coinciding with his, to press the subject on the reconsideration of the Board with all the energy in his power. He accordingly transmitted a copy of his proposition to his gallant friend and associate the late Sir Alexander Dickson, an officer eminently qualified by his great experience, knowledge, and talent to pronounce authoritatively upon all matters connected with artillery service, and received in reply the letter printed in the subjoined note.[a]

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[a] "Valenciennes, 20th April, 1818.

"MY DEAR SIR HOWARD,—Having fully considered the matter, I feel much pleasure, in compliance with your wish, in being able to state that your proposals for the more extended use of locks coincide in the most essential points with my own ideas on the subject.

"The use of locks with heavy ordnance, particularly in the operations of a siege, presents very great advantages; for by the employment of slow-match only the fire is frequently retarded, and nothing can be more dangerous than lighted portfires in a battery. I have seen several very shocking accidents occasioned by the use of them, owing to the want of presence of mind of the gunner having the portfire lighted in his hand at the moment of a shell falling near him. In the sieges I have directed I have ever prevented, as much as in my power, the use of portfires; but Ciudad Rodrigo was the only operation in which I was fully successful in this respect; and it was to the help of about sixteen or twenty naval gun-locks, in addition to the slow-match used, that I was indebted for the vigorous fire kept up in that attack. I trust in future, therefore, that in all siege equipments each piece of ordnance will be supplied with a lock, the use of which, under every circumstance, except in heavy rain, would supersede the portfire, which in the very confined situation of a land-battery, and where much powder is in circulation, is so dangerous.

"In the operation of defence, also, the same arguments, in a great degree, hold good in favour of locks; and they are truly valuable in coast-batteries, and in all night-firing.

"With respect to their being applied to artillery in the field, I am convinced that, with a tube such as you describe, locks would be of infinite service with

Supported by that distinguished officer, the author's proposition received favourable consideration, and would then have been carried into effect had not financial and other considerations rendered it inexpedient to provide forthwith the necessary supply of locks. Subsequently, the discovery of the percussion principle having been made, the author, in 1851, reverted to his proposition of 1817, under a still stronger conviction of the great importance, or, it may well be said, of the pressing necessity, of this measure in the present improved state of artillery science and gunnery practice. This equipment is so forcibly urged in Sir Alexander Dickson's letter with respect to field and siege artillery, that nothing need, or could be said, to add to the weight of that testimony, whilst much that has been stated in the course of this work on the vast importance of the percussion lock and tube in firing at ships in motion, applies strongly to the necessity of providing these means of procuring a more instantaneous explosion to all guns in coast-batteries, which, though at rest themselves, will have to fire at moving objects,—ships advancing, in continued change of distance and position, to that proximity which they must attain to attack batteries or fortresses with effect,—and particularly in firing at steam-vessels, running at full speed across the line of fire of a battery, instead of stopping to engage it in its strongest direction. In this case coast-battery guns will be required to "shoot flying" (Art. 499), but they will have little chance of hitting active steamers at considerable distances, unless, in aiming the gun, allowance be made for the distance the steamer moves in the time elapsed between the firing of the gun and the shot striking the object;

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field-guns in ordinary duties, such as reviews, firing-exercises, and salutes, and in all real service, when not too closely engaged. The effect of the lock being sufficiently certain in these situations, the saving of portfires would be great, and there would be far less risk when in action amongst ripe corn, dry grass in villages, or amongst houses; for the setting fire to a country more generally arises from cutting the portfire than from the discharge.

"In concluding, I have to observe that I do not mean to resolve the question merely into one of economy, as I deem it on most occasions an effectual simplification of manœuvre by saving the trouble of continually lighting and cutting portfires, at the same time affording the means of firing with celerity at moving objects.

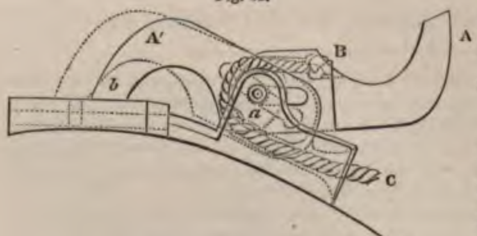
"I remain, my dear Sir Howard, &c. &c.
(Signed) "A. DICKSON.

"Colonel Sir Howard Douglas, Bart.
&c. &c."

in fact, unless the action of the lock and tube be so quick as to produce the most instantaneous possible discharge, the chances of hitting in such shooting will be very remote.

489. This important manner of igniting the charge was first attempted by fixing the lock to the ventfield, out of the way of the explosion from the vent. For this purpose, it was necessary to make the tube of a rectangular form, so that one part might receive the percussion of the cock, and the other part convey ignition to the charge. This construction was found, however, to be so sluggish as not to accomplish the great desideratum in naval gunnery, which is, that the firing of the charge, and the actual delivery of the shot from the gun, shall take place as quickly as possible after pulling the trigger-line, in order that there may be little time for any alteration to take place, from the motion of the ship, in the aim of the gun. Thus it was necessary to devise some means by which the hammer, after having struck fairly upon the head of the tube placed in the vent, should instantaneously slip or be drawn aside, so as to be out of the way of the explosion through the vent. Various modes of effecting this have been devised in the British and in other naval services, but the most efficient and simple implement of this nature is that which was invented by an American named Hidden, and patented in 1842.[a] The hammer was, however, modified and improved, so as to be stronger and better suited to the locks in use in this country, by Colonel Dundas, Inspector of Artillery, to whom the service is so much indebted for his management of that important department, to which he was appointed in 1839.

Fig. 62.



American Lock, improved.

The hammer A (fig. 62), which is of wrought iron of good quality, is fixed into a block or joint of gun-metal by means of a pin *a*, and a *slot* is made in the hammer to admit of a back motion. The

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[a] Ordnance Memoranda. 'Naval Percussion Locks,' by Lieut. Dahlgren, U. S. Navy, Assistant Inspector of Ordnance.

hammer falls, by its own gravity, upon the vent, on the lanyard B C being pulled, when, being liberated from the larger part of the slot in which it is made to turn, it instantly shifts or passes away by the continued action of the lanyard, which pulls it from its first position directly over the vent, as shown by the black lines at A′ in the figure. The weight of the hammer is $3\frac{5}{16}$ lbs.

490. This lock, though extremely ingenious and advantageous from the simplicity of the contrivance by which the hammer, having performed its office, is drawn back from the top of the vent by the same force which causes it to strike the tube, is not so quick in its action as it might be if the motion were produced by a spring. The hammer, as will be perceived in the figure, has a considerable space to pass through ere its face strike the tube at *b*. The motion has to be generated by the pull of a line, which changes its direction by passing round a small axis; and, having a very small leverage at the beginning of the motion, it requires a strong and continued pull to produce a smart blow and instantly draw the hammer back. This lock requires a much stronger jerk than the common spring flint-locks. The hammer has to beat down the head of the tube, and if the pull is not strong and continued, the tube is not exploded. It has been found in exercise that, in nine times out of ten, tubes supposed, from not having exploded, to be defective, will act, on repeating the trial, with a stronger jerk, which shows the failure to have arisen from the captain of the gun not having pulled with sufficient force. It appears, therefore, that a lock constructed upon this principle, with respect to the slot, in which the hammer may be made to act by means of a spring instead of a pull, would be very advantageous, the strength of a spring fully sufficient to produce the desired effect being constant; but the adoption of the friction-tube is likely now to supersede any improvement that might have been expected from the use of a spring for igniting the percussion-tube, and a description of it is therefore annexed in the note below.[a]

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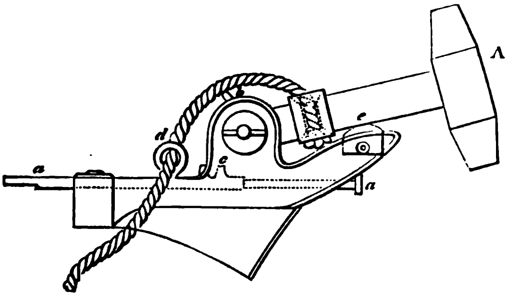
[a] The "friction-tube" invented by Captain Boxer, R.A., by which the instantaneous ignition of the charge is now obtained, is made of copper for field-service and with a quill for the navy. It is filled in the same manner as the ordinary percussion-tube: having a small portion of detonating-composition in

On the rapidity of the action of the tubes, the promptitude of the delivery of the shot greatly depends. Hence, the smallest reduction of the time elapsed between the striking of the lock and the actual exit of the shot, is of vast moment in naval gunnery; and every means which may contribute, in the slightest degree to an approximation towards the contemporaneous action of the lock and the tube, cannot be too much attended to.

491. In the French locks (fig. 63), the hammer A falls over the lock, but there is no mechanical arrangement for removing or drawing it aside; and the fluid which escapes by the vent, throws the hammer back with violence upon the support or crutch *e*, which has a leathern cushion to break the blow. The whole is of gun-metal, with the exception of the centre-pin, the ring-bolt *d*, through which the lanyard passes, and the sliding-bar *a*. The last is intended to cover the head of the tube from rain or the spray of the sea, until just before the hammer can strike it:

Fig. 63.



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the upper part, through which is rove a rough strip of copper, with an eye at one end to take the hook of the trigger-line; the other end, which projects on the opposite side of the tube, being protected by a covering of leather. The method of firing is as follows:—the head of the tube is supported by a metal crutch with a slotway in rear of the vent to admit the eye of the copper bar, to which the trigger-line is hooked. The friction arising from the withdrawal of the bar ignites the tube.

In order to prevent accidental ignition, there is a loop in the trigger-line about a foot from the hook, which is placed over a metal cleat fixed to the breech while the gun is being laid for the object, and removed as soon as the elevation has been correctly obtained.

The detonating-hammer striking over the vent and receding clear of it from the same pull of the trigger-line is still retained in the naval service; but a supply of friction-tubes is also issued to each ship, for the purpose of reporting how they act under all circumstances, and in every variety of climate; and there seems no doubt of their ultimately superseding the detonating-locks.

the cover is drawn away by the action of the 'dog' *b* on the rack *c*. The total weight of the lock is 7½ lbs.

492. In the first percussion-lock which was used in the United States' service, the *cock* struck directly over the vent, and being instantly thrown upwards, it was retained in a position clear of the blast from the vent. It struck on a percussion-patch, and there was nothing between the cartridge and the fulminating-powder. It is said that powder had been ignited by the stroke when enveloped in seven folds of flannel, and even through seven cartridges inclosing the charge, in a 32-pounder gun. The action of this lock was instantaneous; and, if it had stood the work well, it would have been considered, perhaps, the best percussion spring-lock that has been produced; but it was found that the mode of getting the cock out of the way, by causing it to be thrown violently upwards, did not stand repeated firings, and was otherwise liable to considerable objections. In a subsequent contrivance, the cock, instantly on striking, was thrown aside by the expansion of a spring acting horizontally, which in the act of cocking had been compressed. The author has witnessed numerous exercises in which the activity and efficiency of this lock were proved, and it is believed to be still in use in the navy of the United States.

493. The cannon-lock, lately used in the naval service of Holland, consists of a hammer acted upon by the pull of a trigger-line. From the translation of the author's 'Naval Gunnery,' by Captain Gobius of the Dutch Navy (now Deputy-Minister of Marine), which, by the addition of foot-notes and other matter, has been adapted to the purpose, it appears that the cannon-lock now used in that navy (see fig. 1, plate III., Gobius's translation) is exactly of the same pattern as the French lock. A lock of a different construction has since been introduced for trial in Holland. It is placed on one side, and somewhat above the vent percussion-patch, and has a brass tube directed obliquely to the vent, so that the explosion of the percussion-tube is thrown obliquely into the vent, from which it is, however, so far distant that the rush of fire from the vent passes clear of the tube. These locks act with great quickness a force; and the captain of the frigate in which the effects w exhibited at Portsmouth in 1850, said they very rarely misse

494. The Dutch lock resembles very nearly that which has been in general use for some years in the Austrian naval service; but the action of the hammer is produced, in the Austrian lock, by a spring. The lock is placed on one side just clear of the vent, but in a plane inclined from the vertical. Thus the cock acts in that plane upon a tube which is placed in a hole at the bottom of the pan of the lock, and enters with equal obliquity into the vent, which is enlarged a little to the right. The lock acts, as the author has repeatedly witnessed, with activity and certainty.

495. In the Danish navy the action of the hammer is produced by hand (see fig. 31, pl. XII., 'Danish Naval Gunnery,' by Captain Michelson, an instructive and important work); but the mode in which the trigger-line is made to act permits the action to be quicker than in the English lock.

496. Same very interesting experiments were made at Bombay in 1844 and 1845, on a proposition made by Major Jacob of the Bombay Artillery, to apply nipples and percussion-caps to land and sea service ordnance in the same manner as they are applied to other fire-arms.

The nipples used in the experiments were of the flat kind, raised about ¼ of an inch above the line of sight of the gun, with a vent only large enough to admit a 6-pounder gun-bit and priming-wire, and were made with a screw end about ½ an inch long and ½ an inch in diameter, to screw into the vent of the gun. Caps containing various quantities of fulminate were used, viz.:—

1.35	grains of fulminate, or	3	times	the charge of an ordinary musket-cap.
1.8	,, ,,	4	,,	
2.25	,, ,,	5	,,	
2.7	,, ,,	6	,,	
4	,, ,,	8.888	,,	
5	,, ,,	11.111	,,	

All the rounds from both pieces were fired without the cartridge being pricked: we should not, however, recommend the pricking being discontinued, for even with perfectly efficient caps, we think pricking desirable as a *proof of the cartridge being home;* but this process was dispensed with purposely to test the power of the caps in firing the charge through the serge bag.

No instance of a cap *flying* occurred: this result was, no doubt, attributable to the superior quality of the copper used; and the fact is stated in order to remove any apprehension of danger from the large charge of fulminate used in each cap.

The Committee appointed to superintend the experiments expressed a decided opinion that Major Jacob's proposition had been verified by experiment, and that the introduction of percussion-caps to heavy and light ordnance (for the land-service at least) will supersede the use of matches, portfires, tubes, priming-powder, &c.; from which will result economy, both as to expense and space, while there will be gain as to rapidity and certainty of fire, and, at the same time, much of the danger attending the ordinary mode of firing guns by priming-powder will be avoided.

497. The experiments made at Bombay on Major Jacob's propositions are extremely interesting, and are worthy of prosecution in this country. No doubt, many objections and difficulties stand in the way,—such as interfering with the sight, reducing the diameter of the vent, and countersinking the nipple into the gun. No 32-pounder gun fired in the ordinary way is found serviceable after 250 rounds have been fired from it; whereas it appears, by the reports of experiments with steel nipples and percussion-caps, that, after 300 rounds were fired from an iron 32-pounder gun of 56 cwt., with 10-lb. charges, the vent of the gun remained uninjured, though the nipple was countersunk only $\frac{2}{10}$ of an inch, and consequently occupied a very small portion of the channel of the vent.

SECTION IV.—ON THE PRACTICE OF FIRING AT SEA.

498. In the practice of naval gunnery it is most particularly important that the actual delivery of the charge from the cylinder of the piece should follow as instantaneously as possible the action of the lock; for whilst the object aimed at is continually changing its relative position, the direction of the gun is varying so rapidly that if the medium which is to convey ignition to the charge act not very smartly, the elevation of the shot's departure may be two or three degrees above or below that at which the gun was pointed when the trigger was pulled. The nature, quality, and care of tubes and priming, therefore,

are considerations which may justly be reckoned as most particularly affecting the efficiency of practice; and the most minute differences that can be detected, by the nicest means, in the progress of explosion, should be allowed decisive weight in judging and selecting the medium to be used. For suppose a vessel, in action, be rolling eight degrees, performing each roll in about four seconds of time: when the nature or condition of the tube and priming is defective or bad, it will very frequently happen that an interval of one second of time, and sometimes considerably more, will take place between the pulling of the trigger-line and the discharge of the piece; and in that time the elevation of the gun would alter two degrees! With any uncertain or sluggish action of this nature, therefore, it is useless to expect much accuracy of effect, even with the best trained men, and with all other means perfect (Arts. 488, 489).

499. In every case, when there is much motion (and there will be a great deal more in steam-propelled, than in sailing ships), the shot will not be delivered from the cylinder till its direction is altered, more or less, from that in which the piece was pointed when the trigger was pulled. It is therefore not only vastly important to use those means that are best calculated to produce the most instantaneous discharge possible, but also to consider which direction, and what particular part of a vessel's motions, are most favourable for firing the ordnance with the greatest prospect of effect—whether to fire on the weather or lee-roll,—and at what particular stage or crisis of the motion. A steam-propelled vessel, being agitated by rolling and pitching motions, and often, as in a cross sea, by both combined, accompanied also by sudden and violent jerks, will, much more than a sailing-vessel, try the skill and tact of the gunner; in whom, both for shot and shell firing, is required the greatest promptitude of perception, while the utmost intensity in the action of the lock, and vivacity in the action of the tube, are no less necessary. These are very important considerations on which the author would rather invite discussion than pronounce any positive doctrine. He will, however, state his opinion, noticing at the same time what may be advanced against it.

500. In close action, in smooth water, it is not perhaps material whether the ordnance be fired with or against the roll,

provided the captains of guns judge correctly how much their pieces should be pointed above or below the part intended to be hit; but when there is much swell, it is by no means indifferent which of these motions should be preferred, nor what modifications should be admitted for particular cases, in any general maxim that may be established on this subject; and this we shall now endeavour to show. The rule generally laid down for observance in action is to fire when the vessel is nearest on an even keel—that is, upright; and always to prefer a falling side.

501. To deal with considerations respecting the rolling motions only, we shall suppose the vessel to have the wind on the beam; for if hauled upon a wind, the motion would be compounded of rolling and pitching, by the vessel laying across the swell. Now a vessel under sail, with the wind as described, is nearest upright at or near the end of the roll to windward. Were it not for the action of the wind on the sails, she would be upright when she comes to the top of a wave; but this is not the case in a smart breeze, because it requires some degree of counteracting power from the swell, as the vessel sinks upon a wave, to compensate for the heel occasioned by the wind. In a heavy swell, however, a vessel will roll to windward considerably beyond the upright position; but, in stating a case proper for action, we should not suppose the sea to be so rough as to make the vessel incline much to windward. Now a vessel brought to that momentary pause which takes place on the termination of the weather-roll, just before she begins to feel the rising influence of the next coming wave, must be in the hollow or trough of a sea; and in such a position will have a less commanding view, and *prise* of her enemy, than if he were seen from the top of a wave. This preliminary observation may, perhaps, be considered sufficient to show that the maxim of firing when the vessel is on an even keel should not be too generally or absolutely enforced: and having submitted this, we may proceed to consider the important question that results naturally from it—whether it is most advantageous to fire with a rising or with a falling side.

502. A vessel engaging to leeward—that is, fighting her weather side—must be in the trough of asea when the side en-

gaged begins to rise; and whilst it is rising she must be performing a lee-roll. The disadvantage of firing from the hollow between two waves having already been shown in the preceding article, the inexpediency of firing at the *beginning* of the rising motion is also proved, for the one ensues immediately from the other; and a very material objection to the practice of firing *during* any part of the rising motion comes from this—that the lee-slope of a wave being always more abrupt or steep than the weather side, the change which takes place in a vessel's position in making a lee-roll, accelerated and increased by the action of the wind, is much more rapid than in rolling to windward; and consequently the direction, or elevation, of the ordnance, will in this case be much more quickly and considerably disturbed in firing with the rising than the falling motion. It appears, therefore, that in fighting the weather-side, we should prefer to fire at the pause immediately before the commencement of the declining motion or weather-roll (unless the vessel heel so considerably as to incur danger from the increased action of the recoil), because the ship being then on the top of a wave, will command a better view of the enemy, and the declining motion will be operating to lessen the slope in the direction of the recoil.

503. In fighting to windward, some of these arguments are reversed. The declining motion of the side engaged is then a lee-lurch, and at the commencement of that motion the vessel must be in the trough of the sea. We should therefore so far modify the maxim already suggested as to fire at the end of the falling motion of the fighting or lee side, when the vessel comes to the top of a wave, so that the actual discharge may not take place after the pause which attends the change of motion.

504. But modifications, governed by various circumstances, should be made in all such maxims. If, in the first case (fighting the weather-side), a ship be heeling under the influence of a strong breeze, her guns, fired at the commencement of the declining motion, or at the pause which precedes it, will rush in with such violence, from the inclination of the deck being in the direction of the recoil, that the breechings and ring-bolts will frequently be incapable of resisting so severe a shock, particularly when the guns are loaded with two shot; and in such

cases, consequently, the ordnance should not be fired till the declining motion be partly performed: thus observing, in principle, the maxim to prefer firing with a falling side. The rule is so far modified in practice, that in fighting the weather-guns they should be laid so as to bear upon the opponent when the ship comes up to within 1° of the extreme of the weather-roll; and, in fighting the lee-guns, to lay them so that they shall bear when the ship has made a portion of about 1° of the lee-roll from its commencement. In both cases this insures that the roll of the ship is sufficient to bring the guns to bear at a time when the rapidity of the rolling motion has been reduced by the action of the wind; and also that the guns are laid more nearly parallel to the plane of the deck—an important point which has not been sufficiently considered. When guns are much depressed, relatively with the plane of the deck, it requires very great experience and tact on the part of the captain of the gun to fire it accurately at the proper moment; for unless he be a very tall man he cannot look over the gun, at the full extent of the trigger-line, when the breech is much elevated; and if the gun is fired at this great depression, with respect to the plane of the deck, he is endangered by the rapid and heavy recoil, and great strains are moreover occasioned to the breechings and bolts.

Again, when the lee-guns have much elevation, with respect to the plane of the deck, a somewhat similar inconvenience is experienced, though in reverse order, by the captain of the gun having to bring his eye down almost to the level of the deck to look over the gun; and when it is fixed in that position, the recoil being up the very great inclination of the deck, may not be sufficient of itself to bring the gun sufficiently inboard for loading.

For these reasons the modification suggested at p. 239, in the second edition of this work, in fighting the lee-guns, is made general, namely, to fire at the end instead of the commencement of the declining motion, although the vessel must then be nearly in the trough or hollow between two waves; for it very seldom happens to a ship, and particularly a large ship carrying her metal high, to be in action in so heavy a sea as not to have a fair view of her opponent under such circumstances.

505. It may not be improper here to remark that the breechings of naval ordnance, in frigates particularly, are in general considered too weak;[a] and as those on the gun-deck are soon damaged by being continually wet, it is very essential always to have spare breechings ready fitted, and to exercise the people frequently to shift them quickly. Carronades should always be fitted for action with second breeching (see Art. 124). In the "Shannon" the preventer-breechings were reaved through holes in the timbers, and toggled on the outside; and to relieve the ring-bolts and breechings, chocks of timber were placed underneath the hinder part of the slides, when fighting the weather-side, so as to lift them nearly to a horizontal plane when the vessel was heeling 7° or 8°. Carronades thus fitted, run in with less violence, and are more easily run out; and with this species of ordnance, such precautions should invariably be adopted. If a *gun* break loose, it may be rendered serviceable again in a few minutes; but should a *carronade* break its breeching, or draw a ring-bolt, it is very apt to turn over, or split its slide to pieces. In firing carronades with two shot, these precautions are absolutely indispensable; for although this species of ordnance is not calculated to discharge two projectiles, in common, and double *shotting* is forbidden, yet on very special occasions, when within a few yards of an enemy, double charges may be used with great effect, either composed of round and grape or case shot, or of two round shot, according to the circumstances of the action. Thus, in fighting to leeward of an enemy, the inclination of his ship will expose its deck so much to the effects of grape or case shot, that the double charge should consist of one or the other. In fighting to windward, on the contrary, the weather-side of an enemy heeling off, will be so much exposed below the ordinary water-line as to invite the use of two round shot, whilst the declination of her deck covers or defilades her people from grape or case. Thus modifications in any maxims, as to the most favourable moment for firing, should also be governed by the motion and position of the enemy's vessel.

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[a] This having been recently represented, it is now established that all 8-in. guns and carronades shall have 9-in. rope for breechings, and all 32-pounder guns and carronades 8-in. breechings. The breeching-loops have all been enlarged accordingly.

506. It appears to follow, from what has been advanced, that balls intended to take effect upon the hull of an enemy, should rather be discharged with a falling than with a rising side; but that such pieces as may be appointed specially to act against the masts and rigging, should, on the contrary, be fired with the rising motion, the aim being taken low.

507. In close critical action, the great object should undoubtedly be to hit the enemy's hull. For this purpose, it is better that the pointing of the guns should rather be calculated to take effect low, on the body, than to aim high, and, missing the body, to hit the rigging. This is particularly desirable in actions between carronade-armed vessels, or ships armed with shell-guns, because the magnitudes of their shot are so great in proportion to the scantling of the ships, that few body-blows are required to drive the crews of the vessels struck to their pumps. One or two large shot, moreover, taking effect below the water-line, and perhaps perforating both sides of a small vessel, will, in general, either force her to surrender or send her to the bottom, though she may not have sustained any other material damage or any loss of men. Such an injury is much more likely to be occasioned by firing with a falling than with a rising side. On the other hand, a ball taking effect high, can only injure the rigging or a mast, and, if the latter, not with much effect; for a mast, wounded aloft, will be more likely to stand, than if the like wound were inflicted by a shot which had previously perforated the ship's side at the upper deck. It is a great waste of means, therefore, to apply round-shot of large calibre, or shells, to the remote chances of destroying rigging, which, branching out from one trunk or stem, may be more effectually felled by a blow otherwise destructive at the
time. The intention of horizontal firing should, inde
be lost sight of. When vessels are once fairly eng
action, which can only terminate in defeat or vi
object should be to sweep the opponent's deck
possible. Before the contending ships are in
the proper time to try what skill and precisio
the enemy's masts and rigging; and vessels
guns, and manned with expert gunners, will
make previous trials of their arms and

good circumspect management, close action will not fail to begin with advantage; and the author, from his knowledge of the effects of cannon-shot, considers himself justified in concluding that a vessel, equipped in a proper manner, and possessing gunners trained in the way he proposes, cannot fail in tearing to pieces, in ten minutes, any opponent who, not possessing superior advantages in skill or force, is unable to prevent it.

508. Some of the actions between British and American sloops afford some very instructive illustrations on this important question. In the action between the "Hornet" and the "Peacock," the decisive importance of a few body-wounds was unhappily too strongly displayed. The American ship was a good deal injured in her rigging, though comparatively little damaged in the hull; but the British sloop was forced to surrender entirely in consequence of having been hulled so low, that the shot-holes could not be got at; and she sank a few minutes after, having been obliged to yield to this fatal circumstance only!

The "Avon" was brought to the painful necessity of striking to the "Wasp," from being reduced to a sinking state by body-wounds; and went down immediately after the last of her brave crew were removed. In this affair the American first crippled the "Avon's" rigging, with dismantling-shot from long guns, and then aimed at her hull with fatal success. The "Wasp" does not appear to have been materially injured; for she escaped from a vessel (the "Castilian"), in a short chase that took place, before she was recalled by the "Avon's" signal of distress.

In these two actions it is clear that the fire of the British vessels was thrown too high, and that the ordnance of their opponents were expressly and carefully aimed at, and took effect chiefly in, the hull. The inferior effect of our fire may partly have arisen from such errors in carronade-practice as have already been noticed; but it may be suspected to have arisen, chiefly, from not having chosen the most advantageous moment for firing; and this we shall be better able to show, by reviewing the action between the "Frolic" and the "Wasp."

509. This affair would appear to support very strongly what has been said against the measure of firing with the rising

motion. The contending vessels were pretty nearly matched in armament; but the "Frolic" went into action under the serious disadvantage of having her mainyard sprung, and useless. The "Wasp" having the wind, came down and engaged the "Frolic" to windward on the port-side, and consequently fought her lee-side against the weather-side of the British sloop. The American was considerably injured in her rigging early in the action, and also received a few shot in the hull; but much more serious damage and severe loss were sustained by the "Frolic." This difference of effect may fairly be ascribed, in a great degree, to the crippled state in which our sloop commenced the action; but we cannot hesitate to allow, that it may also have arisen from the circumstance of "her motion being much more rapid and violent than that of the 'Wasp,'" as has been remarked by a very intelligent writer.[a] But the "rapid motion" which so much disturbed the direction of her fire, appears to have been occasioned by the quick dips of lee-lurches; for she fired with a rising side, and, as there was a heavy swell, this motion must have very rapidly disturbed the pointing of her ordnance, whatever was her trim. That the Americans did not fire with the rising motion, we know from the parties themselves; that they could not fire in the hollow of the sea, in such a swell, is evident; and that they did not fire in the lee-lurch is clear from the admitted fact, that the ship rolled her carronade muzzles to the water's edge: we may therefore infer, with certainty, that she fired, in general, from the top of the sea towards the termination of the falling motion. That the British sloop fired with the rising motion is also certain—it is so stated in accounts which, however exaggerated in regard to strength and comparative loss, are unhappily true in the main feature; and the explanation of this affair, from authority, so far as it relates to rapidity of motion, states a cause of error which every seaman knows must be greater in a lee-lurch than in a weather-roll.

In previous editions of this work it had been concluded from the foregoing arguments that the falling motion was the most advantageous time for delivering the fire of a ship's guns: nor, indeed, can it be denied that it must be so in *theory;* but subse-

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[a] *James*, 'Naval Occurrences,' p. 146.

quent experience shows that in *practice*, notwithstanding any rule to the contrary, the captain of the gun finds it more favourable to fire with the rising motion, as the drawback of not being able to see the object aimed at till the moment of firing is considered to outweigh all the apparent advantages of the opposite method.

510. When it is expedient to aim partially at the rigging, one or more guns, conveniently placed, and fitted expressly for such purposes, should be named for this service specially, and loaded accordingly. The main-deck guns cannot be elevated sufficiently to effect this, when the enemy's ship is close; and, since case or grape shot from carronades scatter so much as to be very inefficient, ships should always be provided with at least one piece of ordnance on each side of the quarter-deck and forecastle, fitted for this important purpose. Brass field-howitzers, mounted on carriages made to allow of great elevation, are now provided; and they are also fitted for boat-service, as well as to be used for field-service. Dismantling-guns should be capable of being elevated to 30° at least; so that the enemy's main-top may be under the command of a powerful fire of case-shot at close quarters.[a] Guns thus mounted may be fired, en barbette, over the barricades or gangways, and easily brought to bear upon an enemy alongside, or laying across either stern or bow. In the position of the "Cleopatra," when she suffered so much from the "Milan," and of the "Phœbe" when she was so annoyed by the "Didon," before Captain Baker gallantly captured this last, the quarter-deck 9-pounders of those ships might have borne with ease upon the enemy's tops, when no other guns but the stern-chasers could be used.

As, in such positions as these, all broadside-guns become useless, ships' crews should be exercised to form themselves, rapidly, upon the deck, boats, and booms, when called for small-arm duties. If, quickly ranging themselves thus, they be instantly supplied with arms, the enemy may soon be driven

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[a] "Il y a aussi le tir à *démâter*; mais ce tir, fort incertain, qui fait perdre presque tous les boulets et qui est une des plus graves erreurs de nos dernières guerres, est aujourd'hui presque complètement abandonné. Il ne doit être employé que sur l'ordre exprès du commandant du vaisseau. Ce tir consiste à viser de manière à frapper au trélingage, principalement celui du mât de misaine."—*Préaux*, 'Instruction sur le Canonnage à Bord.'

from their tops; and subduing the fire from thence is a favourable preliminary to the assault by boarding.

511. The best method of opposing the enemy's top-men is to have a few expert marksmen similarly posted; and for this service the quickly loaded rifle-muskets, with cylindro-conical shot (see Part VI.), will be highly advantageous; but, at close quarters, ordinary case-shot, or large charges of musket-balls, may be used with great effect from the elevating guns; and for this purpose some rounds of this nature of charge should always be kept ready for any piece that may have the best opportunity of using them with effect.

512. Dismantling rigging, and carrying away spars, are more likely to be effected when it blows fresh than in light airs. Carrying away a stay, or a few shrouds, or wounding a mast or spar, in a strong breeze, may occasion a serious crash, which in a light wind would not ensue. With respect to sails, in moderate breezes the perforations of shot leave only small holes; but in strong winds a sail frequently splits upwards, as far as the reef-bands at least, as soon as it is perforated.

513. Whether pursuing or pursued, the only chance of stopping an enemy is by bringing down some of his rigging; it is therefore most important to consider the best mode of effecting this. The random aim of a whole broadside-battery will be much less likely to accomplish it than the cool and careful use of one well-served gun. Hauling-up, or bearing away, to rake a flying or a pursuing enemy, always produces a very random volley; for as the change of course must occasion much loss of distance, it is necessary to perform it so quickly that the effect is seldom good, the distance, or range, altering very much before the vessel comes to a position proper for opening her broadside fire. This alteration of position brings with it a great and unknown alteration in the ship's inclination; consequently a considerable change in the elevation at which the ordnance may have been laid, and which there is not time to correct. It is almost incredible, indeed, how little effect is produced by this sort of raking fire; and the observation requires therefore to be supported by facts. In a certain action, a 74-gun ship bore up across the stern of an 84, to rake her, at a cable's length distance, in moderate weather and smooth water. The

74 had been upon a wind, and not having, perhaps, allowed for the alteration of elevation that would take place after bearing-up, not one shot took effect! A proof of what may be effected against the *personnel* of a ship by yawing, and giving a close raking fire of well-directed grape, was gallantly shown by the "Inconstant," commanded by the late Admiral (then Captain) Freemantle, who, keeping in the wake of a line-of-battle ship, gave a raking fire of grape with tremendous effect upon her people, who were very much exposed in striving to clear the wreck of her topmasts, which had been carried away by an over-press of sail.

514. The attack of the American squadron under Commodore Rogers, on the "Belvidera," Captain Byron, furnishes a strong proof of the inefficacy of volleys of raking fire with round-shot. Captain Byron, seeing the squadron bearing down upon him in a suspicious manner, and having reason to expect that war had been declared, very prudently kept away also: he gradually made sail, and a chase ensued, during which the "President," outsailing her consorts, came up with the British frigate.

The "President" commenced the attack by firing a heavy bow-gun, by which nine men in the "Belvidera" were killed or wounded; and by continuing to fire from single guns, deliberately aimed, without altering the ship's course, she did much further damage to the chase. But when, gaining further on the British frigate, the "President" yawed and gave her broadside volley (which was several times repeated), she did the "Belvidera" no further damage beyond cutting a brace or two, and wounding a few spars! Our frigate answered these attacks deliberately, with her stern and quarter guns, with such effect that the "President" (having had a gun burst) suffered more than her expected victim; and the steady and determined manner in which Captain Byron conducted both his defence and his retreat, reflects on him immortal honour, and on his crew a full share of credit. These facts serve to show how much more may be executed by cool, deliberate aim, with single guns, in the hands of well-trained gunners, than by repeated random volleys of whole broadside-batteries. Shells, having time-fuzes, and spherical case-shot, may be used with great advantage for dismantling purposes, at very considerable distances, in chasing any vessel; and the moral effect produced by the bursting of a shell is so scaring to a non-combatant vessel, a merchant-ship, pirate, or slaver, that it will rarely fail in bringing-*to* such a chase.

In the chase of the "President," and the action which ensued between her and the "Endymion," some of the best gun-practice ever effected by British seamen was displayed. This operation also affords matter for remark as to the effect of dismantling-fire in chasing.—The "Endymion's" sails were completely torn to pieces, and her spars and rigging much cut, by the American dismantling-shot. One of these shot cut away twelve of fourteen cloths of the "Endymion's" foresail, and stripped it almost entirely from the yard.[a]

515. So great a proportion of an enemy's side is opened by the large ports of a carronade-battery (4 feet in width and more in height), that grape or case shot seldom fail to commit great execution from entering these large ports, as well as from cutting the rigging. Case-shot for 32-pounders, being composed only of 8-oz. balls, have not power to do much mischief against the *matériel* of an enemy, and should therefore only be used, in good opportunities, specially against the *personnel;* but grape-shot may be used in certain proportions from heavy guns, in any close action, because they are capable of committing infinite ravages against both. Three-pound iron balls, of which there are nine in 32-pounder grape, will penetrate the enemy's barricade defences on the upper deck, and though they cannot penetrate a mast, or by any direct wound bring it down, yet they can break chain-plates, cut shrouds or stays, however thick, and, from the number of such chances, will be very likely, in a strong breeze, to dismast the enemy. But it appears, from a close analysis of the reports of the damages sustained by H.M.S. "Shannon" and the United States' frigate "Chesapeake" action with each other (Art. 262), that very few grape passed through the side of either ship below the barric

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[a] The American dismantling-shot which tore the "Endymion's" composed of four or five iron bars, each about two feet long, fastene heads to a strong ring. These dismantling-shot were likewise use actions (as between the "Java" and "Constitution"), but with li effect. The flight is so irregular that they cannot be depended on; a fore round-shot, which may fell a mast, are greatly preferable.

the quarter-deck and forecastle; whereas there were no less than 80 penetrations of grape-shot into the "Chesapeake" through the bulwarks of the forecastle and quarter-decks, which must have produced very fatal effects upon the people stationed there. Nor can the small penetration of grape-shot into the more solid parts of the "Chesapeake"—only from 3 to 5 inches—be easily accounted for. It may therefore be surmised that the upper-deck guns of the "Shannon," chiefly caronnades, were overloaded by putting grape-shot over the round-shot, which, with a charge of only 2 lbs. 10 oz., may have caused the trifling penetration. However this may be, the facts recorded in these instructive reports may create a doubt whether, in general, a double-loading of round-shot and grape should be preferred to double-shotting all the main and lower-deck guns of a ship, in close action. The practice of loading alternate guns with round-shot and grape, which obtained at the time former editions of this work were published, is now discontinued, as the author had always maintained it should be.

516. The firing of the Shrapnel shells, like that of other shells with time-fuzes, may be used with great advantage from ships against troops on shore (Art. 265), or against vessels crowded with men on their upper decks, at distances far beyond the effective ranges of grape or case shot, and in general, wherever the *personnel* of any ship or battery may be seen, and reached. But formerly the service-charges for spherical case-shot being smaller than for other shells, on account of their inability, being thinner, to stand large charges (for which reason those for heavy guns were considerably reduced), the penetrating power, whether of the bullets or the splinters of the shells, was so inconsiderable that this description of projectile was not calculated to produce any effect on the more solid parts of a ship. If the fuze were too long, the shell of the spherical case would most likely break on striking; and, should it explode in a ship, would be far less destructive, from the smallness of the bursting-charge, than the common shell; for these reasons, spherical case-shot were formerly of little use in naval actions, and were supplied chiefly for boat-service and the ship's field-guns; but in the present day Shrapnel shells are fired with the heaviest charges allowed for the guns.

517. Shrapnel shells, to be effective, require to be fired from guns as direct as possible at the body against which they are used; that is, with full service-charges, and the least elevation which the case may admit; but this projectile cannot be employed with any useful effect from howitzers at very great elevations, or from mortars; for the bullets, released from a shell which bursts at a considerable altitude in the declining portion of a very elevated trajectory, will strike the plane below with very little horizontal force, and fall to the ground with very limited vertical velocity, approaching, more or less, to the "terminal velocity" due to bullets of that size and density. The circumstances are similar to those in M. Carnot's project of vertical fire with musket-bullets, the effects of which that celebrated engineer very much over estimated (see Art. 81, Note p. 54) in his system of defence, by disregarding the effects of the resistance of the air.

518. The first employment of shells fired direct from long guns at bodies of troops at considerable distances, was at the memorable defence of Gibraltar in 1781.—Drinkwater's 'Siege of Gibraltar, 4th ed. p. 167.

In firing from batteries placed high on the rock, from which the whole interior of the besiegers' trenches and batteries could be seen, round-shot fired from heavy guns would evidently have been a wasteful and ineffectual practice against the workmen and troops thus exposed to the direct, though depressed, fire of the fortress. The distance being too great for grape or case shot, howitzer shells were tried; but shells fired directly from howitzers had neither accuracy nor force sufficient to take full advantage of the command which the batteries possessed over the works on the isthmus below. The charges being small, the
projectile velocity of the shells, at the moment of bursti
not sufficient to impel the fragments forward with
required to produce the desired effect, whilst the gr
charges which the shells contained occasioned ver
sions of their splinters. Guns were therefore
howitzers, and 5½-inch shells fired from long
as large charges as the shells could resist.
prodigious—the fragments of the shells were
with far greater force—the dispersion was less, o

great preponderance of the projectile velocity—and the effects upon the troops and working parties in the enemy's trenches and batteries were extremely destructive.

This remarkable instance of the efficacy of direct shell-firing attracted the notice of all artillerists. The conditions of this description of practice are materially different, as has been already explained (Art. 271), from that of shells whose effects depend wholly upon their explosive force; but the few fragments into which common shells are broken—usually 15 or 16—forming what may be termed a charge of langrage, consisting of a few irregular lumps of iron—are neither suited in form, nor capable in number, of producing any very extensive effects upon large bodies of troops. The late Major-General Shrapnel had the ability and sagacity to perceive that, under such circumstances, the effects of direct shell-firing might be prodigiously increased by filling the shells with musket or carbine bullets, enlarging the charges in proportion, and reducing the bursting-charge to a quantity just sufficient to break the shell with as little scattering effect as possible upon the bullets; and to that able and distinguished officer, therefore, is due the credit of the invention which has rendered his name so justly celebrated.

519. Numerous reports having been recently received, from all out-stations where practice is carried on with spherical case-shot from heavy guns, to the effect that the shells, in nearly all cases, burst in the guns when fired with the service-charges, and this having been attributed to defects in the fuzes, a series of experiments were made in 1850 to ascertain the real cause of this premature explosion.

The experiments were made from an 8-inch shell-gun, a 32-pounder gun, and a 24-pounder gun, with the full service-charges of 10 lbs. for the two former and 8 lbs. for the latter. The result was, that the shells were invariably destroyed within the guns. The same results took place when the shells were filled in the ordinary way with musket-balls and bursting-powder, *but without fuzes*, the fuze-holes being plugged. The charges were then reduced to 8 lbs. for the 8-inch gun and 32-pounder, and to 6 lbs. for the 24-pounder, when a large proportion of the shells fired burst in the guns as before. The charges were then further reduced to 6 lbs. and 5 lbs. with fuzes fixed, when it was found that the shells resisted the concussion of discharge and burst at the proper time; also, that the penetrations of the bullets were efficient at the ranges tried, viz. 950 yards from the 32-pounder and 24-pounder guns, and 1100 yards from the 8-inch shell-gun; and these charges have been established accordingly for spherical case-shot from all ordnance of those natures and descriptions.

The failures proved that the metal of the shell, in spherical case-shot, is too thin to withstand the necessary charges, not that these were too great for the purpose; for it is essential to the efficacy of spherical case that the shell should be moving with great horizontal velocity at the moment of bursting: it may therefore be doubted whether the evil shown in these experiments might not be better remedied by increasing the thickness of the shell, maintaining the original service-charges, than by depriving this important and useful projectile of so much of its power.

In an extensive course of experiments carried on in 1852 with Shrapnel shells, it was ascertained that the frequent failures of the practice by the premature bursting of the shells, are not occasioned by the concussion of discharge, but that the ignition of the bursting-charge also arises from the friction of the balls on one another and against the interior surface of the shell, the powder being mixed with the bullets. In order to avoid this evil, it was proposed by Captain Siemen, of the Hanoverian Artillery, to cement the balls in one mass by pouring among them liquid sulphur or plaster of Paris, a cylindrical space being left near the fuze for the bursting-powder; and the method appears to have answered the purpose well. But, in 1852, Captain Boxer proposed that the balls in the shell should be completely separated from the bursting-powder by means of a wrought-iron plate, or diaphragm, in the shell. This construction was found to succeed admirably; for, in an experimental trial at Shoebury Ness, 119 8-inch shells and 79 24-pounder shells were fired, with 5½-inch fuzes and with the service-charge of powder, without a single premature explosion; and [illegible] at Shoebury Ness, with shells which had been [illegible] Woolwich (the balls being taken out, the [illegible] refilled with balls), of 656 shells projected, only 37 burst prematurely.

In consequence of this important discovery, and the results of the experiments made with the Boxer fuzes, the reduction of charges recommended by the committee of 1850, and then adopted, have been abandoned, in order to restore to Shrapnel shells the power of which, by that reduction, they were deprived; and thus enable field artillery, if properly used, to maintain the relative superiority of that arm to the improved muskets now so generally adopted in European armies. This will not, however, be by Shrapnel shells fired from 6-pounders: these have neither capacity nor power for an efficient use of that destructive projectile; but 9 or 12-pounder guns, making good use of Shrapnel shells, will fully maintain their superiority over any muskets. It may be a question, however, whether any Shrapnel shell fired from a smooth-bored gun in the field will in the present improved practice with the rifled small-arms be able to maintain this superiority.

520. Range-tables, with spherical case-shot from guns, not having been formed for the naval service, the author inserts tables (XVI. and XVII., Appendix B) abstracted from practice made on board the "Excellent," of the ranges with 7.9-inch, 6.76-inch, and 6.177-inch spherical case-shells fired from 8-inch (68-pounder) 42 and 32 pounder carronades, and with 5½-inch spherical shells fired from a 24-pounder-field howitzer, and the 5½-inch new gun for boats. Table XVII. is compiled from Lieut.-Colonel Burns' practice-cards, published by authority, which contain the most exact and recent directions for conducting this and all other land-service practice.

521. In close action, rapidity of fire is of the most decisive importance, provided accuracy be not sacrificed to it; for, in proportion as we increase the quantity of fire with equal precision, we in fact increase our force. In close battle, when it is scarcely possible to miss, the vessel that can soonest reload her ordnance, and give her second broadside, supposing both ships to have opened their fire nearly at the same time, must have a prodigious advantage over her opponent. The power of doing this with efficacy, as well as rapidity, can only be acquired by the

constant practice of every minute detail relating to the manual exercise and to the pointing of the ordnance.

522. Quick firing depends greatly upon the manual strength of the gun's crew to perform the necessary operations, and particularly that of running the gun out in the least possible time. But it appears, that, in some classes of ships, the number of tackle-men afforded by the total strength of the ship's company has not been increased commensurately with the great weight of ordnance introduced into the naval service. There is no great difference between the number of men forming a ship's crew in our service and the number forming a crew in the French navy on the peace establishment; but, on the war establishment, a French crew is superior in number to an English crew; and the sea-going ships, the squadrons of evolutions, &c., of the French, are, with respect to the number of men, on the war establishment. There is no difficulty in running guns out, however heavy they may be, in a ship which is perfectly or nearly upright, with the regulated gun-crews, aided by the improved mechanical contrivances which have been adopted for this purpose. But these means do not altogether suffice in all the varieties and contingencies of service. In fighting on the weather-side, in a strong breeze, even with full complements of guns'-crews, great difficulty is experienced, and much time lost, in running the gun up the inclined plane which the deck then forms; and, if this be so under ordinary circumstances, how much greater must be the difficulty and loss of time in battle, when casualties happen, from men being killed or disabled, or when firemen, sail-trimmers, boarders, &c., are called away! The deficiency of men is very much felt in heavy-armed frigates and in other vessels; and it has accordingly been found necessary to increase the power of the gun-tackles by a double block at the tail as well as at the head; but this is attended with a proportional loss of time in running the gun up; and, though the time thus lost may be little, yet so great is the importance of quick firing, that every effort possible should be made to expedite the operations of loading and running up the gun. The French have only a single block at the tail of the tackle (see Art. 527).

523. The great attention paid to every expedient [illegible]

contribute in the slightest degree to quick firing is very apparent in all recent French publications on naval gunnery, and in the regulations for the manual exercise of their naval artillery (see Art. 424, *et seq.* 4th edit.). "In all artillery battles," writes De la Gravière, Vol. ii. p. 236, "nothing can dispense, or be allowed to interfere, with the attainment of the utmost precision and rapidity of fire;" and this maxim is enforced with the greatest weight in the Avertissement (p. 8) to the 'Exercises des Bouches à feu en usage dans la Marine.'

524. In the first edition of this work the author recommended that, in reloading guns on any occasion in which rapidity of firing is of the utmost importance, the cartridge, shot, and wad should be set home at one operation.[a] It does not appear that there is any other objection to this practice than that which arises from the ball being apt to roll on the tie of the cartridge and thus become jammed in the gun. Such an accident, however, may easily be prevented by cutting the tie short off, or by fastening it round the body of the cartridge. The reduction in the time of loading by such means may appear trifling, but, in close action, the issue of a battle depends so much upon the rapidity with which the first few rounds are fired, that it is justifiable and even necessary to resort to any expedient, the effect of which cannot be detrimental, while its success may ensure victory.

525. Soon after the French translation of the first edition of this work appeared, experiments were made in France to ascertain whether *la charge simultanée*, as it was called, could be adopted with perfect safety, and with the advantage, which the author of this work proposed, of loading and consequently firing with greater rapidity than in the usual way. In a subsequent publication (1845), M. Charpentier, the translator of the 'Naval Gunnery,' gives the results of the extensive trials of that method, made in the French fleet under the directions of Admiral Lalande, in 1840, extracts of which are given in the subjoined note.[b]

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[a] This method of loading appears to have been practised on one or two occasions during the late war.

[b] "On a essayé de faire usage de gargousses allongées; et après avoir constaté que la diminution de leur diamètre n'exerçait aucune influence défavor-

526. The French, like us, have had much experience of the inconveniences and difficulties in loading chambered guns, and have found it necessary to make a material alteration in the dimensions of the chambers before they could succeed in executing la charge simultanée with the canon-obusier of 80 No. 1, of 1842, which is their principal shell-gun.

When the canons-obusiers were first introduced, each was furnished with two rammers, having heads of different diameters, one to set home the cartridge into the chamber, the other with a hollow in the rammer-head to cover the fuze in pushing home the shell, a wad having previously, by a distinct operation, been put over the cartridge; and, to avoid the necessity of using the worm after every two or three rounds, a small worm was lodged in the end of the sponge, imbedded in the wool, by which means the sponging and worming might be performed by the same operation after every discharge. Next, to obviate the necessity of putting a wad over the cartridge, in order to keep it in its place before the shot was put in, trials were made of wooden wads, and hollow tompions made of tin of different lengths, which were attached to the reduced cartridges, to fill the space in the chamber that would otherwise be left void. But neither of these expedients having been found to answer, the wads were suppressed, and the cartridges elongated[a] suffi-

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able sur les portées, on a poursuivi les essais, afin de s'assurer qu'elles se prêtaient également bien à l'exécution de la charge simultanée.

"On a tiré 40 coups avec le canon-obusier de 30, en pratiquant les différents genres de tir qui peuvent être exécutés dans un combat; la gargousse s'est constamment rendue au fond de la chambre, sans qu'il ait été nécessaire de refouler.

"En expérimentant avec un canon-obusier de 22 centimètres, No. 1, modèle 1842 (Art. 228), on a également tiré 40 coups, dont les vingt premiers à la charge de 3 k. 50 (6 lbs. 12 oz.), sans éprouver aucune difficulté; pour les vingt autres coups, les gargousses étaient de la contenance de 2 kilogrammes (4 lbs. $6\frac{2}{3}$ oz.).

"Dans cette série, la charge s'est arrêtée dès le second coup, au raccordement de l'âme avec la chambre, et cette circonstance ayant été attribuée à ce que la gargousse était encore trop courte, on y a remédié en formant un tampon avec l'excédant de la ligature, au lieu de rabattre cet excédant, ainsi que cela se pratique. Cet expédient a réussi.

"Enfin, la charge simultanée s'est parfaitement bien exécutée avec le canon-obusier No. 2."—(Art. 228.)—(See p. 78, Section on *La Charge simultanée des Bouches à feu*, in the 'Essai' of M. Charpentier.)

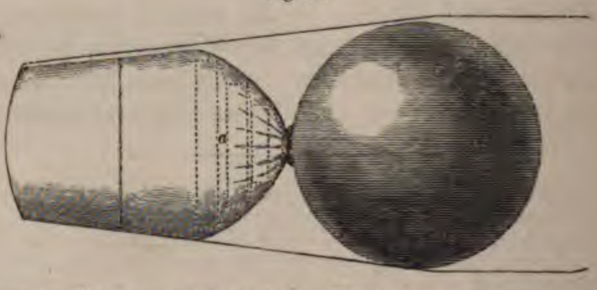
[a] "La forme des gargousses ordinaires ne permettait pas la charge simultanée pour les pièces chambrées, mais une forme nouvelle [illegible]

ciently to occupy the whole length of the chamber, as explained in the Note on Art. 225. See also Charpentier, 'Essai sur le Matériel de l'Artillerie,' p. 79, and the 'Aide Mémoire Navale.'[a] By this contrivance, simultaneous loading has succeeded perfectly with canons-obusiers without the aid of the small-headed rammer (see Charpentier, p. 346; also 4th edition of this work, Art. 428, p. 454 (*Load*), and Art. 432). Cartridges of this formation were likewise adopted for carronades, and all other chambered ordnance, with this difference only, that, as the chambers of carronades are hemispherical at bottom, so their cartridges terminate in that form.

527. The method of simultaneous loading proposed by the author (see the first edition, Art. 192), and adopted in the French navy in 1840, having lately attracted the notice of naval officers in this country, orders were issued in 1851 to make trials of that system on board H.M.S. "Excellent," and to report the results.

Much prejudice existed at first against this mode of loading, and many evils were anticipated. With 8-inch chambered guns it was found necessary to resort to some such expedient as that

Fig. 64.



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gargousses a rendu cette charge possible, et la même méthode a dû s'appliquer à la charge des pièces chambrées."—'Exercices des Bouches à feu de la Marine,' *Avertissement*, p. 8.

[a] Canon-obusier de .22 (8.67 in.):—

	Charge.		Diameter of Plug.	Length of Cartridge.
	lbs.	oz.	Inches.	Inches.
No. 1. . .	7	11.5	5.5	10.24
	4	6.6	4.69	9.06
No. 2. . .	6	9.9	5.48	9.81
Canon-obusier de 30 :—				
	4	6.6	4.73	8.27
	3	5.9	4.29	7.88

described in the notes p. 93, to ensure the reduced cartridge being properly set home in the chamber simultaneously with the shot. This has been effectually accomplished by placing a cork wad *a* (fig. 64) in the top of every reduced cartridge, of a height sufficient, together with about half the shot, to occupy the whole length of the chamber, upon the principle stated in Art. 126, Note [b], instead of putting a grummet-wad over the reduced cartridge to keep it in its place, as heretofore practised on board the "Excellent" (see Note [a], in the article just quoted), so that the shot on receiving the blow of the rammer-head may cause the cartridge, with the cork wad, to spring into its place in the chamber.

528. After repeated trials with guns of all calibres, from the 10-inch gun to the 6-pounder, with single and double shot, and with shells, no objection whatever was experienced; whilst the advantages to be gained are important by obtaining greater rapidity of fire, and a considerable saving in labour, by ramming the whole charge home at one operation.

These results were forwarded to the squadron of evolution for further trials under all the circumstances of service, and particularly when there was much motion. Such objections or inconveniences as were found to exist with respect to the chambered guns, were readily obviated; and the Lords of the Admiralty having witnessed the success of the experiments made on board the "Excellent," directed "simultaneous loading" to be established throughout the fleet.

The only disadvantage arising from the adoption of this expedient is that the bulk of the reduced cartridges, and consequently the space required for stowage, is as great as for those which contain the full service-charge; but this is so trifling an inconvenience compared with the magnitude of the evil overcome, that it is not worthy of consideration in ships armed with a limited number of shell-guns, according to regulation, and does not amount, we believe, to more than the bulk of two or three ammunition-cases in a line-of-battle ship.

In this manner simultaneous loading is as easily practised with chambered as with other guns, and the importance [illegible] method of loading may be stated thus,—that in [illegible] portion the operation of loading may be quick [illegible] proportion is the actual force of the broadside-battery practically increased, as if it consisted of a greater number of guns.

529. Seeing that great inconveniences have been experienced both in the French and British services—and it may be added in all others—from the difficulties which the contraction of the chamber, of whatever form, presents to the operations of loading; and that guns having no chambers may be loaded with perfect facility, simplicity, and rapidity, without the aid of any adventitious expedient, it may well be asked how far it is necessary, convenient, and advantageous, or the reverse, that the guns from which shells are to be fired should be chambered; and whether the truncated cone, which we alone have adopted, is the best form of chambers for guns designed for horizontal firing—as no doubt it is for mortars? (Art. 126.)

530. Much has been written, many elaborate investigations made, and experiments tried, with chambers of all forms and shapes, conical, cylindrical, spherical, and with some of these forms reversed; to ascertain in which description of chamber the impulsive force of the powder acts with the greatest effect against the projectile, and consequently upon the range.[a] The author has carefully and fully consulted all the more important works and documents which treat of this subject, and referred to the experiments which were made at Woolwich (in 1787-9) and elsewhere; and has no hesitation in coming to the conclusion at which Dr. Hutton arrived, "that, however mathematical speculations may show a preference to one form over another, it is found that form is very immaterial, and that in practice the chief point to be observed is to have a chamber of a size just sufficient to contain the charge of powder, and no more, so that the projectile may always be in contact with the powder."[b]

531. To fulfil, completely, this important condition, it is obvious that part of the chamber—the whole, as appears in

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[a] Though it be agreed that chambers of a spherical form, or in the form of a pear, cause the greatest effects to be produced with a given charge, yet the difficulties which they give rise to, both with respect to the formation of the fire-arm itself and that of the charge (les munitions), have induced artillerists to make the chambers cylindrical to all howitzers and to most mortars. Chambers in the form of truncated cones are disadvantageous on account of the form of the cartridges.—'Traité Elémentaire d'Artillerie,' by Decker.

[b] Dr. Hutton. See, in particular, the article *Chambers*, in his 'Philosophical Dictionary.'

fig. 64, p. 488, being, notwithstanding the introduction of the cork wad, too long—might with advantage be removed. Chambers cannot be wholly dispensed with in guns of such high calibre as those of 8 inches and upwards, without augmenting considerably the weight of the gun, and increasing the guns'-crews on already crowded decks, and without incurring fresh difficulties in using reduced charges in bores of that diameter; but it does not follow that the existing chambers should not be reduced in capacity and length. Although, by the employment of cartridges with wads, the stowage-room of filled ammunition, in boxes, is in no ship increased by more than that which is necessary for six cases, yet every ship must take a certain proportion of spare wads of cork or light wood, for filling and completing the regulated number of reduced cartridges to make up for those that have been expended; and it will likewise be necessary to provide supplies of these wads in all arsenals and stations at home or abroad. Is it not, therefore, desirable to ascertain, by actual experiment, whether the chamber of the 8-inch gun of 65 cwt. might not be sufficiently shortened to fulfil the conditions specified in Art. 530, and so render the cork or any other wad unnecessary?[a] This would reduce the chamber to a form and capacity which, on the one hand, would satisfy the objections to the suppression of the chamber, and effectually remove the evil arising from the chamber being, as at present, too long.

532. It appears by fig. 64, p. 488, that a space of about 3 inches would be left void between the projectile and the reduced cartridge, were not the cork wad, as represented by the dotted lines, inserted in the head of the cartridge. If, therefore, the bore were continued cylindrically 3 inches further than at present (fig. 65, overleaf, see also Plate II. fig. 14), the conical part to commence where the cylinder produced from A to B ends, the depths cut away at B and C would only be .225 of an inch each, the quantity diminishing in proportion to the convergence of the sides of the old and new cone, the total quantity of metal to be removed would be 35½ cubic in [illegible] the weight only 9 lbs. 6 ozs., [illegible] quantit [illegible] admit of the

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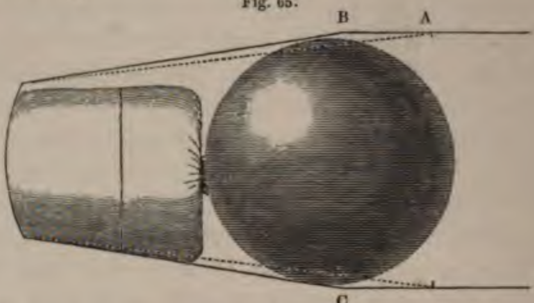
[a] E [illegible] in the reduc [illegible]

projectile being in contact with the powder contained in a reduced cartridge.

Fig. 65.



533. The inconvenience which principally accompanies chambered ordnance is, that the capacity of the chamber, which is calculated for exactly receiving a full charge, is too great to be filled when a reduced charge is introduced. Now the proportion of the length to the mean diameter of a chamber having the form of a conic frustum has not yet been determined; and it appears to the author that no established principle in gunnery would be infringed, but rather benefit would be gained, by shortening the chambers of our 8-inch guns of 65 cwt., and even those of 50 cwt., to the extent requisite for adapting them to the reduced charges. The expedient used by the French artillerists to overcome the inconvenience of the cylindrical chambers in their shell-guns, when reduced charges are used, or when simultaneous loading is practised, is to make all their cartridges of the length of the chamber nearly (Note [a], p. 488), and the areas of the transverse sections proportional to the weights of the charges. Now, although it is stated by M. Charpentier, in his 'Essai' above quoted (Art. 525, Note [b]), from some experiments, that the diminution of the diameters of cartridges, the charges being equal, had no influence on the ranges; yet from other experiments which have been made in France, as well as elsewhere, it has been found that, in projecting both solid and hollow shot, with equal charges, the cartridge which has the greatest diameter gives to the shot the greatest initial velocity[a] (Art. 157). It would be preferable,

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[a] It appears from various publications, and from the facts stated in the several parts of this work, that chambered ordnance are losing favour as well

therefore, to shorten the chambers of our 8-inch guns sufficiently (about 3 inches) to permit the projectile to be in contact with the cartridge when a reduced charge is employed, and thus enable the expansive force of the powder to exert the greatest effect; while the gentle contraction of the chamber at the place where it unites with the cylindrical bore would permit a cartridge containing a full charge to lie without derangement in the chamber and the adjoining part of the bore.

The shortening of the chamber would be advantageous in another respect: in firing single shot or shells with reduced charges, and particularly in firing double shot, when greater charges than 5 lbs. cannot be used, the unoccupied part of the chase being about half a calibre longer with the diminished than with the usual chamber, the projectile would be acted upon by the charge during a longer time under the guidance of the bore, and thus both the initial velocity would be increased and the direction of the fire more correct.

534. The 8-inch gun of 65 cwt. possesses, as has been shown in Art. 254, prodigious strength in resisting the extraordinary charges with which it was tried *à outrance*, and which far surpassed anything that could have been expected or designed; it may, therefore, well admit of the abstraction of so small a quantity of metal as that of 9 lbs. If it should appear on trial, however, that the removal of this small quantity of metal would so far weaken the gun as to be inadmissible in existing guns, that alteration might at least be made prospectively in any new gun that may be required, by adding to the thickness of metal in that part of the gun as much as is taken from within. How far this partial removal of the evil arising from the chamber being too long can be carried in the lighter 8-inch guns is a question which only actual experiment can answer; but, however this may be, if the shortening of the chamber of the 8-inch gun

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in the French land service as in that of the navy; it is proposed* to abolish the field-service howitzer, and substitute 12-pounder guns without chambers, as equally adapted to fire either shot or shell [illegible] easier loading and quicker firing, to which the French [illegible] importance in military as in naval actions.

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* ‘Nouveau Système d'Artillerie de [illegible] République’ (now Emperor of the [illegible]

of 65 cwt. can be effected with safety and advantage, considering that this gun enters so much more largely than the lighter 8-inch guns into the armament of our ships and vessels, there can be no reason why that advantage should not be taken, although it may not be procurable in the lighter guns of that class.

SECTION V.—ON THE MANUAL EXERCISE OF NAVAL ARTILLERY.

535. The following regulations for the exercise and service of naval ordnance in the British service are quoted from the "Instructions" on great-gun exercise established by authority of the Lords of the Admiralty.

FIRST INSTRUCTION.

Assembling at Quarters.

THE accustomed beat of the drum is for Action; the stationary powdermen repair to the magazine-scuttle for two cartridge-cases and two cartridges, and then return to their place in the rear of their guns amidships, ready to receive all further supply of powder from the extra powderman.

The Gun Nos. provide the stores, and with the Auxiliaries cast loose their respective guns, which are to be searched, loaded with full charges, and single shot, and run out without further orders: but they are on no account to be fired without *distinct* orders from the upper deck.

NOTE.—The above arrangement, although it ensures the guns being got quickly ready for action, does not preclude the Commanding Officer from giving orders on beating to quarters, to load with any other charge or projectile he may think best.

The accustomed beat of the drum with one roll is for Manual Exercise, the same as for Action, but no powder is provided.

The accustomed beat of the drum with two rolls is to muster for Inspection: the crews and powdermen repair to their respective sides, unless ordered to the contrary. The stationary and extra powdermen take their places in the rear of their guns amidships. "Fall Out."

NOTE.—The rolls are to be beaten previously: by this means great celerity w acquired when the guns are really wanted for action. Orders for casting loose, an paring for action, will then be unnecessary, as the Officers and men will have been ap of what is required of them.

Detail for Placing the Men.

Take your place in the rear of the gun facing the port, as No. 1, the Captain.

Take your place to the right of the gun close to the ship's side, as No. 4, the Sponger, standing quarter-face to the gun.

Take your place to the left of the gun close to the ship's side, as No. 3, the Loader, standing quarter-face to the gun.*

Take your place to the right of the gun next to No. 4, as No. 6, the Assistant Sponger.

Take your place to the left of the gun next to No. 3, as No. 5, the Assistant Loader.

Take your place to the right of No. 1, facing the ship's side, clear of the recoil, as No. 2, the Second Captain.

These six numbers are Gun numbers, and provide stores for, and cast loose, this gun and the gun on the right in their respective watches. All numbers above these are Auxiliaries, who cast loose this gun and the gun on the right in their respective watches.

Take your place to the	left	of the gun next to	No. 5	as No. 7.
,,	right	,,	No. 6	as No. 8.
,,	left	,,	No. 7	as No. 9.
,,	right	,,	No. 8	as No. 10.
,,	left	,,	No. 9	as No. 11.
,,	right	,,	No. 10	as No. 12.

And so on with higher numbers. "Close up."

"Gun Numbers."

1, 2, 3, 4, 5, 6.

"Auxiliaries."

7, 8, 9, 10, 11, 12, 13, 14, &c.

"Handspikemen."

9, 10.

"Rear-men."

14. The right rear-man. 13. The left rear-man.

(*or the two highest numbers.*)

Gun Nos. as placed in rotation on arriving at the gun :—

1. The Captain.
4. The Sponger.
3. The Loader.
6. The Assistant Sponger.
5. The Assistant Loader.
2. The Second Captain.

NOTE.—The Gun numbers are never to be called unless ordered; and when so ordered, Auxiliaries, Handspikemen, Rearmen, and 1. the Captain, &c., are to be called.

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* Th[illegible]

Manning both Sides.

MAN BOTH SIDES. Each watch will repair to its respective side, the odd numbers standing to the left of the left guns; even numbers to the right of the right guns.

Left guns,	3	remains	3	Right guns,	4	remains	4
	5	becomes	4		6	becomes	3
	7	,,	6		8	,,	6
	9	,,	5		10	,,	5
	11	,,	2		12	,,	2
	13	,,	7		14	,,	7
	1	remains	1		2	,,	1

NOTE.—The left guns are odd starboard and even port. The right guns are even starboard and odd port.

Guns'-crews always man, and powder-boys always supply, adjacent guns, when clearing for action or when fighting both sides.

With a crew of 11 men and upwards, and both sides manned, 2 is *always* to attend the train-tackle.

Providing Stores (both sides manned).

No. 1 provides 3 vent-plugs, priming-wire, tube-box, spare trigger-line, vent-bit, sees the lock fixed and fit for use, and places handspikes.

3, shot, and grummet, spare breeching, wet swab, wads, and fuze-wrench.

4, sponge, rammer, worm, and fire-bucket.

Stationary and extra powderman, two cartridge-cases and two cartridges each.

NOTE.—With 68-pounders and 10-inch guns, 3 should provide a bearer, and 4 should assist him in providing shot. Spare locks and hammers are to be provided by the 2nd Captain. Lanterns should be hung up amidships between the ports and kept in order by the proper No. 4, arrangements being made for lighting them at night-quarters.

Shells are always to be provided by the two highest numbers.

"MAN THE STARBOARD OR PORT GUNS."

Exercise with 14 *Men to a Lower, Middle, or Main Deck Gun.*

No. 1, the Captain, commands, attends the breeching, primes, points, fires, and stops the vent.

2, the 2nd Captain, assists 1, runs out, attends handspikes, coin, and lock.

3 loads, rams home, runs out, and trains.

4 worms, sponges, rams home, runs out, and trains.

5 gives shot and wad to 3, runs out, trains, and spans th breeching.

6 gives sponge, rammer, and worm to 4, runs out, trains spans the breeching.

7 and 8 run out, and train.
9 and 10 run out, and attend handspikes.
11 runs out, and attends handspike.
12 runs out, and trains.
13 runs out, trains, and brings up shell.
14 attends train-tackle.

NOTE.—With more or less than 14 men, the Exercise will be the same as above, except that the proper handspikemen will take the duties of 9 and 10, the assistant handspikemen those of 11 and 12, and the rearmen those of 13 and 14.

The Captain of the gun is responsible that all stores and necessary gear are at the gun, and that throughout the exercise all the Nos. perform their duties correctly.

Exercise with 9 *Men to an Upper-Deck Gun.*

No. 1, the Captain, commands, attends the breeching, primes, points, fires, and stops the vent.

2, the 2nd Captain, assists 1, attends the apron, elevating-screw, lock, and train-tackle.

3 loads, rams home, runs out, and trains.

4 worms, sponges, rams home, runs out, and trains.

5 gives shot and wad to 3, runs out, trains, and spans the breeching.

6 gives sponge, rammer, and worm to 4, runs out, trains, and spans the breeching.

7 and 8 run out, and attend handspikes.

9 runs out, trains, and brings up shell.

NOTE.—With guns mounted on Rear-chock carriages having side-levers for running out, Nos. 7 and 8 will shift the side-tackles, and the left rear-man will attend roller handspike when necessary.

With guns mounted on Hardy's carriages, the Exercise will be the same as above, except that No. 4 will attend compressor when the gun is *out*, and No. 8 when the gun is *in*.

Handspikemen with 5, 6, or 7 men ..	5 and 6
,, ,, 8 or 9 men ..	7 ,, 8
,, ,, 10 or 11 men ..	7 ,, 8
and Assistant handspikemen	9 ,, 2
Handspikemen with all Nos. above 11 ..	9 ,, 10
and Assistant handspikemen	11 ,, 2
Except with 10-inch and 68-pounder guns, when Assistant handspikemen will be	11 ,, 12

With light guns it may be advantageous in some cases to double man the handspikes. The left [illegible] always fire with a hammer or match, and the right [illegible] attend the train-tackle, except [illegible] handspikemen [illegible] will attend it) and in Lower [illegible] attend it).

Arrangement for clearing away Lower-Deck Tables and Stools with 7 Men (both sides manned).

Nos. 2 and 7 to take down mess-gear, and remain on orlop-deck to place tables, stools, and bread-barges.

5 and 6 to pass down tables, stools, and bread-barges.

Each gun's crew should be told off for clearing away the mess before or abaft their gun, according as the foremost mess is before or abaft the foremost gun.

Arrangements should be made for passing the tables and stools of the different divisions of guns down different hatchways, and for placing a certain number of tables on the chests in the fore and after cockpits for the wounded. When the tables and stools are triced up overhead, Nos. 2 and 7 take down mess-gear, as before, and all the other Nos. assist in putting up the tables and stools *before attempting* to cast loose.

Stations for casting loose a Lower-Deck Gun with 7 Men (both sides manned).

No. 1 places handspikes, 3 and 4 bear out, and the other Nos. trice up the port; when the port is up, 1 provides stores, 2 and 7 cast off and hook on train-tackle, 3 and 4 cast off muzzle-lashing, then provide stores and clear away breast-frapping, 5 and 6 clear away and shift side-tackles; when the side-tackles are clear, and train-tackle to the rear and luff choked, 1 gives the word "Elevate," sees the bed properly secured, and places coin at P. B., the gun is then run in, searched, loaded, and run out. While the gun is being elevated, 2 and 7 finish whatever is left undone, and, whilst loading, 2 coils up the lashings, and 5 and 6 span the breeching.

Stations for casting loose a Main-Deck Gun with 6 Men (both sides manned).

No. 1 places handspikes, 3 and 4 bear out, and 1 and 2 trice up the half-port; when the port is up, 1 provides stores, 2 casts off and hooks on train-tackle, 3 and 4 clear away and unhook train-tackle and provide stores, 5 and 6 clear away and shift side-tackles, untoggle breeching and span it when the gun is in; when the side-tackles are clear and train-tackle to the rear, 1 gives the word "Elevate," and withdraws the coin to allow 3 and 4 to put down the lower half-port, he then sees the bed properly secured and places coin at P. B., the gun is then run in, searched, loaded, and run out.

With 7 men, No. 7 will assist No. 2.
,, 5 ,, No. 1 will hook on train-tackle.

If the upper half-ports are made to take off, 3 and 4 will take them off.

Filling up Casualties.

When casualties occur at the guns, the Captain of the gun will give the word "Close up" and then equalize the crew on each side, excepting where either Captain is removed, when the next Gun No. should take his place. For instance, with 14 men at a gun, if 1, 6, and 9 fall out, 2 should take 1; 3, 2; 8 moves up and becomes 6; 10, 8; 12, 10; and 14, 12; 5 moves up and becomes 3; 7, 5; 9, 7; 11, 9; and 13, 11. If the powderman should fall out, the highest No. should take powderman.

Handspike Drill.

WORDS OF COMMAND. —	The Officer commanding numbers off the guns, according to the number of men, 4 men to a gun, viz. 3, 4, 5, and 6.
MAN THE GUNS FOR HANDSPIKE DRILL, AND PLACE HANDSPIKES.	The handspikes are to be placed on the deck with the flat side down and heels inboard, the centre of the handspikes in line with the axletrees, rear handspikes outside. The Nos. stand between the gun and the handspikes facing the ship's side, 3 and 4 in a line with the fore axletree, and 5 and 6 in a line with the rear axletree.
POINT.	The handspikemen pick up their handspikes, face *outwards from the gun*, and place the flat part of them on the deck, clear of the carriage ready to train.
MUZZLE RIGHT. WELL.	6 outside the brackets.
MUZZLE LEFT. WELL.	5 outside the brackets.
TWO HANDSPIKES MUZZLE RIGHT. WELL.	6 outside the brackets and 5 in.
TWO HANDSPIKES MUZZLE LEFT. WELL.	5 outside the brackets and 6 in.
FOUR HANDSPIKES MUZZLE RIGHT. WELL.	3 runs up, 4 runs back, 6 outside the [illegible] and 5 in.
FOUR HANDSPIKES MUZZLE LEFT. WELL.	4 runs up, 3 runs back, 5 outside [illegible] and 6 in.

SHIFT THE REAR TRUCKS.	3 and 4 ground their handspikes, 5 and 6 place their handspikes under the rear axletree cleats, 3 and 4 shift the trucks.
SHIFT THE RIGHT FORE TRUCK.	3 and 4 ground their handspikes, 5 places his handspike under the left rear axletree cleat, 3 takes off the truck and passes it to 4; 5 withdraws his handspike and stands on the arm of the axletree, 6 places his handspike under the arm of the right fore axletree, 4 shifts the truck, 3 replaces the rear one.
SHIFT THE LEFT FORE TRUCK.	3 and 4 ground their handspikes, 6 places his handspike under the right rear axletree cleat, 4 takes off the truck and passes it to 3; 6 withdraws his handspike and stands on the arm of the axletree, 5 places his handspike under the arm of the left fore axletree, 3 shifts the truck, 4 replaces the rear one.
RUN THE GUNS UP. WELL.	The Nos. place their handspikes in rear of the axletrees.
RUN THE GUNS BACK. WELL.	The Nos. facing to the rear place their handspikes in front of the axletrees.
FIRE.	Handspikemen ground their handspikes.

NOTE.—In shifting a fore-truck the rear-truck is passed under the gun to assist in taking it off, the small coin being placed under the fore axletree from *in*, *out*, by 3 or 4, and returned after the truck is shifted.

SECOND INSTRUCTION.

Orders for Manual Exercise.

On coming to the gun, Nos. 1 see the locks fixed and fit for use, vents clear, sights adjusted to the distance named, and the guns searched, loaded, and run out without further orders.

NOTE.—In clearing for action, and on other occasions, all unnecessary noise is to be avoided. The Captains of the guns *alone* should speak, giving their orders in a sharp clear tone, but not louder than necessary for their own crew to hear them.

The heel or inclination of the ship, as shown by a pendulum, or instrument supplied for that purpose to each division of guns, should be given by order, whenever the object cannot be seen from the gun-decks.

The guns are always to be laid horizontal, and sights kept at point-blank, unless contrary orders are given. The depression-chock is always to be used as long as the elevation will admit of it, as the coins are then less liable to be thrown out.

Full charges should always be used, unless contrary orders are given.

Nine Words of Command.

"Prime."
"Point."
"Elevate."
"Ready."
"Fire."
"Stop the vent."
"Sponge."
"Load."
"Run out."

PRIME. No. 1 opens the tube-box with his left hand, takes out a tube with his right, and primes.

NOTE.—Should the vent become choked, it is to be cleared by boring with a vent-bit; and care should be taken not to bend it, as being made of steel it will easily snap.

POINT. No. 1 retires to the full extent of the trigger-line, leaning well over on his right knee, keeping his left foot clear of the recoil. The handspikemen pick up their handspikes, keeping them clear of the brackets, the assistant handspikemen double into them, the right rear-man attends the train-tackle, and the rest of the Nos. man the side-tackle falls.

NOTE.—No. 1 is to give the necessary orders for training the gun, using the terms "Muzzle right," "Muzzle left," when he wishes the muzzle of the gun to be thrown in either direction; he is also allowed to make use of the following signs with the *left* hand to assist in making himself understood.

IN POINTING.—He should move the hand to the right or left, according as he wishes the breech thrown to the right or left.

IN ELEVATING.—He should move the hand up or down *repeatedly*, according as he wishes the breech raised or lowered.

In doubling in to the side-tackles, all the Nos. between the handspikemen and ship's side are to remain on the outside of the falls. The Nos. in the rear of the handspikemen are to pass between the handspikemen and the gun, manning the fall on the inside. 3 and 4 are to keep their eyes on the handspikemen opposite to them, so as to give the time to the other Nos. for hauling on the fall.

Whenever the order is given, "Two handspikes muzzle right" or "left," 1 makes up his trigger-line, lays it across the neck-ring, and passes between the gun and the handspikeman (who comes inside the brackets), resuming his position in the rear of the gun to look along the sight; as soon as the gun is laid, he again holds the trigger-line.

In "shifting" or "taking off trucks," 3 and 4 are to attend the fore-trucks, and rear-men the rear-trucks, 2 and 11 providing spare ones when necessary.

In fighting weather or lee guns, it will sometimes be necessary to take off the rear-trucks, to diminish the recoil in the former case, and to prevent them running out *after* the recoil in the latter.

Whilst training, the men on one side are to be attentive to ease off their tackle as the men on the opposite side haul on theirs.

ELEVATE. The handspikemen place their handspikes on the steps of the carriage under the breeching, and raise the gun off the coin. 2 steps in with his left foot in a line with the gun, keeping his right clear of the recoil, and withdraws the coin to the full extent; handspikemen lower the gun slowly and steadily. At the word "Well," 2 forces in the coin, and when he feels the weight of the gun, gives the word "Down" to the handspikemen, springing up to the safety position on the right.

NOTE.—The word "Ready" is to be given immediately the elevation is correct, and the pointing continued till the word "Fire." Should it be necessary to alter the elevation after the word "Ready," 2 is to "half-cock" at the order "Elevate." If firing with so much elevation or depression as to require the use of "inclined planes," they are to be placed by the rear-men; or if a "tripping-coin" is used for depression, it is to be placed by 2, the lanyard being passed to 4 to be hitched to the breeching-ring.

When side-scales are used for laying guns, the right rear-man is to hold the side-scale, and 2 is to attend the coin, and look out for the elevation, under the direction of 1.

When laying guns by marked coin or side-scale, with the rear-trucks off, an allowance of 2° must be made to correct the elevation.

If a standard be used, 1 is to attend it, and 2 the coin.

Right and left rear numbers raise the breeching for the handspikemen.

READY. No. 2 steps up to the right of the gun, clear of the rear axletree, cocks the lock with his left hand, and retires.

NOTE.—As soon as the word "Ready" is given, the training Nos. are to let go the side-tackle falls and stand steady till the gun is fired, unless the ship is rolling, when they are to be kept in hand till the moment of firing.

In the event of there being no 2, 1 cocks the lock, but if there be no lock, 1 is to retire beyond the extent of the recoil, and the left rear-man is to get the hammer, and place himself in a line with and clear of the rear axletree, facing the port.

FIRE. No. 1 fires with a suitable jerk, springing up to the safety position on the left. Handspikemen ground their handspikes.

NOTE.—Guns with heavy charges or lee-guns that run out again after the recoil, may be prevented so doing by taking off the rear-trucks, or by Nos. 7 and 8 placing stop-coins in the shape of a shoe with handles, under the fore-trucks when the gun is in; 5 and 6 withdrawing them when the train-tackle is taut.

If hammer or match be used, No. 1 is to order the left rear-man to fire at the moment when, allowing for the motion of the ship, he is certain he will hit the object. The match (when used) is to be put to the matched priming *before the vent*, to avoid its being extinguished by the explosion. The left rear-man returns the hammer or match.

The right rear-man is to take in the slack of the train-tackle, and choke or hitch it when the gun is in; 2 will assist, if necessary. The length of the trigger-line should be regulated by the distance required for the gun's recoil. The hook of the train-tackle at the gun is always to be moused.

STOP THE VENT. No. 1 makes up the trigger-line hand over hand, and lays it across the neck-ring, forces in a vent-plug with his left hand, keeping his thumb on it, and fingers extended along the vent-field, half-cocks the lock with his right hand.

NOTE.—The necessity of stopping the vent with a plug should be particularly impressed upon the men, showing them that if the sponge be thrust well home to the bottom of the bore, and well pressed against it whilst two round turns are given, and the vent well stopped so as to prevent a current of air, no fire can remain.

RUN IN. All the Nos. man the train-tackle, except 1, and 3 and 4, who overhaul the side-tackles. When the gun is in, 1 gives the word "Well."

NOTE.—The Nos. are to face *inwards*, in going to the train-tackle. The right rear-man is to run back smartly, ready to choke the luff; when the gun is in, it is to be immediately laid fair for loading and running out.

SPONGE.

Nos. 3 and 4 step inside the breeching together, 3 with his right leg, 4 with his left; 6 faces outwards and takes the sponge, with his right hand over and left under, and gives it to 4, who receives it in the same manner, *forces it hard home to the bottom of the bore in two or three motions*, gives it two round turns, withdraws it hand over hand, gives it two smart taps under the muzzle, and lays it quietly across the breeching; while the sponge is withdrawing, 6 takes the rammer.

NOTE.—When the order "Sponge" is given (if the sponge is kept overhead) all the Nos. in rear of 6 should fall back one pace to give him room to reach it; should 3 (or 4) observe that 1 has omitted to serve the vent, he is to call his attention to it. The gun is to be *wormed* every *fourth* round.

Sponges are frequently supplied too large. Great care should be taken that they fit easy, and go well home into the chamber, particularly with conical chambered guns. A neglect of this is frequently the cause of serious accidents.

Before and after every exercise the guns are to be "searched." Should any burning fragments be drawn out by the sponge or worm, they are to be extinguished by 3, with the wet swab.

LOAD.

No. 3 receives the cartridge from the powderman (facing inboard), and enters it seam sideways, and bottom first, to the full extent of his arm; 5 gives shot and wad to 3, who enters them; 4 receives the rammer from 6, with his right hand under and left over, and assisted by 3, forces all home together, hand over hand, giving them two smart blows; they then quit the rammer, while 1 pricks the cartridge to ascertain if it is home, and gives notice to 4. 3 faces the ship's side; 4 springs the rammer, and lays it quietly across the breeching; 6 returns it; 3 and 4 step out together; 5 and 6 throw the side-tackle falls to the rear.

NOTE.—When "extreme trained to the left," 3 receives and enters the cartridge, 5 enters shot and wad, left rear-man attends sponge and rammer if kept overhead.

When "extreme trained to the right," the powderman comes up to the right of the gun; 4 receives and enters the cartridge; 5 places shot and wad on the gun for 6, who enters them; 8 attends sponge and rammer instead of 6. With 8-inch guns, Nos. 5 and 6 stand inside the breeching when loading.

In "double-shotting," 7 places the [illegible] on the gun.

If ordered to "Load with shell," the [illegible] of the [illegible] left rear-man, in the rear of the gun, amidships [illegible] with the fuze [illegible] 5 gives it to 3, who enters it, takes off the [illegible] that the fuze has been uncapped); 4 immediately [illegible] head, and assisted by 3, [illegible] shell and [illegible] loading should hold the [illegible] ready to [illegible] fuze should be ignited.

With 10-inch guns, 5 [illegible] will enter it by the box-han[illegible]

The cap is never to be taken off until the shell has been entered a short way into the bore; with high elevations, or when rolling, care should be taken that the shell does not slip down the bore, before this is done.

The fuzes of percussion-shells have no caps; these shells are brought up as before, entered fuze outwards, and rammed home as a shot.

Although guns should never remain loaded without a junk-wad between the cartridge and shot, it is unnecessary, when in action, to put in a wad after the cartridge; but a grummet-wad is always to be put in (with the crossing outwards) after the shot. Guns should never remain loaded longer than necessary, as the cartridge quickly deteriorates from damp.—If the gun is to be double-shotted, no wad is to be placed between them: when loading with round and case, or grape, the round-shot is to be put in first. The men are to be frequently exercised in loading with a dumb cartridge, shot, and wad.

Run out. All the Nos. man the side-tackles, except the right rear-man, who attends the train-tackle, and 1, who keeps the gun bearing on the object. When the gun is out, 5 and 6 coil down the side-tackle falls.

Note.—Should there be much motion, or the ship have much heel, the right rear-man, when working lee-guns, is to reeve the end of the train-tackle fall up through the train-tackle bolt in the deck, that he may be better able to check the gun from going out too violently; the left rear-man is to assist him when necessary. When the rear-trucks are off, the handspikemen should work with their handspikes under the arm of the axletree, to diminish the friction in running out.

Lock Practice.

Miss-fire. No. 2 half-cocks the lock; 1 comes up to the left of the gun clear of the rear axletree, makes up the trigger-line, lays it across the neck-ring, replaces the tube, and retires.

Burnt priming. No. 2 half-cocks the lock; 1 comes up to the left of the gun clear of the rear axletree, makes up the trigger-line, lays it across the neck-ring, examines the vent with the priming-wire, if foul, asks 2 for the vent-bit; the vent being clear, primes, and retires.

Shift trigger-lines. No. 2 half-cocks the lock; 1 comes up to the rear of the gun, takes out the tube, puts in a vent-plug, and, assisted by 2, shifts the trigger-line, primes, and retires.

Note.—If the trigger-line is to be shifted whilst the gun is being loaded, 2 shifts the trigger-line, and 1 serves the vent.

Shift locks. No. 2 half-cocks the lock; 1 comes up to the rear of the gun, makes up the trigger-line, lays it across the neck-ring, takes out the tub puts in a vent-plug, and, assisted by 2, s the lock, primes, and retires.

CEASE FIRING. No. 2 half-cocks the lock; 1 comes up to the rear of the gun, makes up the trigger-line, lays it across the neck-ring, takes out the tube and puts in a vent-plug.

NOTE.—Whenever this order is given, the guns if in are to be loaded and run out, unless ordered to the contrary.

"RUN IN."

SEARCH THE GUNS. The guns are to be wormed, sponged, and the vents bored down. The captains of the guns then give the word "Sponge again," holding their faces over the vents to ascertain that the air passes freely through them.

"SQUARE IN THE PORTS, RUN OUT."

Securing Guns.

OUT-BOARD.

SECURE THE GUN. No. 1 gives the word "Elevate," takes out the coin, and places the parts of the train-tackle under the cascable; 2 unhooks and overhauls the train-tackle; 3 and 4 put in the tompion, haul up the half-port, secure the side-tackles, and hook the train-tackle to the side-tackle bolts; 5 and 6 seize the breeching and assist in securing the tackles; stationary powderman returns the powder, and the extra one swabs the deck.

NOTE.—In securing, the breeching (if left-handed rope) is to be rendered through to the *right* of the gun; and the reverse if right-handed rope.

IN-BOARD.

SECURE THE GUN. No. 1 gives the word "Run in," then "Elevate," takes out the coin, throws back depression chock, and sees the gun laid square between the housing-bolts; 2 prepares the train-tackle and superintends bousing taut the frappings under 1; 3 and 4 put in the tompion and pass the muzzle-lashing; 5 and 6 render the breeching through the clinch, clap on the quarter-seizings, pass the frapping-turns ready for bousing, and prepare the side-tackles for frapping and securing; stationary powderman returns the powder, and the extra one swabs the deck.

NOTE.—No. 1 attends the inner block of the side-tackle and hooks on to the lashings; 7 overhauls it; 2 takes the large side [illegible] of the gun, and remains there to pass the ends of the lashings.

Method of passing the Lashings.

The muzzle-lashing is spliced into the after eye-bolt, four turns are passed from in, out, towards the ship's side, and a half-hitch taken round all the parts close up to the after eye-bolts ; the end is expended in frapping-turns down towards the muzzle, boused well taut, and stopped.

The breast-frapping is rove with a running eye round the after-part of the breeching, about 18 inches from the horns of the carriage; three turns are passed over the breeching forward, and under aft, towards the carriage, and boused well taut; then three turns over the gun, hauled hand taut and frapped, commencing close up to the gun; the end is expended in frapping-turns, down towards the breeching, boused well taut, and stopped.

The side-tackles are hooked to the side-loops in the carriage and the side-tackle bolts in the ship's side, hauled hand taut and hitched to their own parts, about a foot from the horns; the foremost fall is passed under the after side-tackle, and over the foremost one towards the ship's side, and boused well taut; the after fall is passed towards the carriage, hauled hand taut, and stopped.

The train-tackle is hooked on the foremost side of the gun, to the rear loop in the carriage, and to the side-tackle bolt in the ship's side, hauled hand taut, hitched, and the fall passed as the after side-tackle; the coin is placed between the parts of the frappings.

NOTE.—The apron is immediately put on by 1, as the lock is very liable to be injured by the train-tackle fall in securing. The tompion is not to be put in till the guns are laid in the housing position, and no man is to pass his arm over the muzzle of the gun till it is so placed. No. 1 is answerable that the gun is not let down into the housing position, while there is risk to any man, from being between its muzzle and the upper port-sill.

Great care must be taken that at least 2 inches of the faces of the muzzles of all guns house against the ship's side.

When the gun is secured, the Captain of the gun must examine all the implements, and report particularly to his Officer the state in which he finds them. That Officer is to cause every deficiency to be made good, and see that all the implements are carefully replaced in the different situations, ready in all respects for further use, when wanted.

N.B.—During the Second Instruction the men should be put through the 1st part of the Pointing Practice, and should also fire from a boat in motion.

THIRD INSTRUCTION.

REMARKS ON THE DIFFERENT FIRINGS.

Independent Firing.

By this is meant, firing the guns independently of each each Captain of a gun seizing the most favourable oppor-

This firing should always be used in Action (unless ordered to the contrary) whenever the object is visible, the smoke from one gun not greatly impeding the firing of another.

(See Detail for Independent Firing.)

Firing in Succession.

By this is meant, firing one gun after another in regular order, commencing from the foremost or after gun, according as the wind is blowing from *aft* or *forward*. This firing may be used with advantage, whenever a *continuous steady fire* is desired, as the smoke from one gun will not impede the firing of the next.

Quick Firing.

By this is meant, rapid independent firing, the tangent-sight not being raised. This firing should be used when close alongside an enemy, as then but little pointing would be required.

(See Detail for Quick Firing.)

Broadside and Divisional Firing.

By this is meant, firing the whole broadside or a division of guns simultaneously, by order. Broadside firing should be used when the smoke hangs about the ship for some time, and Divisional firing when the smoke clears away at shorter intervals, as then the fire would be more continuous. Broadside or divisional firing could also be used with greater advantage within a moderate distance against stone forts than independent firing, from the increased concussion caused by a number of shot striking at the same moment. In divisional firing, each deck, or the half of each deck, should be considered as a division according to circumstances.

(See 'Guide on Drilling Quarters,' page 97, as to the mode of conducting this firing.)

Concentrated Firing.

By this is meant, firing guns previously laid by the aid of lines or battens, so that the shot may cross each other at a given distance. This firing would be most effective in case of smoke or darkness, the object being visible from the upper deck or mast-head, and may be used at distances within and beyond the point of concentration, but the latter [illegible] exceed double [illegible] at which the shot cross.

DETAILS.

In Independent Firing.

No. 1 raises the tangent-sight according to the charge and distance named, lays the gun for the object, and gives the word "Ready" as soon as the elevation is correct, keeping the direction on with the handspikes, and taking care not to fire till the side-tackle falls are clear.

NOTE.—The gun is to be sponged and loaded without orders, and when the distance remains the same, the bed and coin should be chalked, after the gun is once carefully laid; by this means time will be saved in firing, as 2 will replace the coin to the chalk-mark whilst the gun is being loaded, and No. 1 will fire when the motion brings the object on with the points of the sights; but if the heel or distance should alter, the gun must be relaid by sight.

In action or exercise the guns are to be *wormed* every 4th round, and *invariably* to be loaded and run out after the last round, unless ordered to the contrary.

In Quick Firing.

No. 1 sees the gun laid horizontal and run out for the object, primes as the gun goes out, taking care not to cock the lock till the muzzle is clear of the port-sill, and not to fire till the side-tackle falls are out of hand.

The only words of commands to be given are, "Run in," "Run out," and "Ready." 2 chalks the bed and coin, and the guns are relaid whilst loading.

NOTE.—But if the object is before or abaft the beam, and the gun cannot readily be run out for the object, No. 1 is to give the word "Point," in order to get the direction on, before giving the word "Ready," falling back with the lock half-cocked.

The gun is to be sponged and loaded without waiting for orders, and the rear Nos. are to coil the side-tackle falls in their hands as the gun goes out.

LOWER-DECK EXERCISE.

Before commencing, the guns should be run in, and the ports lowered.

In Lower-Deck Exercise, No. 1 sees the gun laid horizontal and square in the port, primes as the gun goes out, taking care not to cock the lock till the word "Trice up," and not to fire till the port is clear of the explosion; 2 attends the port-tackle fall; 3 and 4 shift the side-tackles to the quarter-bolts.

At the word "Trice up," 2, 7, 8, 9, and 10 haul up the port, 3 and 4 bear it out with the handspikes. The side-tackle falls are kept in hand till the word "Ready," the rear Nos. keeping the ends coiled up; when the gun is in, *both* rear-men who attend, hitch the train-tackle. 2 chalks the bed and coin, and the guns are relaid whilst in (*first for the scuttle*, and *after the gun is loaded, horizontal*).

NOTE.—As "Lower-Deck Exercise" is meant for working guns in a sea with much motion, the rear-trucks should be taken off and the side-tackles hooked to the quarter-bolts to steady and train the guns. When the gun has recoiled, and the port is lowered, 1 trains the gun to admit of the staff-sponge being used through the scuttle. If the order is given "With staff-sponge, Sponge," 3 (at the caution "*With staff-sponge*") opens the scuttle, taking care to close it when the gun is loaded. As soon as the gun is relaid, No. 1 gives the word "Haul taut," when the gun is to be run out till the muzzle is close to the port; he then waits for the order "Trice up," and fires when the port is clear, without running the gun *further out*. 9 and 10 assist with their handspikes in running out, then pass them to 3 and 4, and man the port-tackle fall.

When the rope-sponge is used, 6 holds it, with the sponge-head in his *right* hand, and rammer-head in his *left*. On the sponge being withdrawn by 4, 6 passes the rammer-head on his left, and behind him, so as to hold the rammer-head in his *right* hand, and sponge-head in his *left*, ready for 4 to use the rammer in loading. *Both* rear-men are to attend the train-tackle, and the end of the fall is to be rove up through the train-tackle bolt on the opposite side of the deck when practicable.

When clearing for action, "Lower-Deck Exercise," the gun is to be run into a taut breeching, and the train-tackle hitched, before elevating.

The above exercise is only applicable to close action in a sea way.

Arrangement for Fighting both Sides.

When necessary to fight both sides, the whole of the guns are to be manned and worked with "Half crews" (as in Casting loose); but if from casualities or other causes this is not practicable, the Right guns should be left *in* after the first round, and the Left guns manned and worked with whole crews.

NOTE.—In action or exercise, the working with "Half crews" should not be continued beyond 3 or 4 rounds, as after this, owing to casualties and the fatigue of working on this plan, the firing would be more efficiently kept up by working every other gun.

Securing a Gun for Non-Recoil.

In close action, and when the crews are so reduced as not to be able to work the guns in the usual manner, it may sometimes be advantageous to fire the guns secured as follows:—

Run the gun out so as to bring the muzzle over the centre of the lower port-sill, and shorten the breeching up to this position; then run the gun taut in, and hitch the train-tackle, take off the rear-trucks, pass the breast frapping round the breeching as taut as possible, and chock the fore-trucks before all. The side-tackles are not required.

The muzzle of the gun, when in its proper position for firing, should be about flush with the inner part of the port, the gun is then laid horizontal and fired. After every three or four rounds, the train-tackle should be re-secured, or the breast-frapping re-passed, so as to keep the breeching perfectly taut.

It has been proved that a gun may be loaded and fired on this plan with reduced charges and single shot without injury to the breeching, and that three or four men, for the heaviest description of guns, are sufficient.

Shifting Breechings.

SHIFT BREECHINGS. Nos. 9 and 10 hitch the side-tackles; right rear-man the train-tackle; 3 and 5 (or 4 and 6) take off the seizing, cast off the hitch, open the clinch, and unreeve the breeching; 2 and 11 bring the spare breeching up to the side of the port, opposite the old clinch, reeve it through the breeching-ring, through the clinch, and point the end through the neck-ring; handspikemen and rear-men haul it through. 1 sees the breeching properly secured, and takes care that his gun is so placed as not to interfere with the training of adjacent guns.

SPONGE, LOAD, AND SHIFT BREECHINGS. Nos. 3, 4, 5, and 6 sponge and load, and 7, 8, 9, and 10 take their duties in shifting breechings, whilst so employed.

NOTE.—The breechings are to be rove with an *inside* clinch from right to left, if with a *left*-handed rope, and the reverse with a *right*-handed rope. As soon as the end of the spare breeching is rove through the opposite ring-bolt, No. 1 gives the word "Run out," to bring the muzzle over the inner part of the sweep-piece, so that 3 or 4 may form the hitch; when the hitch is formed, No. 1 again gives the word "Run out," and lays the gun for the object, taking care not to fire till 3 or 4 indicate that the seizing is secured.

Extreme Training.

EXTREME TRAIN, MUZZLE RIGHT (OR LEFT). Nos. 3 and 5 (or 4 and 6) shift the side-tackle to the bolt of the next port; 6 keeps sponge, rammer, and worm in a line with the gun, right rear-man the train tackle, handspikemen assist with their handspikes; the rest of the Nos., except 3 or 4, man the right or left side-tackle.

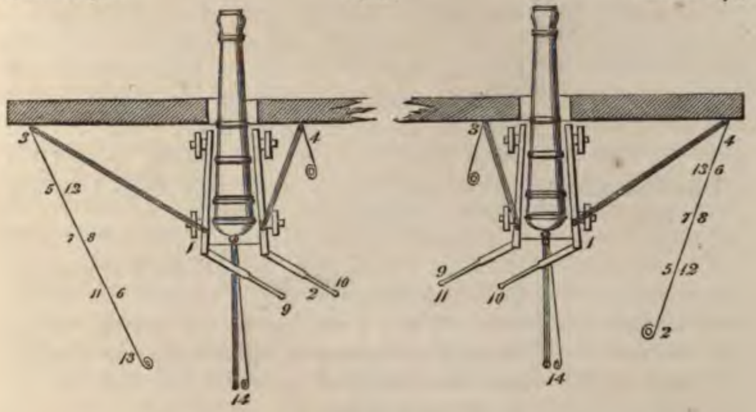
NOTE.—No. 3 or 4 should give a signal with the hand when the side-tackle is hooked.

SQUARE THE GUN. Nos. 3 and 5 (or 4 and 6) shift the side-tackle to the quarter bolt; 6 keeps sponge, rammer, and worm in a line with the gun, right rearman the train-tackle, handspikemen assist with their handspikes; the rest of the Nos., except 3 or 4, man the right or left side-tackle; 1 looks out till the dispart is on with the centre of the port, and gives the word "Well," "Muzzle right" (or left).

NOTE.—In squaring the gun, 1 is to take up a position *abreast* of the port, to enable him to bring the dispart on with the centre of it. In extreme training or squaring the gun, No. 1 renders the breeching about 18 inches through the span and neck-ring; the left rear-man or No. 2 coils up the side-tackle fall, and at the word "Well" gives it to 7 or 8, who puts it on the deck after the side-tackle is shifted back; the gun is then relaid, if necessary.

Stations for Extreme Training.

Fig. 66.



INSTRUCTIONS FOR A SIMULTANEOUS CONCENTRATED FIRE.

"*The lines should always be hooked on at the ports directly after casting loose.*"

The bearing, heel, and distance, having been given from the upper deck, the officers of the different divisions of guns will name the elevation or depression to be given by marked coin (allowing for the distance and heel), together with the bearing, and then give the order "Lay the guns;" on which the Nos. 1 are to give the orders for training, holding the lines *immediately under* the marks overhead, denoting the bearing, and the guns are to be trained till the sights are *parallel* to the lines: Nos. 1 then give the word "Elevate," and direct 2 to give the guns the required elevation or depression, making the lines fast to hooks overhead; they then resume the trigger-lines, and wait steadily for the orders "Ready," "Fire," which are to be given by the Officer attending the Director.

NOTE.—A person should be stationed at the tube on the upper and gun decks, to report when the guns are *laid*, and to repeat the orders to the quarters. (See Departing Instruction on Concentrating, and the use of Moorsom's Director.)

The above method of laying guns could be used with advantage for directing [illegible] of *single* guns, so long as the *distance* is known and the ship remains steady [illegible] bearing; the only orders required from the upper [illegible] as the officers of the different divisions would [illegible] elevation or depression and bearing as before; the [illegible] of each other.

Or when rolling past the centre, the Nos. 1, if [illegible] judge when the ship came on an even keel and [illegible] be attempted at short distances.

Dismounting and Mounting.

DISMOUNT THE GUN. No. 1 gives the word "Run in," then "Elevate," takes out the coin, throws back depression-chock, and sees the gun laid square between the housing-bolts; 2 prepares the train-tackle, hooks it to the runner, and lowers the gun; 3 and 4 pass the muzzle-lashing; 7 and 8 take out the keys, throw back the cap-squares, unhook the side-tackles, and see the carriage clear; rear-men provide and hook the runner.

When the muzzle-lashing is passed, 1 gives the word "Dismount," and all the Nos. man the train-tackle, except 1, 3, 4, and the handspikemen; 3 and 4 remain at the muzzle-lashing until all parts bear an equal strain; handspikemen assist until of no further use, and then go to the train-tackle.

MOUNT THE GUN. Everything will be replaced by the same Nos.

NOTE.—When ordered to "*Dismount,*" No. 1 makes up the trigger-line round the lock, attends the coin to assist the handspikemen, leaves it on the bed ready for mounting, and when the gun is high enough, gives the order "Well! Run the carriage back," he then replaces the depression-chock.

Securing with a Double Breeching.

The spare breeching is rove through the spare ringbolt on the side of the port, opposite the clinch of the standing breeching; the end passed up between the side-tackle and bracket on one side, then under the cascable, and down between the side-tackle and bracket on the other side, and secured to the other spare ringbolt, taking the after side-tackle fall for a frapping, and the train-tackle to bouse it taut; the train-tackle is then hooked as in securing inboard, and the fall passed round the after part of the spare breeching, instead of round the after side-tackle.

Securing with a Stout Hawser.

One end is lashed abaft to one of the spare ringbolts in the [illegible] side, the bight passed under the cascables of all the guns, set [illegible] hand-taut forward and lashed; the train-tackles are hooked [illegible] quarter-bolts between every two guns, and to a strop roun hawser; the falls manned and boused taut together, the ends pended round the hawser and through the quarter-bolts.

INSTRUCTIONS FOR THROWING LOWER-DECK GUNS OVERBOARD, WITH 20 MEN TO EACH, OR UPWARDS.

No. 1 provides a short strop, to be placed under the neck of the gun; 9, 10, 11, and 12, two capstan-bars, and attend them; 3 and 4 attend port lanyards. When cast loose, lay the gun horizontal, and ease it out, so that the muzzle may be just clear of the inside of the port.—Two side-tackles are to be hooked to the strop under the neck, and to the housing-bolts, hauled well taut, and kept manned; 7 and 8 throw back the cap-squares, and then, with 2, man the port-tackle falls. A train-tackle is to be hooked to each rear loop, and to the train-tackle-bolt in the deck, hauled taut, and attended by 17, 18, 19, and 20. The breeching is to be unrove. When ready, 1 looks out for the roll, and gives the order "Heave and haul"; when the side-tackles are hauled upon, the capstan-bars hove upon, and the carriage eased out by the train-tackles; the port being hauled up at the same time. When the gun is clear, the port is to be barred in. The capstan-bars are used with the small ends under the gun.

NOTE.—In case of a ship getting on shore, and it being necessary to throw the guns overboard to lighten her, the breechings could be used for weighing them, by securing the clinch to the button, and lashing the breeching to the chase, using the breast-frapping as a buoy-rope, with a truck for a buoy.

ORGANIZATION OF SEAMEN FOR LANDING TO ACT WITH TROOPS ON SHORE.[a]

536. The following rules are extracted from the 'Instructions for the exercise of Small-arms, Field-pieces,' &c., set forth by the Admiralty for the use of Her Majesty's ships.

As the efficiency of Seamen, when landed in any considerable number, depends most materially upon a proper system of organization and training previous to their being landed, and without which they are inefficient, the following system is to be strictly observed in all Her Majesty's Ships:—

1st. The Small-arm men are to be formed into Companies of 80 men, with 3 Petty Officers; each Company to be commanded by a Lieutenant, with 2 Mates or Midshipmen.

2. Every Ship of the Line is to have two Com[illegible] properly drilled and trained for landing, Frigates one Comp[illegible] Sloops half a Company.

3rd. The Men to be [illegible] Bayon[illegible]

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[a] The Light Infantry and Battalio[illegible] upon those used in the army.

pany is to be told off into Subdivisions and Sections, and to be exercised in such movements as are absolutely necessary to manœuvre a Company, by the Officers who are appointed to command them.

4th. The Companies when landed are to fall in and number from the right, according to the seniority of the Captains of their respective Ships, Flag Ships being No. 1 and 2, so that they at once will fall into their places according to their numbers when landed: each Ship of the Line is to be prepared to land with their Small-arm men, 6 Pioneers, viz., 2 with a saw and axe each, 2 with a pickaxe and spade each, 2 with a small crowbar and sledgehammer; Frigates will send 3, and Sloops 1, the tools to be slung on the men's backs.

5th. When landed for service, each man is to have 60 rounds of ammunition, each Ship is to send a Bugler with her men if she has one; he is to be able to sound the "Assembly," the "Retreat," "Commence Firing," "Cease Firing," "Close," and "Extend," which sounds the men are to be accustomed to on board.

6th If the men are likely to be on shore during the night, they should have a havresack and blanket slung across their shoulders.

7th. As muskets are apt to miss fire the first time, if not properly clean, the greatest precaution is to be taken to see that the nipple is perfectly clear before loading; first, by blowing down the barrel and placing the finger to feel if the air passes through the nipple, and afterwards by snapping a cap off to dry up any oil or moisture that may be in the barrel.

8th. When Field-pieces are landed, the guns are to be brigaded together according to their calibre, numbering from the right in the same manner as a Company.

9th. Line-of-battle Ships should send an Armourer with cleaning-rods, screwdrivers, spare nipples, &c.

10th. When firing in close order the front rank should fire *kneeling*, as owing to the shortness of muskets accidents are frequently taking place.

Scale of Companies to be sent from each Ship.

Line-of-Battle Ships, 2 Companies of 80 men each.
Frigates .. .. .. 1 Company ,, ,,
Sloops .. .. .. ½ ,, ,, ,,
10 Companies to form a Battalion.

INSTRUCTIONS FOR LANDING SEAMEN, MARINES, AND FIELD-PIECES, FOR EXERCISE OR SERVICE ON SHORE.

1. The boats should be formed in divisions according to t
niority of the Captains of their respective ships, numberi

No. 1 on the right. The Seamen and Marines should be told off in Companies previous to leaving their ships, and on landing they will form immediately in the same order.

The Field-howitzers should be mounted as Boats'-guns, the Field-carriages and limbers being stowed in the bottom of the boat. The crew should be told off to their respective duties for landing gun and limber, 9 men being stationed to the gun and the remainder to the limber. On the boat touching the beach, the Gun Nos. should immediately jump out, mount the carriage, and run it up to the bows to receive the gun, which should be hoisted out by small sheers, or by a tackle hooked to a strop half way up the mast; but in the case of surf, the gun should be thrown overboard, and hauled on the shore by a hawser or drag-ropes. The limber and limber-boxes should be passed out by hand; when landed, the gun is to be limbered up, or brought at once into action, according to circumstances.

2. Each division of boats should have a distinguishing flag. Launches will carry two scaling-ladders, intrenching tools, &c.; barges and pinnaces, one ladder each.

3. The boats will always land a boat's-length apart. Before leaving the ships, four boat-keepers for each gunboat, and two for the others, with an officer in charge of each division of boats, are to be told off, and are on no account to leave them.

A fast-pulling boat with Medical Officers will attend in rear of the line.

4. Should the distance from the point of landing be considerable, the boats of each division, in tow of each other, commencing with the lightest boats, will pull in,—the leading boat of each division abreast, leaving space for the whole to form line abreast when ordered; on approaching the beach, the tow-ropes should be cast off, and the gunboats dress up in line, ready to open fire if necessary to clear the beach. The Officer in command will commence firing from the gunboats when he thinks fit, but no musketry is to be fired without orders.

5. When the Commanding Officer perceives the beach to be cleared (or when he considers it proper), he will order "Cease Firing," and direct the boats with Skirmishers and light Field-pieces to pull in and land as quickly as possible. On landing, they will immediately extend, but not open fire till the Officer commanding them sounds "Commence Firing." The Main body then pull steadily in and land, forming line in rear of the Covering party. The Field-pieces form on the flanks of their own Divisions, or in Batteries, according to orders. The scaling-ladders remain in rear until required for service. The Main body being formed, they will

advance in line or column according to circumstances, preceded by the Skirmishers, firing if necessary.

6. After landing, the boats should be hauled off into deep water to prevent a surprise, and those with guns might be employed on the flanks, to cover the advance or retreat when practicable.

7. Should the boats be employed for the disembarkation of troops, the same arrangement as to the divisions of boats should remain. It will then be desirable that every boat should carry a flag similar to that of the Commanding Officer of its Division, and when in large numbers the boats should also be painted according to the colours of the flags, that the troops may readily know their own boats.

On these occasions the launches, barges, and pinnaces will form a front line so as to clear the beach, the light boats will tow troop, paddle-box boats, &c., and be ready to succour any boats that may be damaged by the enemy's fire.

8. The re-embarkation should be conducted on similar principles to the disembarkation; the Skirmishers and Light Field-guns extending in rear of the line, which will then "pass by fours from the right of Companies to the rear," through the intervals, forming line again if necessary to support the Skirmishers, who will retire firing, and reform in rear of the line; they are again extended, and so on until the Main body have embarked. The Covering party then embark under cover of the boats' guns.

N.B. The following Boatswain's Calls will be found useful amongst Seamen in the event of there being no Bugler.

"Extend,".............	"Pipe down or Veer Cable."
"Close,"	"Stand by Hammocks."
"Commence Firing,"....	"Lower."
"Cease Firing,".........	"Belay."
"Assembly,"	"Pipe to dinner."

ON MANNING AND ARMING BOATS.

537. The following is a list of Stores that are required for Boats when called away "manned and armed," with the number of Officers and Men required for the undermentioned Boats:—

Launches pulling 20 oars; barges, pinnaces, and paddle-box boats pulling 14 oars; cutters pulling 10 oars, and gigs 4 oars.

Boats'-crews to be armed with cutlass and rifle; bowmen, coxswains, carpenters, and gunners with cutlass and pistol.

Nature of Stores, &c.	Launches.	Barges, Pinnaces, Paddle-Box.	Cutters.	Gigs.
Crew required in the Boat	21	15	11	4
Gunner's Mates, or Seamen Gunners	2	1	..	..
Carpenter's Crew	1	1	..	..
Marines	14	8	4	2
Nature of Guns	24-pr. H^{r}	12-pr. H^{r}	..	..
Priming-Wire and Tube-Box for each Gun	1	1	..	..
Spare Trigger-Line, Vent-Bit, and Spare Lock or Hammer	1	1	..	..
Spare Breeching	1	1	..	..
Sponge, Rammer, and Worm	1	1	..	..
Cartridges	48	48	..	..
Round Shot	24	24	..	..
Spherical Case filled	12	12	..	..
Common Shell filled	12	12	..	..
Common Case	6	6	..	..
Wood Fuzes	30	30	..	..
Set of Instruments for fitting Fuzes	1	1	..	..
Tubes for each Gun	80	80	..	..
Range-Table	1	1	..	..
Muskets for Blue Jackets	18	12	8	4
Ammunition for each Musket	60	60	60	60
Percussion-Caps	2,500	1,500	1,000	500
Revolver Pistols	6	5	3	3
Cartridges for each Pistol	50	50	50	50
Caps for Pistols	400	350	200	200
Pikes	4	4	4	2
Tomahawks	4	4	2	1
Cutlasses	24	17	11	4
Blue Lights	4	2	2	2
Rockets	4	4	2	2
Water Baricoes, full	10—9 gal.	6—9 gal.	6—7 gal.	3—7 gal.
Provision Baricoes	4	2	2	1
No. of days' Provisions, or according to circumstances	2	2	2	2

Carpenter's Bag, containing

Fearnought and grease, nails, set of tools, strips of copper for oars, corks for stopping musket-holes, and other materials for stopping leaks.

Boatswain's Bag, containing

Lead and line, cable-punches and cold chisels, canvas, palm, needle and twine, rounding, spunyarn, and marlinespike.

Boats'-compass, and anchor and cable in each boat; masts and sails, 2 spare oars, spyglass, signal-book, ensign and answering-pendant; two tourniquets, a saw, axe, and sheet-lead, bucket and piggin, lantern and candles, and slow-match.

NOTE.—When it is considered desirable, more ammunition than is here laid down should be sent away in each boat, the powder being stowed in half cases.

ARMSTRONG GUN DRILL.

538. The following is a near approximation to what the Exercise with the Armstrong Gun *will be*, as, the mounting not being yet fully decided on, modifications will necessarily occur:—

The crew are assembled in the following order:—

1, the Captain, in rear of the gun, facing the ship's side.
2 on the right of 1, standing quarter-face to the gun.
3 on the left of 1, standing quarter-face to the gun.
4 in rear of 2, 5 in rear of 3, and so on.

Providing Stores, &c.

On coming to the gun, No. 1 looks through the gun to ascertain if the grooves are free from dirt or rust, sees that the copper rings in rear of chamber and in front of vent-piece present a smooth even surface, and provides and fixes tangent-scale.

2 provides vent-piece, tube-box, and spare trigger-line.
3 provides sponge, rammer, and water-bucket.
4 provides spare breeching and fuze-wrench.
5 and 6 provide shot and handspikes.

The following exercise is detailed for a gun mounted on a "top and under" carriage.

NOTE.—The "top and under" carriage is the same as that at present supplied with the brass howitzers for boats, with holes cut in the brackets for the breeching to reeve through.

Exercise with 6 *Men.*

No. 1, the Captain, commands, screws and unscrews the breech, attends tangent-sight, primes, points, and fires.

2 attends vent-piece, elevating-screw, and trigger-line, and hooks on tube.

3 runs out, trains, sponges, and rams home.

4 runs out, trains, sponges, enters shot or shell and cartridge, and sets the fuze under the direction of No. 1.

5 runs out, and attends handspike.

6 runs out, gives shot or shell to 4, and attends handspike.

Powderman, supplies 4 with cartridge.

These Nos. will be increased as necessary according to the weight of the gun, and their duties will be modified by the manner of mounting it.

NOTE.—When necessary, No. 2 assists 1 with breech-lever, and 3 assists 2 with elevating-screw. With heavy guns the shot and shell are brought up on a bearer by the two rear Nos.

The exercise with 6 men to a 32-pounder Armstrong gun, mounted on the Armstrong carriage is the same, omitting the words "Runs out," and adding "attends compressors" to the duties of 5 and 6.

At the word—

With "Shot" (or "Shell"), "Load,"

No. 1 steps to the left of the breech, 2 cleans and primes the vent-piece, 3 takes up the sponge with the right hand over and left under, moistens it at the tank, forces it up the bore of the gun and withdraws it to the mark, draws it backwards and forwards two or three times and withdraws it, 1 looks through the bore to ascertain that it is clean, and gives the word—

"Shot" (or "Shell").

3 returns the sponge and picks up the rammer, 4 receives the shot from 6 and enters it, 3 forces it home with a hard blow, bringing the weight of his body on the rammer. No. 1, when he sees by the mark on the rammer-staff that the shot is home, gives the word—

"Cartridge."

4 enters the cartridge with the tie end first, 3 presses it against the shot, and 1 gives the word—

"Home."

3 springs the rammer and returns it, 2 drops the vent-piece into its place and hooks a tube on to trigger-line, 1 screws up the breech, giving two smart taps with the lever on the cams to harden the screw home.

At the word—

"Prime,"

1 places the tube in the vent, taking care that the loop of the trigger-line is over the half-cock cleat.

NOTE.—No. 2 carries the tube-box strapped round his waist.

At the word—

"Point,"

1 retires to the extent of the trigger-line, handspikemen pick up their handspikes, the rest of the Nos., except 2, man the side-tackles.

At the word—

"Elevate,"

1 gives the necessary orders to No. 2, who raises or depresses the breech by the elevating-screw.

At the word—

"Ready,"

2 cocks the lock with his left hand, the Nos. on the side-tackles see them clear and out of hand.

At the word—

"Fire,"

1 fires, springing up to the safety position on the left, closes up to the rear of the gun, makes up trigger-line and unscrews the breech, 2 takes out and cleans vent-piece.

At the word—

"Run out,"

All the Nos. man the side-tackles except 1, who keeps the gun bearing on the object; when the gun is out, 5 and 6 coil down the side-tackle falls.

NOTE.—The duties are arranged for the tangent-scale on the left of the gun, and half-cock cleat on the right.

Exercise with 16 *Men to an Armstrong Pivot-Gun, mounted on a common slide carriage, with holes cut in brackets for breeching.*

1, the Captain, commands, screws and unscrews the breech, attends tangent-sight, primes, points, and fires.

2 assists 1 with breech-lever, attends coin and trigger-line, hooks on tube, and attends train-whip and rear-bolt.

3 traverses, attends vent-piece and fighting-bolt.

4 traverses, assists to raise vent-piece and attends stop handspike.

5 traverses, sponges, enters shot or shell, and rams home.

6 traverses, sponges, enters shot or shell and cartridge, and rams home, and sets the fuze under direction of 1.

7 and 8 run out, attend traversing-tackles and shift side-tackles.

9 to 12 run out, and attend handspikes.

13 and 14 run out, traverse, and attend compressors.

15 runs out, traverses, and brings up shot or shell.

16 runs out, traverses, brings up shot or shell, and attends stop-handspike.

Stationary powderman gives cartridge to No. 6.

No. 6 is only to assist in ramming home shot or shell, the cartridge is forced home by 5 alone.

If an inside compressor is used, No. 8 attends it.

In this exercise it is intended to run out while the gun is being loaded.

15 and 16 will assist to run out as soon as shot or shell is placed in rear of gun, and 5 and 6 as soon as their duties in loading is complete.

ON THE RANGES OF THE ARMSTRONG GUNS.

539. At present no definite table of ranges can be given for any but the 12-pounder field-gun, as, with the exception of one or two, there have been no larger guns to take ranges with. It is expected, however, that soon there will be a good number, when the ranges will be ascertained for each description. In the mean time the following rule, which is of course merely an approximation to the truth, is considered by Sir Wm. Armstrong sufficiently accurate for all practical purposes:—

For every 10 yds., up to 500 yds., raise the tangent-sight 1′.

(Thus, 500 yds. will require 50′ elevation.)

From 500 to 1000 yds., each minute of elevation gives 17 yds. of additional range.

From 1000 to 3000 yds., each minute of elevation gives 6 yds. of additional range.

540. The following account of the mode practised in the French navy of passing up by hand, and through scuttles opened in the decks, the cartridge-cases for the supply of the ordnance in the several fighting-decks, and of returning the empty ones to the magazines, appears worthy of attention, and is therefore given in this place. The frames for receiving the cartridges are not placed in the scuttles until the crew are called to quarters, but are kept on the fighting-decks: the scuttle is, till then, closed with a tompion. The man below, placed on the orlop-deck, receives the cartridge-case from the magazine, and keeps it in readiness to place it in the frame above, as soon as the preceding cartridge is taken out. The man on the middle or main deck, according as the ship may be a three or a two decker, is, in like manner, always prepared to slip a case into the frame over his head for the supply of the main deck, or upper deck. The man above is represented as putting an empty case into the canvas hose, down which they slide through all the decks to the orlop. The process shown in fig. 67, overleaf, is for the supply of the upper deck and for the return [illegible] cartridge-cases from it. Each [illegible] plied in lik[illegible] by a separate arrangement, and [illegible] ships of all classes.

Fig. 67.

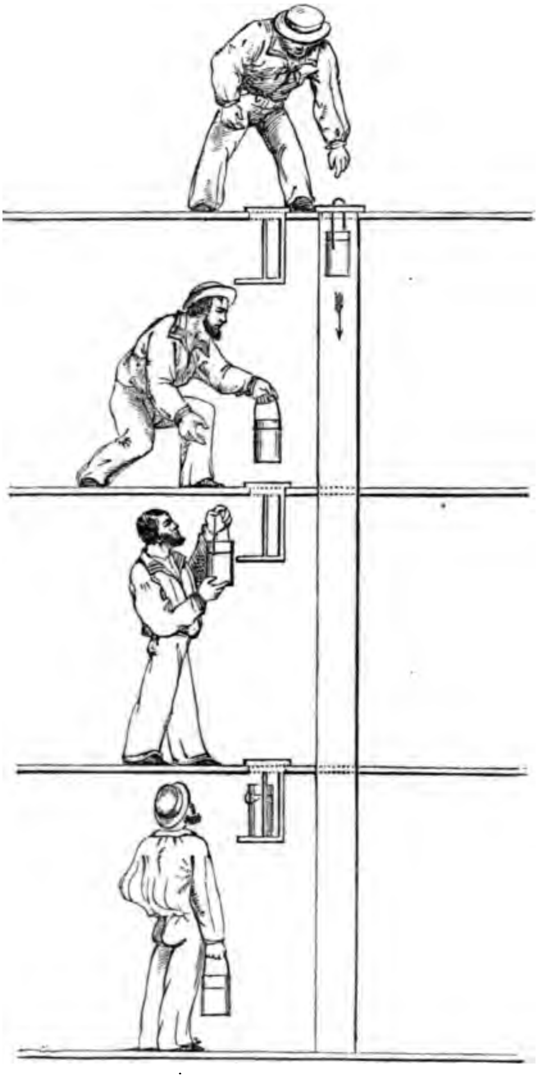

Illustration of the French mode of handing up Cartridges for the supply of the Batteries on the Decks of a first-rate Ship, and of returning the empty Cartridge-Cases to the Orlop.

SECTION VI.—ON GUNPOWDER AND GUN-COTTON.

541. Great errors in the practice of gunnery arise from those diminutions in the strength of powder, which invariably result from any absorption of moisture. Naval ammunition, being particularly liable to be thus injured, should be protected with special care and precaution from the influence of those pernicious damps to which it is continually exposed.

The only sure way of discovering whether a ship's magazine be damp or not is to observe the indications of an hygrometer. In default of a proper instrument of this kind, soak a sponge in a solution of salt of tartar, or common salt and water, and then let the sponge be well dried and weighed; on placing it in the magazine, if the latter be damp, the sponge will become heavier.

542. The most effectual method of protecting gunpowder from damp is to keep it in close vessels with air-tight covers; copper cases have accordingly been provided for this important purpose; and all gunpowder, whether in bulk or made up in flannel cartridges, is stowed in metal-lined cases or barrels, each case containing 120 lbs., and each barrel 90 lbs. The top is removed by means of a key, and the bung-hole underneath is made air-tight, with a tubing composed of beeswax and tallow. No expense should be spared in providing a supply of these vessels sufficient for a state of war; for so long as gunpowder is exposed to suffer great and unknown losses of strength, all attempts to attain much accuracy in practice, will, in cases of protracted service, be defeated.

543. No degree of care, however, can altogether preserve naval ammunition from receiving some degree of injury by exposure to marine damps; because a quantity sufficient for immediate use must always be kept ready for serving out, and consequently unpacked from the close vessels; and in the exigencies of service in remote regions, ammunition of doubtful quality may be procured from stations which may not have been recently supplied; or it may be necessary to use powder obtained from the capture of an enemy's magazines or vessels. It would appear, therefore, to be desirable that vessels, sent on distant and protracted service, should be provided with means by which to ascertain the condition and strength of their

ammunition; otherwise ships stored abroad, or that may have been long at sea without having their powder examined and tried by competent persons at ordnance stations, may be exposed to go into action with ammunition, apparently in good condition, but so deteriorated in strength as to produce very disastrous consequences. This, it may fairly be suspected, has very frequently occurred; perhaps much more frequently and seriously than we are aware of. It must, indeed, have been from such circumstances, that, at different times, an inferior degree of strength has, without reason, been ascribed to English powder.

544. If the condition and strength of naval ammunition were to be ascertained by actual experiment, from time to time, by the proper authorities in the ship to which it belongs, commanders would no longer be liable to make the mortifying discovery of the weakness of their ammunition in the important moment of service-practice. Provided with the means of doing this previously, officers would either be enabled to report the damaged or unserviceable state of their gunpowder; or, knowing its condition, endeavour to procure a supply of better quality, if their own could not be restored to serviceable efficiency by drying. It is requisite, therefore, that naval officers, and particularly master-gunners of ships, should be qualified to judge correctly of the condition of their gunpowder by inspection, and be taught to conduct those experiments by which its strength may be ascertained. For these important reasons, instruction on this subject is considered indispensable in the course of training established at the depôts of naval ammunition.

545. The only infallible test of the goodness of gunpowder is experiment; but there are certain appearances and indications by which an estimate of its quality may be formed.

Gunpowder should be of uniform colour, approaching to that of slâte. The particles should be perfectly granulated, free from cohesion, and should admit of being readily poured from one vessel into another; if otherwise, it may be concluded, either that the powder has been imperfectly glazed, or that it is damp. Gunpowder should be devoid of smell: if it have a disagreeable odour, it may arise from a practice which the author believes is not uncommon—that of heating the nitre excessively, for the purpose of drying it the more effectually. By this process a portion of the nitre may be decomposed; if so, potash,[a] instead of nitrate of potash, will form a part of the powder. Nitrate of potash, it is true, must be very highly heated in order to produce potash; but when over-heated in the process of fusion, too large a portion of nitrate is converted into potash, and this last, being very deliquescent, is not so efficient as undecomposed nitre. To ascertain whether the nitre has been decomposed to the degree of evolving potash, dissolve some of the powder in pure, or rain water, and add a solution of silver to that of the powder. If a black precipitate be formed, it may be concluded that sulphuret of potash exists in the powder.

It is possible, however, that the nitre may have been partly decomposed by having been over-heated, and consequently that the powder will be liable to become damp, from the deliquescent nature of the potash, although no sulphuret of potash may have been formed.

546. Gunpowder will very readily attract moisture from the air, if manufactured with nitre containing deliquescent salts, such as impure common salt: if this be the case, a solution of silver, added to one of the powder, in pure water, will give a white curdly precipitate. If an impurity of this nature be found to exist, or if powder, though originally composed of well-purified ingredients, should once become so damp from the influence of sea-water as to increase its weight beyond the quantity allowed in the proof, no dependence can be placed on the quality of the powder; for sea-water contains so larg
quantity of deliquescent salt, that, as in the precedi
although the powder may frequently be dried, a
appear not to be damp, yet it will re-attrac
moist atmosphere as often as exposed to
salt is not deliquescent; when salt de
that it contains muriate of magnesia.
different samples of nitre depends upo

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[a] Nitrate of potash may be formed by the heat
it is doubtful whether pure or free potash is; i
heat, if not more, for that purpose.

contained *impure* common salt, and that, in the process of refining, the whole of the deliquescent salts have not been separated. It is by no means uncommon to adulterate crude nitre with common—that is, with impure salt. Nitrate and muriate of lime, and nitrate of magnesia, are also deliquescent salts; but well-made gunpowder does not get damp by exposure to air, at least not so much as to deteriorate it—the glazing and the other ingredients prevent, or correct the hygrometric property of pure charcoal.

In powder which, however, *has* become damp, large lumps are formed. If the injury be not very considerable, these concretions may be reduced by drying, rubbing, and loosening; but gunpowder thus affected, never altogether regains its lost force.

547. Dampness in powder of good manufacture does not, in general, arise, as is commonly supposed, from the nitre attracting moisture. Pure nitre is not in the slightest degree deliquescent, it is not even hygrometric, whereas charcoal, particularly when newly made, imbibes aqueous vapour with such avidity, that a piece of perfectly dry and well-made charcoal, exposed to the action of the air for a week, will increase in weight about 14 or 15 per cent., and the matter absorbed consists principally of aqueous vapour. Thus powder of the best quality is liable to become damp from a circumstance which cannot be prevented by any degree of care in preparing the ingredients, and which can only be avoided by effectually excluding the atmospheric air. It has been thought right to state these circumstances, for the purpose of showing to the members of the profession the vast importance of a general adoption of air-tight vessels for stowing naval ammunition; and it may be added, that they should be introduced by degrees into all powder-magazines.

548. It will not, in general—perhaps never—fall to the share of naval officers to restore damaged gunpowder, by drying it in large quantities by artificial heat: it may, however, become necessary for them to do so occasionally in small quantities. But whatever be the improbabilities of naval officers or gunners being called upon to superintend or conduct such a process, it is proper they should know the precautions that ought to be observed.

In drying gunpowder that may have become damp, great care should be taken to regulate properly the degree of heat applied to the process; for there are several temperatures, considerably less than that required to explode the mixture, which are nevertheless capable of injuring it extremely. If the heat to which it is exposed be above 140° of Fahrenheit, the sulphur will begin to rise in vapour. At about 240° of Fahrenheit the sulphur will melt, without igniting the nitre,—the uniformity of the granulation will then be destroyed, and a number of small knotty lumps formed. These effects upon the sulphur may easily be shown by scattering a few grains of gunpowder upon a plate of metal heated unequally. The grains that fall upon parts much heated will instantly explode. In other parts the small, blue, lambent flame of the sulphur will be seen to rise and subside without exploding the mixture. A still less degree of heat will cause the sulphur to melt and sublime, and a certain inferior degree of temperature will also cause it to volatilize. The degree of heat used in the stoves for drying gunpowder, should not, therefore, be above 140° of Fahrenheit.

When gunpowder has become utterly unfit for service, the nitre may be separated by putting it into vessels containing water, by which the nitre will be readily dissolved, and may then be crystallized by evaporation.

549. The strength of gunpowder has been so much increased of late years, that tables of ranges, formed before the commencement of the war (1793–1815), are no longer considered correct rules for practice. This improvement in the strength of ammunition is principally owing to the process of charring wood for the manufacture of gunpowder, in iron cylinders,—hence the term *cylinder-powder*. The wood, properly seasoned and prepared, is put into cast-iron cylinders, placed horizontally over stoves, and the front openings closely stopped. Heat is then applied; when the pyroligneous acid passes over, and inflammable gases are evolved through tubes inserted in the back parts of the vessels. The gas is generally suffered to escape—the acid liquor collected in casks—and the carbon left pure in the iron retorts.

550. Lay a drachm or two of powder on a piece of clean writing-paper, and fire the heap by means of a red-hot iron

wire: if the flame ascend quickly, with a good report, leaving the paper free from white specks, and do not burn it into holes, the goodness of the ingredients, and proper manufacture of the powder, may be safely inferred.[a]

When good gunpowder is blasted upon a clean plate of copper, no tracks of foulness should be left.

Gunpowder exposed for seventeen or eighteen days to the influence of the atmosphere should not increase materially in weight. One hundred pounds of powder should not absorb more than 12 oz. If it increase in weight more than 1 per cent., it is a proof that deliquescent salt abounds in a degree which should warrant the condemnation of the powder.

551. The modes of examining merchant's powder are, by eye, by hand, and by ladle. The colour should be dark purple; that of a brown colour is of bad quality. If the powder be soft or tender in grain to the touch, or dusty, or if a cubic foot weigh less than 55 lbs., the powder is rejected: if the grain be hard, clean, and good, and the powder pass the trial for specific gravity, it is then proved by three rounds being fired in the eprouvette mortar, and if it pass with respect to range, it is then put into a box perforated with holes, for not less than twenty-one days, having been previously weighed, and it is again weighed on being taken out. Three rounds are afterwards fired with 8-inch solid balls from a mortar, and a mean of the ranges is compared with that of three rounds fired with the original sample, 5 per cent. less than Waltham Abbey government-powder being allowed. If it pass in range on this occasion, "flashing" on copper plates is the last proof.

552. To prove the strength of large-grain or common powder, 2 oz. are fired from 8-inch Gomer mortars, at an angle of 45°, placed on stone beds, and so fixed as not to recoil. These mortars are loaded with shot weighing 68 lbs.; and the average of such ranges, with the government-powder of Waltham Abbey, is 250 feet.

Powder made of common pit-charcoal will only project such a ball, under the same circumstances, about 220 feet. Powder that has been re-stoved will only produce a range of from 107

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[a] 'Observations on the Manufacture and proofs of Gunpowders,' by R. Coleman, of the Royal Powder Mills.

to 117 feet under like circumstances. These facts show the vast reductions in force, and the great loss of accuracy, which invariably and irremediably attend any deterioration in that full-proof condition of gunpowder upon which all rules of practice are formed.

A musket charged with 2 drachms of fine-grained, or musket-powder, should drive a steel bullet through 15 or 16 half-inch elm boards, placed $\frac{3}{4}$ of an inch from each other, the first board being set at 40 inches from the muzzle of the musket; but with re-stoved gunpowder the bullet will only perforate from 9 to 12 of the boards.

The quality of large-grain powder is ascertained like that of the merchant's powder, by its general appearance, its firmness, glazing, uniformity of grain, and density. The weight of a cubic foot of government-powder must be 58 lbs. The process of "flashing" is also used to ascertain the quality of the gunpowder. About 3 drachms are placed on a copper plate, and fired with a red-hot iron to see that no residue or foulness be left.

553. The quality of fine-grained powder for muskets, &c., is tested in the same manner as the large-grain cannon-powder; and its strength proved by firing 2-oz. charges from the half-pounder gun-eprouvette.

But the proofs of gunpowder by range, in the manner stated, require means which can only be found at the principal Ordnance establishments at home: they cannot be resorted to by the navy on most foreign stations, and are not always to be had on home-service.

554. To practise with the eprouvette, charge it with a small quantity of loose powder, by means of a ladle. Raise the muzzle by pushing the piece forward, and press the powder lightly together with a rammer-head; then set the index, by pressing the limb in contact with the head of the frame, and note the division pointed out. The piece should be primed with a thread of quick-match, and fired by a port-fire. After the eprouvette has made freely its first recoil, the vibrations should be gradually stopped, taking care not to touch the index or its limb. The division pointed out on the quadrant will then show the effect of the charge; and the strength of the powder may

be estimated by comparing the extent of the vibration with that which is known to be due to powder of proof strength.

The vibrating eprouvette being fired with 2 oz. of powder, the index should describe an arc of recoil of 26° with proof powder; and with re-stoved and all other descriptions of powder, not less than 24°.

ON GUN-COTTON.

555. In 1846 some experiments were made in Paris with the recently-invented gun-cotton, in a musket suspended from a horizontal axis similarly to the gun-pendulum or eprouvette; and the following is a table in English denominations of the initial velocities obtained with different charges of the cotton, the charges being so pressed that their lengths might be nearly proportional to their weights:—

Charge in Troy Grains.	Velocity in Feet.
15.44	497
30.89	1035
46.33	1348
61.78	1565
77.22	1700

On comparing these velocities with those which were observed to result from equal charges of gunpowder, it was found that 77.22 grains of gun-cotton produced an effect on a musket-ball equal to that of about half an ounce of common gunpowder; and from some experiments made by M. Arago, the force of the cotton appeared to be about three times as strong as that of gunpowder.

The report is said to have been strong, but less fatiguing to the ear than that of gunpowder: there was no appearance of smoke, a short flame only being seen at the mouth of the piece. After each fire there was left in the bore a quantity of condensed vapour of water, with a little carbon; and unless the bore was cleaned after each firing, the velocity was sensibly diminished.

It may be observed here that the successive increments of velocity arising from the successive increases of 1 gramme (.035 oz.) in the charge, form a regular decreasing series. This law is peculiar to the gun-cotton, and seems to result from the regularity of its chemical transformation: common gunpowder, being an imperfect compound, does not exhibit such regularity.

In firing against a plate of cast iron at the distance of 15 yards, with a charge equal to 4.6 grains troy of gunpowder, the leaden ball was compressed as much as half its diameter; while an equal effect was produced by .76 grains only of gun-cotton.

Experiments with gun-cotton have been carried on at Washington; and from these it was found that the initial velocity of a ball whose diameter was 5.69 inches, and weight 24.33 lbs., with a windage equal to .135 inch, and a charge of cotton equal to 1 lb., was 1080 feet; with a charge of 2 lbs. the initial velocity was 1413 feet. A musket-barrel loaded with 120 grains of cotton, and carrying one ball, with a wad, burst at the breech.

556. In order to ascertain the relative force of gunpowder and gun-cotton for mining operations, the French experimenters caused a hole to be bored in a piece of rock having the form of a prism, and placed in it 4.6 ounces of gunpowder; the hole was tamped, and the charge being fired, the rock was split by the explosion in two lines at right angles to one another: thus dividing the mass into four equal fragments. A similar piece of rock, of the same size nearly, being bored, and the hole charged with 1.66 ounces only of gun-cotton, the explosion split the rock in one line, dividing it into two nearly equal parts, thus producing the effect of nearly three times the quantity of gunpowder.

557. The following circumstances, from the second report of Major Mordecai on his experiments at Washington in the years 1845, 1847, and 1848, for the purpose of determining the fitness of gun-cotton as a substitute for gunpowder in the military service, will be read with interest:—

1. Explosive cotton burns at 380° Fahr., therefore it will not set fire to gunpowder when burnt in a loose state over it.

2. The projectile force of explosive cotton, with moderate charges, in a musket or cannon, is equal to that of about twice its weight of the best gunpowder.

3. When compressed by hard ramming, as in filling a fuze, it burns slowly.

4. By the absorption of moisture its force is rapidly diminished, but the force is restored by drying.

5. Its bursting effect is much greater than that of gunpowder, on which account it is well adapted for mining operations.

6. The principal residua of its combustion are water and nitrous acid: therefore the barrel of a gun would be soon corroded if not cleaned after firing.

7. In consequence of the quickness and intensity of its action when ignited, it cannot be used with safety in the present fire-arms.

8. An accident on service, such as the insertion of two charges before firing, would cause the bursting of the barrel; and it is probable that the like effect would take place with the regular service-charges if several times repeated.

PART V.

ON THE TACTICS OF SINGLE ACTIONS AT SEA, WITH OBSERVATIONS ON SOME NAVAL OPERATIONS BETWEEN THE SHIPS OF GREAT BRITAIN AND THE UNITED STATES.

558. ALTHOUGH the alliance between steam and wind in the propulsion of ships of war, whether the two motive powers act in combination to produce the tactical evolutions of a fleet, or whether steam-power is merely an auxiliary to that of wind in the movement of a single ship (called by the French in this case *bâtiment mixte*), will no doubt make a great revolution in the modes of maritime war—a subject which the author has treated in a separate work (see 'Naval Warfare with Steam,' 2nd edit., Murray, 1860); yet, as has been well observed in a recent publication,[a] sailing-ships, particularly frigates, in seas remote from Europe, will probably for many years have to contend in the ordinary manner, and according to the principles of the existing tactics for sailing-vessels. On this account the author purposes to repeat, with some corrections, what he had stated in the former editions of this work concerning the tactics of single ships, with the observations he had made on some naval actions which had taken place during the war between Great Britain and the United States in 1813, 1814.

559. A review of the tactics of some of our naval actions with the United States will be found to yield many useful deductions in support of much that has been advanced in the course of this work.

The reasons which have induced the author to attempt a review of these important occurrences, are to show that the United States' commanders so circumspectly and cautiously adapted their tactics to the superior powers of their armament, that, even when opposed to very inferior numbers and quality of ordnance, they would neither approach, nor [illegible]

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[a] 'Note par le Prince de Joinville.'

close battle, until they had gained some decisive advantage from the superior faculties of their long guns in distant cannonade, and from the intrepid, uncircumspect, and often very exposed approach of assailants who had long been accustomed to contemn all manœuvring, and who only considered how to rush soonest into yard-arm action. Such, unquestionably, was the character of these proceedings. The uncircumspect gallantry of our commanders led our ships, unguardedly, into snares which wary caution had spread; and, in point of fact, our vessels were, in almost every instance, so crippled in distant cannonade, from encountering rashly the serious disadvantage of making direct attacks under the powerful fire of whole broadside-batteries, that all those close actions which terminated unfavourably to us may fairly be considered to have been fought under very disadvantageous tactical circumstances, even had the force of the contending ships been equally matched.

560. In the action between the "Macedonian" and the "United States," the American frigate avoided close action for a full hour after fire commenced. Captain Carden states, "that from the enemy keeping two points off the wind, the British frigate was not enabled to get so close to her as was desired; and that it was not till after an hour's cannonade, when the enemy backed and came to the wind, that close battle commenced." This shows that Commodore Decauter's plan of operation was to keep at long-shot distance for some time, to try the effect of relative precision of fire—to avail himself of the superiority of his long 24-pounders over the 18-pounders of the "Macedonian"—and by edging away from the British frigate, which gallantly attempted to close directly from the windward, to prolong a preliminary operation so much in his own favour. How far he succeeded is shown by the opinion of the court-martial, "that the 'Macedonian' was very materially damaged before close action commenced." When the British frigate was completely crippled, the American came to the wind: the event is well known. As a display of courage, the character of the service and of the country was nobly upheld; but it would be deceiving ourselves were we to admit that the comparative expertness of the crews in gunnery was equally satisfactory. The author's object being to press home the absolute necessity

of training to expert practice master-gunners, their crews, and captains of guns, he supports his opinion of the vast national importance of such a measure by strong, impartial, and unreserved appeals to facts. Now taking the difference of effect, as stated by Captain Carden, we must draw this conclusion—that the comparative loss in killed and wounded (104 to 12), together with the dreadful account he gives of the condition of his own ship, whilst he admits that "the enemy's vessel was comparatively in good order," must have arisen from inferiority in gunnery, as well as inferiority in force. That our frigate should be captured was not at all surprising, considering the great odds against her; and the comparative ravages in the two vessels indicate the disadvantages under which this gallant officer was compelled to engage. The action between the "Java" and "Constitution" was also a very gallant display of that undaunted resolution which carried the British frigate forward to dare her antagonist to close action; but this was not a very favourable method of joining in battle with a cautious enemy, who knew well the advantages he might reap by opposing circumspect caution to the open audacity of his too bold assailant.

561. So much depends upon the way in which a vessel is approached, or brought to action, that the author finds it impossible to avoid making a few observations upon the tactics of single actions, more particularly as it appears, from a close and attentive study of the manœuvres of the American vessels, in action with ours, that the tactics of those operations were not matters of chance, nor of individual determination, but a general predetermined plan of operation, expressly calculated to procure those advantages which our resolute, straightforward, but not very prudent methods of attack were expected to present.

In entering on this part of his subject, the author is not without apprehension that he may be considered as touching unnecessarily upon a professional question rather foreign to the subject he has undertaken, and quite beyond his powers; but, to bespeak indulgence for this obtrusion, he must submit that an essay on the service-practice of Naval Gunnery, according to the view the author h[illegible] and to the plan he has [illegible], is so inseparably conn[illegible] that he cannot [illegible] avoid touching upon them, notwithstanding his inability to treat the important subject as it deserves.

562. The form of action which, in tactical circumstances, has been most unfavourable to us, is the attack from the windward. Of this character were the actions in which the "Macedonian" and "Java" were captured. The serious disadvantage of running down directly upon an enemy to leeward, to engage him in close battle, is so obvious that we can only consider such a plan of operation to have been adopted from the unguarded confidence inspired by the intoxication of glory in our naval warfare, which had taught us to despise all manœuvring for position, and to consider circumspection as unnecessary. Guided by such sentiments, it appears to have become an established maxim of the profession, that whenever an enemy can be attacked, the only method worthy of our flag is to come at once to the point: but, in the actions above referred to, we have seen that the opposite party was perfectly aware that such a mode of attack would be adopted, and was coolly and cautiously prepared to receive it; and his success may be considered as a proof that this plan of approach, bold and dignified though it be, contributed very materially to the great loss of British blood on the occasion. If this be so, there is abundant reason for endeavouring to bring back that respect for manœuvring for position, particularly in attacking from the windward, which was formerly entertained in the profession. Borrowing an established maxim from the tactics of land-operations to support this admonition, let it be well remembered that he is considered the best officer who effects most by manœuvre.

563. There is this fundamental difference, however, between naval and military tactics, that great advantages belong to the offensive operations of well-constituted and well-commanded armies, whereas in naval operations the point of attack is so undisguised that, if the defensive operation be well managed, the attacking force must be exposed to great and often decisive effect previously to close action. That generous intrepidity, therefore, which belongs to the commonest person of our nation, and which disdains anything that can be called foul play, should, when opposed to an enemy, intelligent, cautious, and, in force,

generally superior, be restrained by some circumspection: the word may shock the feelings of some who will read this; but the observation is introduced with due support from facts, in order to show that our resolution, courage, and want of circumspection, have occasionally contributed to the successes of a wary enemy. The stigma which rash men might attach to a prudent observance of circumspection, in the mode of bringing on close action with a vessel of superior or equal force, should not deter our officers from acting with that discretion which will lead to a close terminal struggle, in which, upon even terms, their native courage will secure for them the advantage. The author will now endeavour to show how this contempt of manœuvring for position has been promoted, and why this error ought to have been avoided in some late affairs. In doing this he avails himself, with infinite satisfaction, of the supporting observations of Sir Philip Broke, the distinguished captain of the "Shannon" (to whom the author is greatly indebted for information upon many professional points), some of which are given nearly in his own words.

564. In a great many of the single actions of the late French war (1794–1814), the enemy thought of nothing but escape; and, in bringing on a running fight, he deprived himself of those advantages which a ship may reap by coolly awaiting her enemy's approach, with appropriate manœuvre of sail and helm. By such a measure the enemy gave us all that British valour desired—an opportunity of coming at once to close action without previous loss, as soon as our vessel could come up with her antagonist. Thus all scientific manœuvre became superfluous, and under such circumstances was properly disregarded.

That the intrepidity of our ancient naval commanders had given them likewise a dislike of refined manœuvre, is very evident in the pages of our naval history; but this disregard of all caution in approach to action is only a character of the time, arising out of peculiar circumstances, and should now yield to considerations of a very different [illegible]

Our most accomplished officers, [illegible] at the beginning of the war arising from [illegible] 1793, not only displayed more caution in [illegible] for action than was subsequent [illegible] period of the naval war, but also held in high respect all scientific manœuvring, with a view to gain the most favourable position for action. That this *was* the professional feeling is well known—that it *is not* so now is the consequence of that deterioration in the European navies already noticed (Art. 3), which first led us to relax our warlike circumspection, and then taught us to contemn it entirely.

565. Our modern ships of war, particularly frigates, are not perhaps so well calculated for manœuvring as the old-fashioned ships were, being so much slower in turning, on account of their flat futtock and great length; but any *system* of manœuvring was hardly ever thought of in latter times, and indeed would seldom have been appropriate, sure as we were that if we could only outsail the enemy, we should be able to bring him to close action on very advantageous terms. Under such circumstances it would have been absurd, and justly injurious to a commander's character, to have attempted any manœuvring for advantageous position, even in the most scientific way, when it was in his power to lay his enemy alongside without difficulty. For there is always some danger in bracing and trimming sails, and particularly in backing them, after ships have exchanged a few well-directed rounds, and are under each other's fire. Engaged in such manœuvres, should a chance shot have crippled the assailant, the use the enemy would have made of the accident would have been to escape, in which case a British commander would justly have been severely reprimanded for losing by his theories a victory which the courage and ability of his officers and seamen would have ensured had they been led at once to an abrupt, impetuous attack. Thus, in our warfare with European navies, the escape of an enemy after we had brought him to action was felt by us as a defeat, and indeed the enemy boasted of it as a victory. These circumstances and considerations seem to justify, and even to demand, a bold and uncircumspect approach to that critical position in which, though we might be disabled ourselves, we were generally certain of preventing the enemy from leaving us, having him so much under our fire that any refit would be impossible. Thus stood the case, as it regarded single actions in general, during the French war; but when we come to meet an enemy so much

nearer our own stamp of character, and whose warlike navy (so long as it is inferior in proportion to his mercantile navy) must be well manned, and who will try, in most classes of his ships, to keep some advantage of size and armament,—if such an enemy seek to join science to his other advantages, we must be prepared to answer him in his way when we cannot have our own.

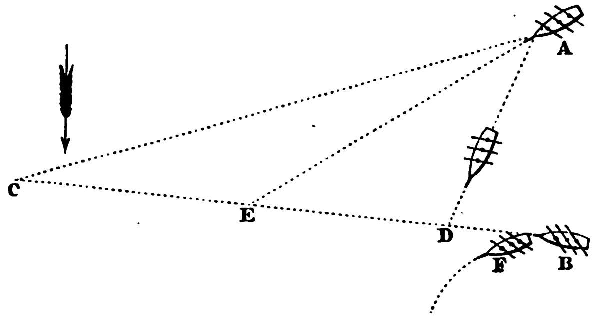
566. In the tactic of the action between the "Guerrière" and "Constitution," there was a good deal of manœuvring, yet the general courses of the two ships gradually converged towards each other in a degree which admitted of at least an hour's occasional cannonade before close action commenced. The wind was fresh from the north. When the vessels first distinguished each other, the "Guerrière" was to leeward, close hauled upon the starboard tack, the American on the weather-beam, standing S.S.W. The "Guerrière" opened her fire first (which it is said fell short), and soon afterwards the American opened his battery, and continued to fire occasionally as he came down. When he began to draw near the "Guerrière," the British frigate several times wore to avoid being raked. This prudent counter-manœuvre, to avoid a serious disadvantage, operated against closing, which accordingly did not take place till about an hour after the action had commenced. Thus, from the time the fire opened till close battle began, the vessels, steering free, kept up a sort of running fight upon courses gradually converging towards each other. Various very untoward circumstances conspired to terminate this affair in an unfortunate manner. Our frigate was very short of hands; her powder, it may fairly be asserted, from the testimony of the American commander, who says "that her shot fell short," was deteriorated by long keeping and damp (Art. 543). Several of her guns and carronades broke loose, owing to the perished condition of their breechings (Art. 505), and the decayed state of the timbers through which the long bolts passed. The armament, in guns (28 long 18-pounders), was very inferior to the 30 long 24-pounders opposed to her. The loss of the mizen-mast by a chance carronade-shot, and its unlucky fall to windward, threw the ship up in the wind in a singular manner; and her other masts, which fell soon afterwards, had been crippled previously by stress of sail and decay. These untoward circumstances are quite sufficient to account for

the capture of the frigate, and to show, indeed, the impossibility of preserving her, notwithstanding the gallantry with which she was defended; but they are not sufficient to account for the great disparity of loss in killed and wounded, viz., 78 to 14. If the author is at all correct in what he has stated in Arts. 513, 514, respecting the incredibly trifling effect usually produced by random broadside-volleys, given in sudden changes of position, he would say that, in wearing several times to avoid being raked, and in exchanging broadsides in such rapid and continued alterations of position, and consequent elevation of her ordnance, the "Guerrière's" fire was much more harmless than it would have been had she given it in a more steady position.

567. It appears that the most advantageous way in which a vessel to leeward can receive a direct attack, and bring on close action, with an enemy coming down the wind for this purpose, is to come to the wind herself, and there wait, making as little way as possible, whilst the offensive movement is in progress. This opinion requires some introductory explanations.

If two ships, A and B, fig. 68, move at an equal rate, upon courses equally inclined to each other, they will approach gradually upon equal terms, and come close to each other, when arrived at C. If the two vessels be equal in force and quality of crew, an action brought on in this way would be alike favourable to both; but if either should possess any superior power of guns, such as might induce her commander to prefer commencing with distant cannonade, and approximate gradually to close battle, then it is evident that the other vessel should vary its

Fig. 68.

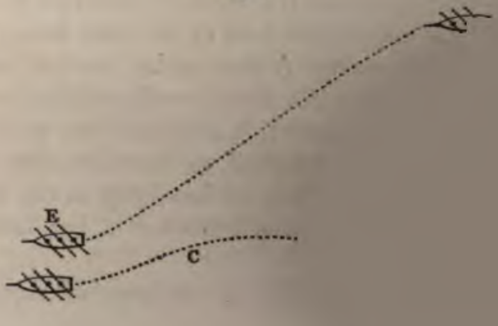


plan of operation, to defeat the purpose which the enemy has in view, and which is soon perceptible in his actions.

According to the well-known principle of chasing to leeward, the course should be so regulated that the chase always bear on the same point of the compass. If she be found to draw ahead, the chaser must haul more up; if the chase draw aft, the pursuer must keep more away. Applying this to fig. 68, the more B draws aft, that is, the slower he goes, the more direct must be A's approach, according to this principle of chasing. Now suppose B, instead of standing-on rapidly in the line B C converging gradually to A's course, were to remain as stationary as possible, keeping her broadside turned towards A, it is evident that A (whom we suppose desirous of coming to close action) cannot approach under the fire of B without obvious disadvantage; consequently the slower B moves on the line B C, the more inclined to that line must be the course of A's advance, as A D, and the more he will be exposed to a raking fire in coming down. If the ship A be so circumspect as to come down on a line A E, out of range, B should not, upon any account, stand-on to meet him, if the relative force of the ships demand circumspection on the part of B; for doing this would be acting exactly in the manner A wishes, as is evident by such a movement falling in with his plan of attack. But if A come down in any line A D within range, then B should follow him with his broadside steadily bearing, as F, and in this way should not object to come to close action, the previous advantage having been his.

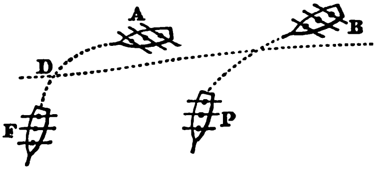
568. If, having moved upon the line A E, fig. 69, out of

Fig. 69.



range, the ship A should come to the wind at E on the same tack as B, and there wait, B should then run up to close action and raking A's stern, as at C, engage him to leeward, if he wil permit. If A should decline this, and bear up, as F, fig. 70, t

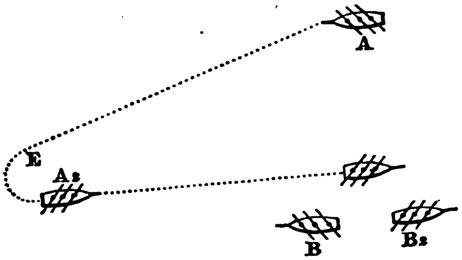
Fig. 70.



avoid being raked, B may either do so too, and engage him going free, as at P, on even terms, or stand-on, and, crossing hi stern at D, keep his wind and manœuvre afresh.

If A, having come down in the line A E, out of range, shoul haul up at A 2, fig. 71, on the contrary tack, B, if he i

Fig. 71.

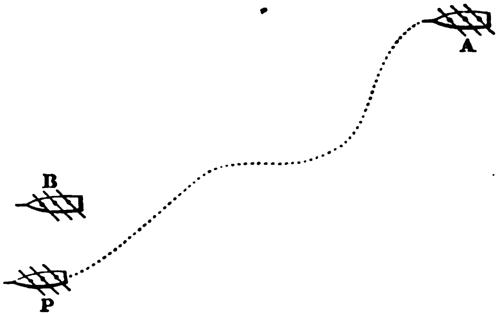


desirous of close action, should immediately wear, or tack, and stand-on slowly, as B 2. If A keep his wind, B should wait fo him, and thus engage to leeward upon equal terms; but if A attempt to bear up, across B's stern, to rake him in passing t leeward, then B may either bear up to avoid being raked, and thus, as in fig. 70, engage A close, going free; or waiving this, accept close battle upon A's terms, as the "Shannon" did the "Chesapeake." To execute this, B should not reduce his sail, but by keeping the maintopsail to the mast, avd the others shaking, or, when off the wind, by *bracing-by* as flat as possible, just keep the vessel under the influence of her helm, and n more.

569. But it may be said, a cautious, intelligent enemy,

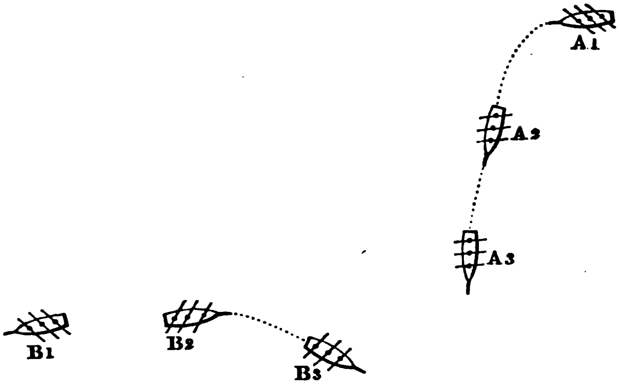
attacking from the windward, will come down abaft B's line of fire, fig. 72, as the "Chesapeake" did upon the "Shannon," and, when nearly in his wake, either run up to windward, or

Fig. 72.



pass to leeward, as he may choose, if B will wait for him, or if A outsail B. But whether the action is to be thus fought or not, will neither depend upon B's sailing nor upon A's pleasure, if B manœuvre properly; for if he have any reason for not desiring such a plan of action, and should not think proper to give A an opportunity of raking his stern, in passing to engage him to leeward, he should tack or wear at a convenient time, and stand-on slowly the other way. Thus if A 1, fig. 73, perceiving

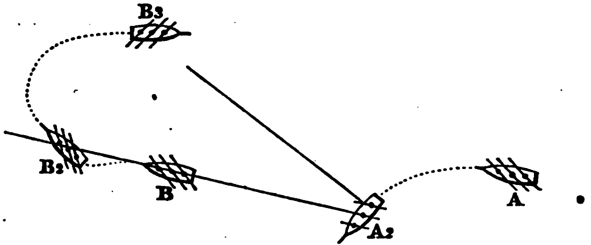
Fig. 73.



B 1, laying to leeward, shape a course to run down into his wake, B 1 should tack or wear in time, and stand on as B 2, towards A 2; and this manœuvre will bring the case exactly

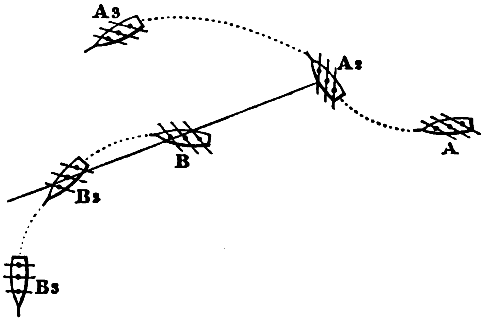
to that which has been considered in figs. 68, 69, 80. If B
neglecting or waiving this, stand-on, and let A 1 get close in hi
wake, then A 1 may bear up, and, raking B 1's stern, engage hi
to leeward. This is an obvious advantage which the "Chess
peake" might have availed himself of (as Sir Philip Brok
admits) instead of ranging up to windward of the "Shannon;
and it is one which, had it been taken, would most probabl
have gained some previous advantage. There is no way i
which B 1, having permitted A 1 to come close in his wake, ca
now avoid sustaining some previous disadvantage, if A 1 shoul
try to rake his stern. For if B 1 tack to avoid it, he will fir
expose his stern, B, fig. 74, to be raked;—he will be severel

Fig. 74.



punished whilst in stays by a fire in great part diagonal,—if
hang in stays he will be utterly destroyed; and in comin
round upon the other tack he may fall off, nearly end-o
towards A 2, as at B 3. No good officer, indeed, would attem
such a method of avoiding being raked; and if, on the contrar
B bear up, as B 2, fig. 75, to prevent this, her opponent

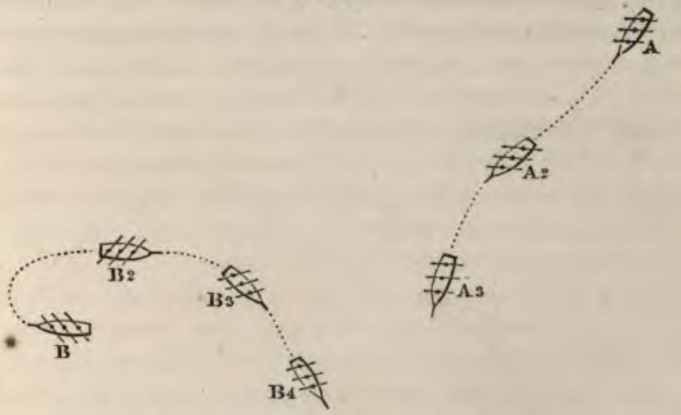
Fig. 75.



may luff-to, and rake him before B can get away, and then manœuvre for fresh advantage.

Now if, on the contrary, B should have tacked, as suggested in Art. 568, and stand-on towards A, as B 2, figs. 74 and 76,

Fig. 76.

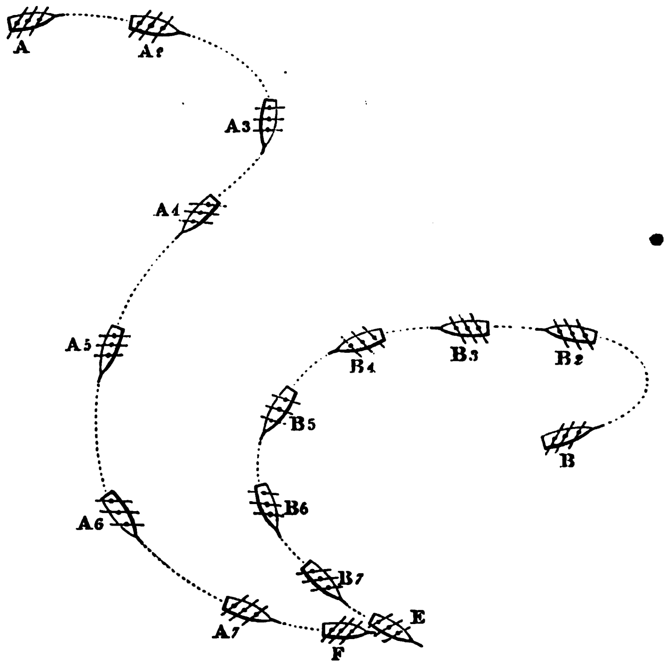


then, if the offensive movement be continued within range, B should deaden his way as much as possible, and open his fire upon A coming down, keeping his broadside, as at B 3, B 4, steadily bearing, and thus follow the movement of A 2, A 3, gradually, till both ships come close; and thus again the commander of B could have no objection to close action, the previous advantage having been his.

570. If this reasoning be correct, the best way for a vessel B, fig. 77, overleaf, to leeward, to receive an attack with circumspection, from a vessel A, to windward, is, never to let A come down into his *wake*; but having tacked in time, as B 2, stand-on slowly till A approach within B's fire, from which time B should keep as stationary as possible. Supposing the vessels to be of nearly equal force, it may be assumed that A has no intention of avoiding action; but after he is once brought to the position A 4, it is evident he cannot approach nearer to B manœuvring thus without receiving a mass of fire which he cannot return. If he shape his course to cross B's bows, the counter-manœuvre which B should apply is not velocity, but gradual change of position, in steady broadside-bearing, with as little way as pos-

sible, following A's bow with the broadside, so long as he tri to cross B's bow,—an attempt which can only be continued ti A come close to the wind on the larboard-tack; and here aga there would be no objection to bring on close action in this wa the previous advantage having been to B. If, in thus roundin to, the vessels should get foul of each other, it will be in a po tion favourable to B, as E, F, fig. 77, if the manœuvre ha been properly and steadily executed; and this will bring on character of combat (boarding) which we always desire. The manœuvres will, at all events, refuse to A the opportunities which we have supposed him to be desirous, viz., previous dista cannonade on his own terms; and therefore it appears that th method of manœuvring, in receiving an attack from the win ward, is favourable for ships which are not at liberty to recei battle under any disadvantageous tactical circumstances.

Fig. 77.



571. The author is quite aware that there may be difficulti

as well as facilities in executing these manœuvres that will require modifications, and in some cases perhaps abandonments, in the theories he has endeavoured to suggest. But many of those cases which demand modifications, or which present facilities, have already been noticed in the several articles (507 to 514 inclusive) which relate to distant practice, close battle, raking fire, dismantling-shot, &c. There are, however, some general considerations which it will always be necessary to keep in mind, with strict application to the immediate case, by which the experienced commander will not fail to be correctly guided. From the improved construction of our ships in quality of sailing, they are not so well calculated to manœuvre quickly as our old ships were. In a considerable breeze it is extremely difficult to moderate their velocity, when nearly before the wind, by *bracing-by*. This renders it very difficult to keep a free course for any particular bearing of the guns, without either going too fast to preserve that bearing, or yawing frequently. In luffing-to, also, our long ships are very slow, and in executing it run over a great space of water; so that in the smoke of a broadside discharged in this act, there is great risk of a ship getting a-back, and being obliged to *box-off*, or of losing her head-way, and remaining for a considerable time in this position, which is forcibly termed being *in irons*. To get her out of this awkward position the ship must be *paid off*, by backing the head-sails. This exposes her to the chance of making a strong stern-board (particularly with the fore-sail set), and will, at all events, throw her long *out-of-hand* before she recovers head-way; and then heavy yards are to be braced round, perhaps under the guns of a closing enemy. Before any manœuvre is attempted, therefore, the actual position of the contending ships, the state of the sea and weather, should be considered, and experience consulted, as to the time the ship may take to tack or wear, compared with the distance the enemy may run in that time, or the time required for the enemy to make whatever counter-manœuvre may seem to suit the case, and the consequent po tions to which the two ships will thus be brought.

572. The action between the "Macedonian" and the "Un States" was, in tactical circumstances, of a nature different fi those cases which have been considered in Arts. 567 et

The British frigate was to windward, and ran gallantly directly down upon the American; but in doing this was so severely damaged that the upper deck was almost entirely disabled by the raking fire of the "United States," then laying steadily to leeward.

In the action between the "Java" and the "Constitution," the British frigate was to windward. The American vessel tacked and stood away free soon after she was discovered. At 11 A.M. the "Java" hauled up, bringing the wind on the port quarter. At 1 50 P.M. the "Java" shortened sail, bore down upon the "Constitution's" quarter, and received her first two broadsides, which did little or no damage to the "Java." The British frigate then luffed-to on the American's weather-beam, almost touching, gave her first broadside, which killed and wounded between forty and fifty of her people; but from the total inexperience in gunnery of the crew of the "Java," she appears to have seldom hit her opponent afterwards. In manœuvring, the British frigate was well handled, and obtained positions which, had they been as effectually taken advantage of by good gunnery as they were conceived and executed with great nautical skill, must have produced a very different result from that which unhappily ensued. The "Java" passed at one time under the stern of the "Constitution" so close, that her ensign almost touched, when the latter put her helm up and made sail, upon which the "Java" instantly put her helm down, passed up close under the stern of the "Constitution," and got again on her weather-quarter. Soon after this the "Java" lost the head of her bowsprit, and became much damaged from the fire of her opponent; when it was determined, as a last hope, to board the "Constitution," and the "Java" bore up for that purpose. Whilst doing so, the head of her bowsprit actually rubbed along the quarter of the "Constitution," which brought the "Java" up in the wind; and in this position she remained for upwards of an hour, a mark for cool target-practice. The "Constitution" at length came under the broadside of the "Java," when, finding her fire far from being silenced, the American frigate made sail, and went out of action for an hour, leaving the "Java" with her mainmast only standing, with the weather-half of her main-yard broken aloft, which she soon afterwards rolled away. A topgallant-mast was rigged as a jury-foremast, and a stay-sail set, forward, in the vain hope to get before the wind. The "Constitution," seeing this attempt, returned to the fight, and took a position right a-head of the "Java." Further resistance would have been unavailing, and the "Java" accordingly struck her colours. It is impossible to pass from the relation of this action, in which so much nautical skill and gallantry were unavailingly displayed by Captain Henry Lambert, who fell mortally wounded by a musket-ball fired from one of the tops,[a] and by her first lieutenant, H. D. Chads, without noticing, as a remarkable and interesting incident in the career of Rear-Admiral Chads, that he was, by his great merits, placed in a situation which—if sufficient extension and permanency be given to the corps of seamen-gunners to meet the wants and exigencies of the service (Art. 27, 33)—will effectually prevent the recurrence of disasters arising from such a cause, by the zeal, experience, and practical skill with which this distinguished officer directed and superintended the important institution over which he presided, for teaching the science and improving the practice of gunnery in the British navy.

573. In this action there was, on the side of the British frigate, excess of gallantry, but very little circumspection; and it is melancholy to reflect that such gallantry should have terminated so disastrously. If the British frigate had manœuvred, the "Constitution" would not have run away. Its commander might have hesitated to meet the manœuvre, and join fairly in close battle: he would probably have waited to see whether or not the British commander would be so incautious as to approach him, knowing well that such a step would operate in his favour. If our frigate had run down astern, the American would either have tacked or *waited;* if not, he had fled, and we had triumphed: but no—if we had been *more* cautious, he would have been *less* so. It appears, th efore, that battle should first have been offered upon equal t by commencing the ordinary

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the fate of Nelson in urging
of the improved rifle and

manœuvre of running down in the wake. If the British frigate, represented by A, fig. 78, declining this, had brought-to, as at A 2, the American, B, fancying her rather shy, would certainly, after some time, have approached. This he probably would have done by tacking, as at B 2, and standing close upon the starboard tack into A's wake, and then tacking towards her, as at B 3. Now, if B tack in A's wake, B cannot go to windward of A, nor rake him, except partially, by luffing-up in the wind, or by keeping away, both of which would be random and very in-

Fig. 78.

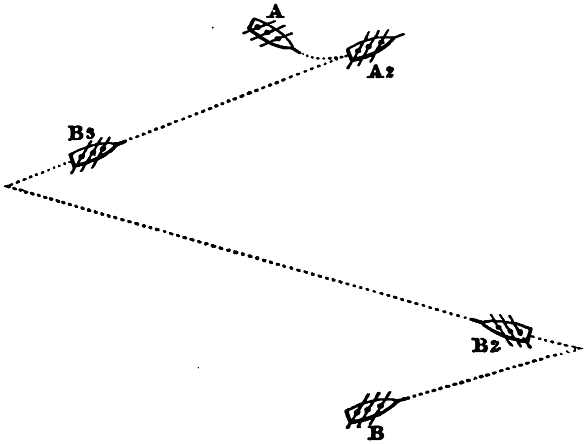
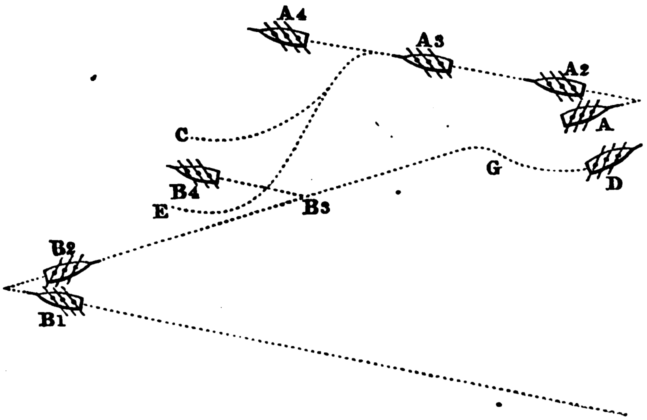
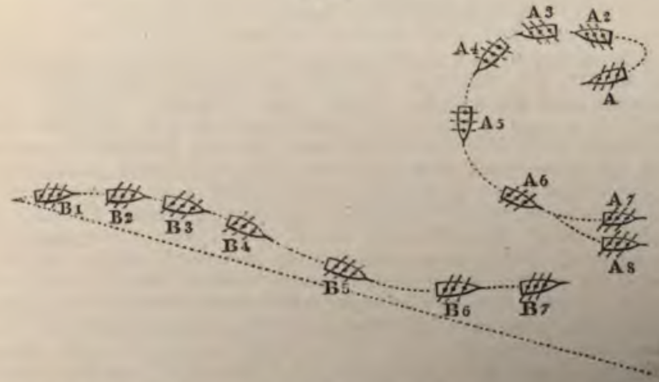


Fig. 79.



efficient volleys (Arts. 513, 514). But if B should stand-on, as at B 1, fig. 79, and tack, as at B 2, to windward of A's wake, then it would be advisable for A to tack also, as at A 2, because B, by acting thus, may be suspected of an intention of crossing A's stern, to rake him before he engage him close to leeward, as at D. Now if A tack, it is evident that upon this course also he will go to windward of B; and if B proceed to B 3, A 3 may lay across his bows and rake him. This B will not, of course, suffer; and, to prevent it, must either wear or tack again. If he tack and there wait, as at B 4, A may run up alongside, and engage him to windward at C, in close action; or, crossing B's stern, fight him to leeward, as at E; in either of which cases A will accomplish, by previous manœuvre, the very nature of action which he had offered at first, but which B then declined. If, from the position B 2, fig. 79, B keep away, as B 2, fig. 80, when he sees that A has tacked, as at A 2, figs. 79 and 80, then

Fig. 80.



A (being still either out of range or at very random distance) should wear round to engage B, going free, if he goes away as B 4; but if B try to cross A's bows, he should wear round gradually, deadening his way as much as may be necessary to keep his broadside bearing upon B, as A 5, A 6, A 7; and thus have no objection to close action, either by hauling up, as A 7, or waiting for B, or by standing-on, A 8, and crossing B's bows to rake him.

574. The action between the "Shannon" and the

peake" reflects upon the victors immortal honour, and no discredit on the vanquished. Its characteristics are, that though the enemy did not, as usual, commence with distant cannonade, yet he was so far circumspect in his approach, as not to have been pre-exposed to the "Shannon's" fire, having come down astern, and only received the fire of the British frigate's aftermain-deck gun and quarter-deck carronade before he opened his own fire. The rapidity and precision of the "Shannon's" fire were irresistible;—the enemy was beaten in eleven minutes![a]

In this remarkable combat, however, it must be observed that an error in principle was committed on both sides. The "Shannon" gave the "Chesapeake" a great advantage in permitting her to approach as she did. The "Chesapeake" committed an error in not taking advantage of it as she might have done; for the American frigate might, when near, having considerable way, suddenly have put her helm up, and raked the "Shannon"

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[a] It is not easy to account for the facts stated in the report given in the notes to Art. 109, respecting the deficient powers of penetration of the 18-pounder solid shot fired from H. M. frigate "Shannon" into the "Chesapeake." It appears by that Report, which was made from an actual survey, that sixteen 18-lb. shot did not perforate, but only penetrated, some 4, 5, and 6, and others 8 and 10 in.; and that, of the shot which passed through, the greater number were 32-pounder carronade-shot. Some unexpected circumstances with respect to relative position may perhaps account for this. It is stated in James' 'Naval History,' vol. vi. p. 201, that the captain of the "Chesapeake," finding he was ranging too far a-head, brought his ship so sharp to the wind in attempting to deaden her way, that she lay, in consequence, for some time with her stern and quarter exposed to her opponent's broadside, the "Shannon's" aftermost guns firing diagonally into the "Chesapeake;" and that (p. 202) the "Chesapeake" making, it would appear, a sternboard, fell with her quarter upon the "Shannon's" side, just before her starboard main-chains, and hooked with her quarter-port the fluke of the "Shannon's" anchor stowed over the chest-tree. These changes of position may be considered as illustrations of what has been said—(Art. 108)—that naval actions are subject to sudden and unforeseen mutations in the positions of the contending vessels, in consequence of which one of them may suddenly be exposed to oblique, diagonal, or raking fire, and thus require that the loads of metal, and charges of powder, should be varied so as to insure penetration into and through the enemy's ship, however she may be struck. The penetrating power adequate to this end, in every position of the opponent, should never be sacrificed to the practice of using only the load and charge, which may be barely sufficient for penetrating in direct broadside-action. May not inattention to this important rule have been omitted in the practice on board the "Shannon"? It appears, moreover, that the shot fired from the "Chesapeake" were likewise deficient in penetrating power (Art. 262).

by her stern, and then either hauled off, or, coming up again, engaged the "Shannon" to leeward. To frustrate the operation of being raked by the stern, which the "Shannon" had every tactical authority to believe was the American's intention, the "Shannon" should have kept away or tacked as soon as she saw such a course shaping towards her; but these manœuvres would have brought on a running, and perhaps a less decisive fight. The captain of the "Shannon," under the peculiar circumstances of the case, abiding by the terms of the defiance he had sent to the captain of the "Chesapeake,"[a] resolved to offer the advantage which his position presented, and not to appear to shrink from the contest he had long sought.

"'Twas vain to seek retreat, and vain to fear;
Himself had challenged, and the foe drew near."

The gallant foe disdained to avail himself of the tactical advantage which his bold opponent offered, and for each it may be said,—

"But open be our fight, and bold each blow;
I steal no conquest from a noble foe."

The captured frigate was taken to Halifax, and there her gallant captain, killed in the action, was buried with military honours, his funeral attended by the civil authorities, the troops in garrison, and the surviving officers of the "Shannon," with the exception of her victorious chief, who was severely wounded in the fight.

"The stone shall tell the vanquish'd hero's name,
And distant ages learn the victor's fame."

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[a] James's 'Naval History,' vol. vi. p. 109.

PART VI.

ON RIFLE-MUSKETS.

575. THE common and the rifle musket are weapons of which sufficient use has not hitherto been made in the British navy but the latter, in its present improved state, is become of such importance, that in all probability it will henceforth be very generally used in the naval as well as the land service, and will become a matter of great public interest. An account of the new muskets for projecting elongated rifle-shot of various forms (see Arts. 179, 180, 181) will therefore be deserving of specia notice in the present work.

576. Naval history furnishes many melancholy proofs of the danger which is incurred of setting fire to the sails and rigging of a ship in action by firing muskets from the *tops;* and Nelson was so well convinced of the reality of such danger, that he forbade the practice on board the "Victory" in the action o Trafalgar. The destruction of the "Alcide" and "L'Orient" on former occasions, and of the "Achille" and "Redoubtable" in that engagement, prove that his apprehension of such a catastrophe was well founded; but it is remarkable that a shot fired from the rigging of the "Redoubtable" inflicted on this country the severest loss it ever sustained in battle—the death of the gallant admiral himself.

We refer to these facts, and might quote numerous instances on record of ships in action being burnt or disabled by an indiscreet and reckless firing of musketry from aloft, amongst the sails; and we would strongly urge the necessity of prescribing by regulation the circumstances under which, only, musketry should be used on board ship, the extent to which it should be adopted, the positions of the marksmen with respect to the sails and the direction of the wind; we would also urge that every

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[a] *De la Gravière*, translated by the Hon. Captain Plunket. See Art. 311 Note p. 309.

precaution possible should be taken to avoid this danger, the most formidable that can happen to a ship in action.

577. The new rifle-muskets are wholly indebted to the adoption of the elongated projectile for their efficiency and celebrity. Elongated shot possess, when their axes are coincident with the path they describe, the properties of being less resisted by the air, having longer ranges and greater penetrating power than spherical projectiles of the same diameter. In accordance with these views, it is proposed to give a short account of the circumstances which led to the introduction of the elongated shot in the French army, and to explain the several modes by which it has been proposed to force the shot into the rifle state in the several muskets and carbines that have since been constructed; also to describe more particularly the several improvements that have been made up to the present time in that description of rifle-musket which has been adopted in the British service.

578. It is a remarkable fact, that the use of the rifle as a military arm was abandoned by the French in the early campaigns of the Revolutionary War;[a] and it was not revived in the service till after the "Restoration," when it was brought forward by M. Delvigne in the novel form which bears his name.

To obviate the difficulty and loss of time in loading ordinary rifles, by forcing the ball into the barrel by repeated blows of the ramrod or a mallet, on account of which the use of that arm had so long been suspended, M. Delvigne proposed that the bullet should have sufficient windage to enter freely into the barrel, in order that, when stopped by the contraction of the chamber with which this arm was furnished, it might be forced to expand and enter into the grooves, on receiving a few smart blows; thus, the piece being fired, the bullet would come out a forced, or rifle ball, without having been forced in.

But this ingenious contrivance was not found to answer. The

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[a] Favé, 'Des Nouvelles Carabines, et de leur Emploi,' p. 3. Paris, 1847. In 1793 a very small number of French light infantry were armed with carabines rayées, loaded in the ordinary way by forcing the ball with a mallet; but, as the French armies in the campaigns of that year were little familiarised with arms of this complicated description, and could not be [illegible] to their uses, the rifle was given up; and during the [illegible] Republic and of the Empire was not thought of.

edge of the chamber on which the ball lodged, not being opposite to the direction of the blow, did not form a sufficient support upon which to flatten the ball when struck by the ramrod, and thus cause the bullet to expand; whilst portions of the charge of powder previously poured in, having lodged on the contraction, cushioned and still further impeded the expansion of the shot; and as, obviously, no patch could be used, the grooves were liable to get foul, and to become leaded, to an extent which by no means could be effectually obviated.

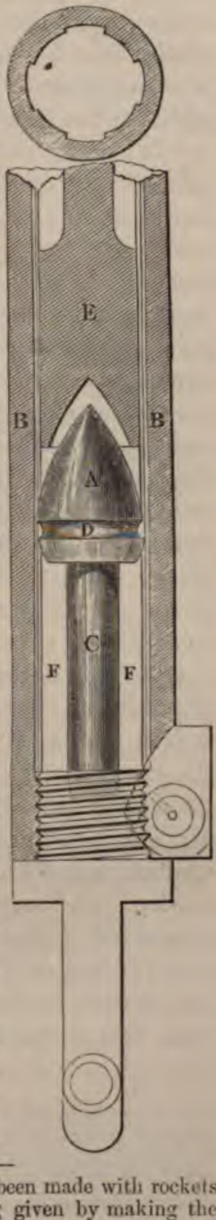
579. To remedy this defect, Colonel Thouvenin proposed in 1828 to suppress the chamber, and substitute a cylindrical tige or pillar of steel (C, fig. 81, opposite), screwed into the breech in the centre of the barrel, so that the bullet, when stopped by, and resting upon the flat end of the pillar, directly opposite to the side struck, might more easily be flattened and forced to enter the grooves.

580. But here another defect appeared. The pillar occupying a large portion of the centre of the barrel, and the charge being placed in the annular space which surrounds it, the main force of the powder, instead of taking effect in the axis of the piece, and on the centre of the projectile, acted only on the spherical portion of the bullet which lies over this annular chamber, and thus the ball, receiving obliquely the impulse of the charge, was propelled with diminished force. ('De la Création et de l'Emploi de la Force Armée,' pp. 44, 45, Paris, 1848.) The next improvement, which was proposed by M. Delvigne, was to make the bottom of the projectile a flat surface; the body cylindrical, and to terminate it in front with a conical point (A, fig. 81, opposite), thus diminishing the resistance of the air comparatively with that experienced by a solid of the same diameter having a hemispherical end. The form of the projectile was, therefore, an approximation to that of Newton's solid of least resistance (Art. 179).

581. While engaged in the conquest of Algiers, a French army of one hundred thousand men was long kept in check by the nomadic inhabitants of that country, a people ill-armed and quite destitute of military organization. Favoured by their power of rapid movement, the Arab horsemen, keeping themselves at a distance, directed against their opponents, who were

deficient in cavalry, a destructive fire of matchlocks, and immediately retired beyond the range of the muskets carried by the European infantry, whose solid columns, encumbered with artillery and baggage, were unable to follow with sufficient rapidity. The necessity of arming the French infantry with weapons capable of affording, with considerable precision of fire, a more extensive range than could be obtained from common muskets, was immediately felt; and ten battalions of chasseurs (infantry), which were organized in 1840, were armed with the pillar-breech rifle-musket. (*Delvigne*, 'De la Création et de la Emploi de la Force Armée,' pp. 14, 15, 16, 45.) It is probable that the circumstances above mentioned drew the attention of military men in general to improvements in the musket and rifle. In 1841 a patent was obtained by Captain Tamisier for his method of giving steadiness to the flight of cylindro-conical shot, by cutting three sharp circular grooves, each .28 inch deep, on the cylindrical part of the shot, by which the resistance of the air behind the centre of gravity of the projectile being increased, the axis of rotation was kept more steadily in the direction of the trajectory; the grooves being to this projectile what the feathers are to the arrow, and the stick to the rocket.[a]

Fig. 81.



582. The following is a brief account of the French Pillar-Breech Musket, with its latest improvements:—

"The pillar-breech musket is loaded at the muzzle with a leaden projectile of the form shown at A, in fig. 81 annexed; this projectile is .657 in. diameter, and weighs

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[a] Some very interesting experiments have recently been made with rockets without sticks, a rotatory motion on their axes being given by making the

728 grains. The barrel, B B, of the musket is 34 inches long, rifled with four grooves, and has an elevating-scale or sight 3¼ inches high; the 'tige' or pillar, C, is screwed into the face of the breech-pin. The cartridge, containing 2½ drachms of powder, is made of strong paper, which is tied round the projectile at the groove D, near its base.

"In loading, the soldier breaks the cartridge, when the powder falls into the space, F F, round the pillar, and he throws away the paper of the upper part of the cartridge; the ball, which is nearly of the same diameter as the bore of the piece, is then made to rest with its flat end on the head of the pillar; the end, E, of the rammer being countersunk of the same form as the point of the ball, the soldier gives three or four smart blows upon the latter, which, being supported by the pillar, is shortened in length and widened in diameter, so as to force the lead and paper round it into the grooves of the rifle. The point of the ball is held in the axis of the barrel by the head of the rammer, which is so nearly of the same diameter as the bore, that no sensible variation in the position of the ball can take place: when fired, the projectile is constrained to follow the grooves of the rifle, and the paper protects the barrel from being leaded."

583. This method of forcing the shot into the rifled state has been adopted by the Austrians and some of the smaller German states; and the French Chasseurs d'Orléans are still armed with the carabine-à-tige. The method of forcing the shot into the grooves of the rifle has also been adopted in this country by Mr. Lancaster, in his pillar-breech rifle, which is much used by sportsmen, and was proposed by him for adoption in the military service; the length of his musket is 2 feet 8 inches, the charge of powder 2½ drachms, and the weight of his cylindro-conoidal shot 710 grains (troy). The grooves, of which there are four, are straight to the extent of 18 inches from the breech; they then take a spiral form, gradually increasing to the muzzle

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orifices out of which the inflamed and compressed composition rushes oblique to the axis instead of direct. By this contrivance the rotatory and propelling powers are combined; and so long as the former continues, the rocket will proceed in the direction of the trajectory, at right angles nearly to the plane of rotation (Art. 340).

(*gaining twist*), making a quarter of a turn from its commencement: this, it was presumed, would give to the projectile great accuracy of flight, with the least recoil; but it appears that, whatever may be the advantages of the *gaining twist* in firing a spherical bullet or a conical *picket* (an American practice), it is totally inapplicable to a cylindro-conoidal shot, for reasons ably stated by Lieut.-Colonel the Hon. Alexander Gordon, in his pamphlet entitled 'Remarks on National Defence,' Appendix, p. 32.

584. But the pillar-breech musket having been found inconvenient in cleaning, the chamber round the stem becoming soon fouled, the pillar liable to be broken, and, after firing some rounds, the operation of ramming down so fatiguing to the men as to make them unsteady in taking aim, M. Minié, previously distinguished as a zealous and able advocate for restoring the rifle to the service in an improved form, proposed to suppress the tige, and substitute for it an iron cup, *b* (fig. 82), put into the wider end of a conical hollow, *a*, made in the shot: this cup being forced further in by the explosion of the charge, causes the hollow cylindrical portion of the shot to expand and fix itself in the grooves, so that the shot becomes forced at the moment of discharge.[a] A slip of cartridge-paper is wound twice round the cylindrical part of the projectile, so that, as the latter does not become forced or rifled till the charge is fired, it fits so tightly to the barrel as to be free from any motion which would be caused by the carriage of the rifle on a march, or by its being handled before the shot is fired.

Fig. 82.

The reader will perceive that, unless the cup *b* (fig. driven, by the first action of the explosion of the c into the conical space in which it is placed, as to to enter into the grooves of the rifle before the

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[a] This is the expedient for forcing the shot, so we on rifle-shooting in Ceylon, which appeared in the March, 1851, and which the reader of that article wi method.

will be no rotation—the paper wrapt round the shot not sufficing for this purpose.

In the experiments of 1850 it was found that the hollow part of the Minié cylindro-conical shot was very frequently separated entirely from the conical part by the force with which the cup was driven into the hollow part of the shot, and sometimes remained so firmly fixed in the barrel that it could not be extracted; but in the more recent trials with shot made by compression and with better lead, no such failure occurred.

585. The principle of placing and igniting the charge in front of the projectile by means of a needle, was patented in England by Abraham Mosar on the 15th of December, 1831; his musket was submitted to the Board of Ordnance for trial in 1834, but the method of loading, namely, at the muzzle, was very complicated; and the inventor not having pecuniary means sufficient to improve and carry out his invention, no trials were made. While efforts were being made in France to augment the power and accuracy of small-arms, loaded at the muzzle, as already described, M. Dreyse, of Sommerda, in Thuringia, was led to try whether the inconvenience of ramming down and flattening the shot might not be got rid of by loading the barrel at the breech—an old project (see Art. 234); and he suggested a plan for this purpose, which has been adopted to a great extent in the Prussian army.

586. The Prussian rifled musket for firing cylindro-conical shot is designated "zundnadelgewehr," from the ignition of the charge being produced by passing a needle through the cartridge, to strike the percussion-powder placed in the wooden bottom, or spiegel, as shown in fig. 83, opposite. The following is a description of the musket, which is loaded at the breech:—

"The barrel, A A, which is 34 inches long, is rifled with four grooves, and has a 'hausse' or sight adapted to distances of 600 metres; it is screwed into the end of a strong open guider or channel, B B: the chamber, properly so called, is bored out from behind, conically in a slight degree, so that when the cartridge is placed in it, the shoulder, C D, of the ball shall meet and be stopped by the projections or ribs of the rifling, the body of the shot being of sufficient diameter to fill the full depth of the grooves. Inside of the guider slides an iron tube, E E, with a strong 'hebel' or handle, F, attached, and having at the front end a space, G G, of about 1½ inch in length. In the middle of this space is a 'tige' or pillar, H, which, instead of being solid, like that of a pillar-breech musket, is pierced with a small hole in its entire length, and through this passes the needle, N, which is to ignite the charge: the steel tige is screwed from behind into a solid plate of iron, J J, left in the tube E E; and this plate it is which (like the breech-pin of the ordinary musket) receives the whole reactionary force of the charge. Behind the plate, J J, there is a second tube of iron (which could not be shown in the drawing) having a double catch-spring attached, and carrying within it a small inner tube of iron, K K fig. 84), having two projecting rings, L L (figs. 83, 84), on one moiety of its length, and a spiral spring, M M, sliding on the other half. Through the tube, K K, passes the needle, N N N N, which is a thin steel wire about ·03 inch diameter, bluntly pointed at the end, which is to ignite the charge; at the other end it is screwed into a brass head, O, and this

Fig. 84.

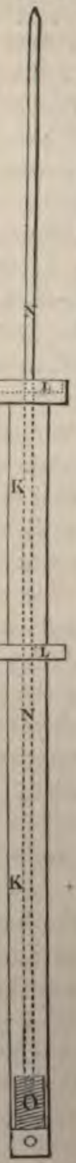
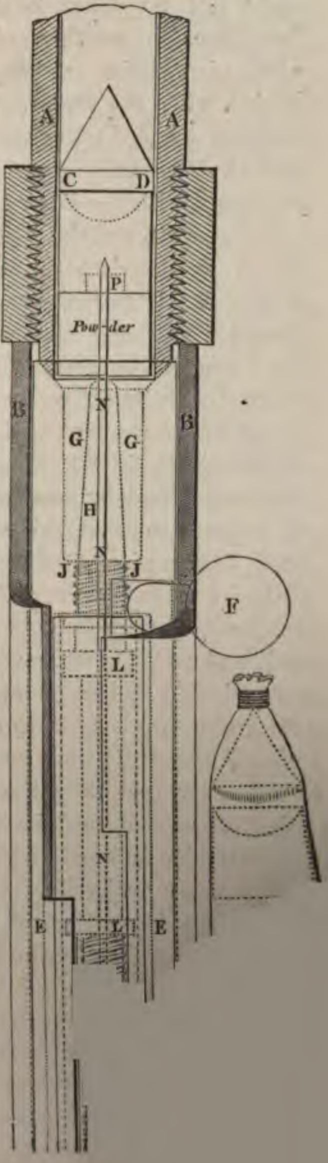


Fig. 83.



the inner tube, which carries the spiral spring. The trigger, which is of a peculiar form, and has a bolt-movement in firing, could not be shown intelligibly in the diagram. It has a knuckle-catch, so that, when pressed down, it admits of the whole mechanism of the tube, E E, being drawn out from behind, when the parts can be taken to pieces, cleaned, and put together again by the soldier in a few minutes, there being no pins whatever and no screw, except that by which the needle is connected with the inner tube.

"The shot for the 'needle-prime' musket is of the form shown by the dotted lines in the upper part of fig. 85, and weighs 437½ grains, or exactly one ounce avoirdupois; its diameter at the shoulder is .632 in. Underneath the shot is the 'spiegel' or bottom, of equal diameter, formed of wood, covered with brown paper and hard rolled, with a hollow at the upper end to receive the lower end of the ball; beneath it is a small cup (P, fig. 83), to contain the igniting composition, which is pressed hard by mechanical means. The cartridge is made of paper somewhat thicker than that used in our service; a small square piece is first pressed by the hand against one end of the wooden *former*, and this constitutes the end or bottom; another oblong piece is pasted on the edge of one side and one end, and rolled once round the *former*, the pasted end being pressed close and flat round the bottom; when dry, the powder (62 grains, or about 2¼ drachms) is first put in; after which the spiegel with the priming-composition is placed downwards upon the powder, and then the shot. The paper is tied round the point of the shot, and its end is cut off smooth. This end of the cartridge is dipped into melted tallow as far as the shoulder (C D) of the projectile.

"At the lower part of the barrel is the sliding tube through which passes the needle for igniting the charge: this tube is capable of being moved backwards or forwards in the barrel, near the breech, by means of a pin or handle in its side, which passes through a perforation similar to a bayonet-notch in the side of the barrel. When the tube is drawn as far as the perforation will allow towards the stock, there is formed an open chamber between its extremity and the nearest extremity of the barrel; and, by means of this chamber, the charge is introduced into the barrel. The tube is then pressed forward till its extremity, which is in the form of a frustum of a cone, is in contact with the rear extremity of the barrel; this extremity having the form of a hollow cone to receive the end of the tube: the pin, or handle, being then turned round in the notch, the tube is, as it were, locked in close contact with the barrel. In this state the needle in the tube is in connection with the trigger of the lock, and the musket is ready for being fired."[a]

587. The escape of gas at the junction of the chamber and barrel is considered by all as a great objection to the needle-prime musket: it is stated that the point of the igniting-needle soon becomes furred, so that it is difficult, and, after a time, impossible, to draw it back by the thumb. The Prussians, however, appear to be quite confident of the superiority of the latter over other rifle-muskets; their Government is said to have caused 60,000 stand of these arms to be executed, and at least half as many more are ordered. Their fusiliers, who are armed with the needle-prime musket, have also a short sword, with a cross hilt: this they plant in the ground; and, lying down, they use the hilt as a rest for the purpose of taking a steady aim.

In 1850 some experiments were made at Woolwich, under the direction of the Committee on Small Arms, when it was found that in the operation of opening and closing the breech, by withdrawing to load, and replacing, when loaded, the bolt (which acts in a manner resembling that of fixing the bayonet) required a great deal of manual strength, particularly when the piece got heated and foul. Also, while attending the experiments of 1850, at Woolwich, the author was very much struck with an important objection in the very apparent escape of gas from the breech. This defect increased to such a degree in continued firing, even with a new piece, that the flash indicating a copious escape of gas became very apparent, and was at lengt

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[a] The use of carbines loaded at the breech is much recommende General Rémond. The General proposes, with them, to employ in formed three, and even five deep—the front rank men being not expos the fire of those in the rear, which is the case when the muskets are loa the muzzle, by the men raising the right hand to the head in usin ramrod. (P. 6.)

sensibly felt in the face of the man who fired, and the soldier on his left. The escape of gas will evidently be much greater in long-protracted firing, from the effects of friction both upon the bolt and the barrel. The escape of gas takes place chiefly from the left side of the breech; which indicates an imperfection in the contact between the chamber and the barrel on that side, arising from the want of central or direct support for the tube which carries the charge, when it is pressed up to the top of the chamber, in order to close the breech, previously to the musket being fired. This defect in the contact, apparently goes on increasing during the repetitions of the firing. It is possible that the evil may be remedied by giving to the lower part of the barrel the form of a hollow frustum of a cone, and to the upper part of the tube carrying the charge of a corresponding form, so that, in closing up the tube to the barrel, the contact of the conical surfaces may be sufficiently close to prevent the escape of gas. By this construction, even in the event of these surfaces being in part worn away by friction, it will be possible, by pressing the tube still closer to the barrel, to preserve the accuracy of the contact.

588. The advantage of placing the composition above the gunpowder is supposed to be, that it secures the ignition of the whole charge. The mode of producing ignition by placing the percussion-powder in the body of the cartridge is, however, very objectionable. If the cap put on the nipple of an ordinary lock should fail, another may be instantly put on; if ignition fail to be produced in the Prussian cartridge, it must be withdrawn bodily, and it becomes useless till made up afresh.

589. It is, no doubt, in some respects, an important advantage in the Prussian rifles, that they may be loaded more quickly than the ordinary musket or rifle; but here, too, we agree with M. Favé ('Des Nouvelles Carabines, etc.,' p. 40), that rifle actions are generally decided, not by mere rapidity of fire, but by each soldier taking time to use his arm in the most efficient manner possible. Although, as has been already stated, the use of the rifle was suspended in the French armies throughout the whole of the general war (1794–1815), yet the French infantry, armed with the common musket, were well trained to act *en tirailleur*, and showed great aptitude for that kind of service, in which a

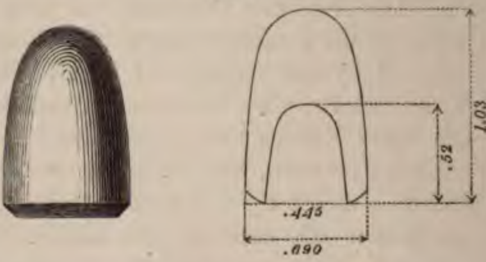
mere militia or new-levied troops, in many circumstances, render as much service as veteran soldiers.

590. Public attention having been excited by M. Favé's interesting work, 'Des Nouvelles Carabines,' as well as by the efficient use made of the *carabine à tige* by the Chasseurs d'Orléans in Algiers, and by the adoption of its rival, the needle-prime musket, by the Prussian Government, experiments with muskets of the latter construction, which had been made in England from foreign patterns, were, in 1850, carried on in this country, in order to compare them with the British regulation-musket and the British rifle carrying the belted ball. It was proposed to ascertain the relative merits of those arms, and particularly to discover whether the method of loading at the breech, as in the needle-prime musket, considered under all aspects, could be adopted with advantage in the British service. The results of these experiments showed that the Prussian needle-prime musket was by far the quickest in loading and firing. The English regulation-musket came next, Lancaster's pillar-breech the third, and the English regulation-rifle the slowest; that the hits, in 60 rounds fired at a target 6 feet square at the distance of 150 yards, were, respectively, in the order in which the arms have been already named, 40, 29, 50, and 30; and, lastly, that the average percentage of hits at different ranges up to 600 yards, were, in the same order, 33, 25, 35, and 37; but, for the reasons already stated, muskets loaded at the breech were condemned as arms for general service in the field, however useful they might be in the hands of a few expert men for special purposes.

591. Good patterns having been obtained of the Delvigne carabine à tige, the French and the Belgian Minié rifles, experiments were made at Woolwich in 1851 with these three arms and with Lancaster's pillar-breech rifle, in order to test their relative merits in firing at a target 6 feet square, at 400 yards' distance. The results of these experiments were considered to have so fully established the peculiar advantages of M. Minié's method of quick loading, and forcing the shot into the rifled state, that the manufacture in this country of a large supply of what has been called the regulation Minié musket was ordered.

The form of its projectile, which is simply conoidal, is given in fig. 86 annexed.

Fig. 86.



592. The only mode in which elongated shot can be employed without either increasing the weight of the ammunition carried by the soldier or reducing the number (60) of rounds in his pouch, is to diminish the calibre of the fire-arm, so that the elongated shot may not be heavier than the regulation bullet. With a view to effect this object most conveniently, the late Viscount Hardinge, then Master-General of the Ordnance, invited some of the principal gun-makers of England to submit pattern muskets, in the hope of obtaining a lighter and more efficient arm with a smaller bore. The following makers accordingly prepared, and sent in, muskets for trial—Mr. Purday, Mr. Westley Richards, Mr. Lancaster, Mr. Wilkinson, and Mr. Greener: Mr. Lovell, the inspector of small-arms, also prepared a new musket at the Government manufactory.

593. The projectiles for all the muskets are conoidal or cylindro-conoidal. Mr. Wilkinson's projectile is cast solid, and has two deep grooves round the lower part. It is intended to be used without paper or patch of any kind, the two grooves being merely filled with grease; and the method of loading is the same as that which is now in use with the rifle regiments of the service, the powder being made up in a small cartridge by itself, and put into the barrel before taking the ball out of the ball-pouch. The muzzle of the barrel has been countersunk, so as to receive the ball before it is rammed down, which is a great convenience. The grooves are of a spiral form, having one turn in 6 ft. 6 in. Mr. Purday's projectile is cylindro-conoidal,

with a belt round the lower part: one of the two kinds of projectile has the simple Minié cavity, and the other has a cavity with a plug, which is driven into the cavity by the force of the fired powder. The grooves have the character of the *increasing* spiral; they commence with one turn in 6 ft., and end with one turn in 4 ft. 9 in. Mr. Lovell's heavy shot (No. 1) made excellent shooting at all distances, but the difficulty of loading, and the great weight of the shot, render it unfit for troops of the line. Even with a strong wooden rammer it was sometimes difficult to drive the shot home. The lighter shot (No. 2) made very good shooting up to 400 yards; but sometimes, after firing a dozen shots, it became uncertain, and the difficulty of loading was as great as with the heavier ball. The grooves are regular spirals, with one turn in 6 ft. 6 in. The grooves of the Brunswick rifle have one turn in 2 ft. 6 in.

Mr. Lancaster, who invented the ordnance with an elliptical bore, spirally formed, as described in Art. 197, and the pillar-breech rifle (Art. 582), proposed also a description of musket having a bore of a similar kind. No grooves are cut in the interior surface of the barrel; but, in a transverse section, the bore has the form of an ellipse of small excentricity, being *freed*[a] at the breech: the projectile is cylindro-conoidal, with a circular base, and, when heated by the fired gunpowder, it expands so far as to take a form corresponding to the elliptical section of the bore. The bore, being a continuous spiral, fulfils the object of grooves, and causes the shot, in passing along it, to acquire a rotatory motion on its axis. The spiral is not uniform in its whole length, but has what is called by the Americans a *gaining twist* or *an increasing spiral.* The advantages of this rifle are supposed to be,—greater accuracy of practice, less recoil than other muskets have, and no tendency to cause the rifle to turn over sideways.

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[a] To be freed at the breech signifies that the bore is made larger there than in the anterior part of the barrel: the term is also used to denote an enlargement of the grooves at the same place. The Americans enlarge in this manner the whole of the barrel up to within 1½ inch of the muzzle; English gunmakers only as far as 2 or 3 inches from the breech. The object is to facilitate the operation of ramming home. Not much value is attached to the construction in this country: it may be advantageous for the American rifles, which carry smaller shot than ours; and the like may be said of the American practice of increasing the twist of the spiral grooves towards the muzzle.

In December, 1853, a trial was made at Hythe of Mr. La caster's elliptically-bored muskets freed at the breech, in ord to compare their shooting with that of a rifle-musket of .57 bore, having three grooves regularly spiral of one turn 6 ft. 6 in., which was manufactured at Enfield in the same yea the Report of this trial was in favour of the Enfield rifle, La caster's muskets evincing a strong tendency to *strip*,[a] and at t longer ranges this defect was very marked.

594. The following table, kindly communicated by Colon Hay, on the subject of the rifle-practice at Hythe, shows t comparative accuracy of shooting at different distances, with t common percussion-musket of 1842 and the rifle-musket 1851; the former carrying a spherical bullet, and the latt

Distances.	Percussion Musket, 1842.				
	Number of Hits in the			Hits.	
	Bull's-Eye.	Centre.	Outer.	Total.	Per Cent.
Yards. 100	7	48	94	149	74.5
200	3	20	62	85	42.5
300	4	9	17	32	16.
400	2	..	7	9	4.5

Distances.	Minié Rifle Musket, 1851.				
	Number of Hits in the			Hits.	
	Bull's-Eye.	Centre.	Outer.	Total.	Per Cent.
Yards. 100	10	68	111	189	94.5
200	9	47	104	160	80.
300	6	32	72	110	55.
400	5	29	71	105	52.

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[a] The cause of this stripping was not at the time satisfactorily account for; the defect, however, appears to have been quite remedied by the adopti of the bullet with wooden plug recommended by Colonel Hay, and now general use in the service. There is little doubt therefore that the strippi was caused by the Pritchett bullet, without cup or plug (with which the tri were made), not expanding sufficiently, on the explosion of the powder, so at all times to fill the grooves.

the regulation Minié shot (a cylindro-conoidal projectile). Twenty men fired ten rounds each, 5 in file-firing and 5 in volley-firing, against a target 6 feet high and 20 feet broad, equal to a front of 11 file of infantry, or 22 men.

595. In 1858 Mr. Whitworth of Manchester produced a musket having a hexagonal bore of a spiral figure, making one turn in 20 in., by which the projectiles—either of hexagonal or cylindro-conoidal form—in passing along the barrel acquire a swift and steady rotation on their axes. This species of rifle has been found considerably superior in accuracy of shooting to the Enfield rifle, which has been adopted by the Government.

In order to test the relative merits of these two kinds of weapon, a series of trials were made at Hythe, under the direction of Colonel Hay, the able Superintendent of the School of Musketry at that place, and the results are stated in the following table. The rifles were fired from rests, and ten or twenty rounds were fired from each at the several distances The numbers in the fourth column express, in feet and decimals the means of the distances of the ten or twenty points of impact on the target, from a nearly central point of the group in each trial.

TABLE showing the results of experiments with the "Whitworth" and "Enfield" Rifles.

Description of Rifle.	Distance in yards.	Angle of elevation.	Mean radial deviation.	Remarks.
		° ′	Feet.	
Enfield	500	1 32	2.24	
Whitworth	..	1 15	.37	
Enfield	800	2 45	4.20	
Whitworth	..	2 22	1.00	
Enfield	1100	4 12	8.04	
Whitworth	..	3 8	2.62	
Enfield	1400	..	..	Shooting so wild, no diagram taken.
Whitworth	..	5 0	4.62	
Enfield	1880	..	..	Not tried.
Whitworth	..	6 40	11.62	

596. The superiority of the Whitworth rifle in accuracy of fire is hence manifest; and it may be added that, from its form, the bore is less liable to be worn than that of any grooved rifle. As the projectile may be made harder, it will, consequently,

have greater penetrating power; and, in fact, the Whitworth projectile went through 35 half-inch planks of elm wood, and remained in a bulk of solid oak beyond, while the Enfield projectile went through only 12 such planks.

597. The great superiority in accuracy of shooting of the Whitworth, in comparison with the Enfield 577-bore rifle, was attributable in a great measure to the smallness of Mr. Whitworth's bore, viz. 451, the weight of bullet and charge of powder used being the same. It was decided, therefore, to manufacture rifles on the Enfield plan of rifling, of the same bore as Mr. Whitworth's. Although the accuracy of shooting of these rifles (described as the "Enfield small bore," in which the exact degree of spiral used by Mr. Whitworth, viz., one turn in 20 inches, was adopted) was much greater than that of the Enfield 577 bore, it was found at a trial which took place at the School of Musketry at Hythe, at which several of these small-bore Enfields were produced by the Government contractor of the Birmingham gun-trade, that Mr. Whitworth's rifle fully maintained its superiority in accuracy. In this trial Mr. Whitworth fired only the cylindro-conoidal leaden bullet without alloy, an objection having been made by Mr. Goodman, who represented the Birmingham gun-trade, to the hardened hexagonal bullet being used.

598. Till within the last twenty years, no *sight* was considered necessary for a common musket—the stud at the muzzle being sufficient for the purpose of taking aim. When percussion-arms were first introduced, a fixed block-sight for 120 yards was adopted; and when the Rifle Brigade was supplied with two-grooved rifles, a block-sight for 200 yards and a leaf for 300 yards were affixed to the fire-arm. At present every rifled musket is furnished with a complicated and delicate sight.

599. In a letter lately received from the East it is stated that the rifles used by the Russians at the battle of the Alma were of good construction: they are said to have been formed with two grooves, and to have carried solid conoidal shot, each weighing 767 grains, equivalent in weight to a spherical bullet of 9 to the pound, consequently much heavier than the English regulation Minié shot. They are flat at the base, and have projections at the sides corresponding with the grooves of the musket.

The great weight of these projectiles is very objectionable; the soldiers who carried them must have been very much distressed by the loads in their pouches, or these must have contained a smaller number of shot than are carried by English or French soldiers.

The Russian missile is more pointed than the English Minié shot, and, no part being cylindrical, it must be liable to irregular movements in the barrel, and, consequently, to unsteadiness in its flight. It has the designation of a Minié shot, a term now generally but improperly applied to all elongated shot for musketry, since they differ from one another both in form and weight.

600. The rifle used in the French service up to the commencement of the late Italian war consisted only of the carabine à tige, and these only to special corps of riflemen. However eminent the authority of Colonel Minié on the subject of rifles, his method of rifling was never introduced into the French service. Throughout the Crimean war the French infantry of the line were armed with the smooth-bored regulation musket. Some time previous to the Italian campaign the whole of the French infantry had their old muskets rifled, and conical shot introduced—the rifling principle being a triangular hollow cut in the bottom of the shot, without any cup, as in the Minié system. The efficient range did not exceed 600 yards, and was very inaccurate beyond 400 yards. This imperfect measure, as admitted by the French authorities, hardly kept pace with the general improvement in small-arms, but they were restricted by considerations of economy, which did not admit of any general alteration of the muskets in store. Thus all the French infantry during the late campaign used these defective rifled muskets, with the exception of the chasseurs, who retained the carabine à tige, the range of which was far superior to the ordinary musket rifled as explained. The tige will however be done away with as soon as possible, and an elongated shot similar to that in general use adopted, and consequently much heavier than the spherical bullet of the carabine à tige; and with an increased charge of powder it will produce a more extensive range.

APPENDIX.

(A.)

Copy of the Prospectus compiled by Sir S. J. Pechell from the 'Naval Gunnery' for the Establishment on Board the "Excellent," as stated in his Letters to the Author, Note, pp. 8, 9, *Part I., and in the Text, p.* 10.

Their Lordships having had under their consideration the propriety and expediency of establishing a permanent corps of seamen to act as Captains of Guns, as well as a depôt for the instruction of the officers and seamen of His Majesty's Navy in the theory and practice of Naval Gunnery, at which a uniform system shall be observed and communicated throughout the Navy, have directed, with a view to the formation of such Establishment, that a proportion of intelligent, young, and active seamen shall be engaged for five or seven years, renewable at their expiration, with an increase of pay attached to each consecutive re-engagement, from which the important situation of Master Gunners, Gunners' Mates, and Yeomen of the Powder-room shall hereafter be selected, to instruct the officers and seamen on board such ships as they may be appointed to, in the various duties at the guns, in consideration of which they will be allowed 2*s*. per month, in addition to any other rating they may be deemed qualified to fill, and will be advanced according to merit and the degree of attention paid to their duty, which, if zealously performed, will entitle them to aspire to the important situations before mentioned, as well as that of Boatswain.

Their Lordships have therefore directed the "Excellent," with her present fittings (already placed in a situation where practice may be carried on with shot without risk of injury to any individuals), to be established as a sixth-rate, with a complement of 200 men, and appointed Captain . . . . . . to the command of her.

The following instructions are sent for your guidance and that of Captain . . . . . . in the execution of these duties:—

Complement.

		Boys of Second Class.
Captain	1	
Lieutenants	4	
Surgeon	1	
Purser	1	
Assistant-Surgeon	1	
Midshipman	15	
Clerk	1	
Warrant-officers	3	
Ship's cook	1	
Cook's mate	1	
Carpenter's crew	2	
Armourer	1	
Purser's steward	1	
Sick-boy	1	
Captain's servants	2	1
Gun-room ditto	2	4
Midshipmen's berth	2	1
Warrant officer's ditto		3
Purser's steward		1
Marines	34[a]	
Seamen-gunners	116	
	190	10

As in the establishment of the officers and crew of the "Excellent," a Lieutenant, three non-commissioned officers, and two privates of the Marine Artillery are included in her complement of Marines, it is intended that the theoretical instruction required for the officers and seamen-gunners should be furnished by them, and you will take care that every facility and assistance be given then to insure the performance of this duty, the most material points of which are the names of the different parts of a gun and carriage, the dispart in terms of lineal magnitude and in degrees, how taken, what constitutes point blank and what line of metal range, windage, the errors and loss of force attending it, the importance of preserving shot from rust, the theory of the most material effects of different charges of powder applied to practice, with a single shot, also with a plurality of balls, showing how these affect accuracy, penetration, and splinters; to qualify them to judge of the condition of gunpowder by inspection; to ascertain its quality by the ordinary tests and trials, as well as by actual proof, these being very indispensable qualifications; to instruct them also in the laboratory works required for the naval service,[b] such as making rockets for signals, filling tubes, new priming them and filling cartridges, precautions in airing and drying powder, care

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[a] Including 1 officer of Marine Artillery, 3 non-commissioned officers, and 2 privates.

[b] Laboratory works being dangerous, ought to be taught on shore.

and inspection of locks, choice of flints, correct mode of fitting them, &c. &c.

You are to understand that it is the intention of their Lordships that the Gunners from His Majesty's ships in ordinary, and also from the ships in commission when they can be spared, should assemble on board the "Excellent," in divisions of such numbers as the Commander may deem convenient, to carry on (assisted by the Marine Artillery already embarked in her) the fullest experiments as to the power and ranges of the various natures of sea-ordnance from point blank to the highest elevation the ports of the "Excellent" will admit of (or as may be safely tried without danger of the shot reaching the shore beyond the mud-banks), also the ranges at similar elevations with different reduced charges of powder, likewise the difference in the ranges when two shots are introduced instead of one,[c] and in such cases to observe and note down the apparent divergence of both shots from the direct line. Also, if it can be tried with safety, the range and force of grape and canister shot; and, in short, every experiment of such description which will tend to give the gunners and others who may attend such practice the most perfect knowledge of the exact powers of each nature of gun in every manner in which it can be tried.

To facilitate these experiments their Lordships consider that Beacons may be fixed in the mud at different measured distances from the ship, say at every hundred or every two hundred yards, or at such other distances as may be found most convenient.

At the same time that the above-mentioned experiments are going forward it will be the duty of the Captain and of the Lieutenants to assist him, to endeavour to ascertain the comparative value of the several descriptions of sights for cannon which have been submitted by various individuals, some of every kind of which the Board of Ordnance has been desired to cause to be put on board the "Excellent."

It is also their Lordships' intention that the efficiency of the improved tube-boxes, powder-flasks, and all other implements of every description connected with sea-gunnery practice, should be proved, as far as may be done, on board the "Excellent," and Captain . . . . . . is to consider it an important part of his duty to report impartially his opinion on all the implements in question, and to submit for their Lordships' consideration any alteration of any of them deemed likely to prove advantageous by himself or any of the officers assisting him in conducting the duties hereby ordered.

The Captain is also to make known to their Lordships any improvements he may have been informed of, either in guns them-

[c] Two shots are as many as ought to be used for safety and effect.

selves, or in the mode of mounting, or fitting, or fighting them, or of the implements for serving them which may not have been furnished by the Ordnance Department to the "Excellent," in order that they may cause them to be also supplied for trial and report.[d]

Another material branch of the duty of Captain . . . . . . will be to perfect the gunners and all others who may attend on board the "Excellent" for that purpose, in the established exercise or service of the guns, to the end that each of them may fully understand and be able to explain the object of every movement ordered; that they likewise understand perfectly the principle of the sights, moveable targets, and everything used in gun practice, either for exercise or real service.

All these points, after being fully considered and tried in the various exercises and practice to be daily carried forward, are to be fully reported upon to their Lordships, in order that they may give directions for the general adoption of that system which shall be found and admitted, upon full and fair trial, to answer best in practice.[e]

It is further to be understood that any ships in commission, the Captains of which are desirous of sending any portion of their officers, captains of guns, or others of their crews, to attend the practice or exercise on board the "Excellent," to gain instruction on any of the points detailed, are to be at liberty to do so, and it is to be an essential part of the duty of Captain . . . . . . and the Lieutenants to give every useful information to persons so sent for instruction, and to advance them on the points most useful for them to understand, to such extent as the short time they can probably be spared will admit.

Their Lordships have requested the Board of Ordnance to give instructions to their officers to render every assistance in forwarding the objects of these instructions, and to supply such quantities of ammunition or other articles as may from time to time be required by Captain . . . . . . and approved by you for the purposes above detailed.

Captain . . . . . . is to be assisted in conducting these duties by the officer of Marine Artillery to the utmost of his abilities, and the latter officer is to be directed to obey whatever directions he may receive from Captain . . . . . . or the Lieutenants for the objects stated whilst on this service.

Their Lordships desire that you send a copy of this letter to Captain . . . . . ., that he may be fully apprised of the duties he is to execute, directing him to govern himself and those placed

[d] The improvements or inventions ought to be first submitted to the Admiralty.

[e] A register to be kept on board of all experiments, that the Commanding Officer may be able to contrast the results.—A second register to be kept of the exercises which are carried on daily, containing a nominal list of the persons under instruction.

APPENDIX (B).

I.—A Practical Table of Approximate Ranges, with the Times of Flight.

Nature of Gun.	Charge of Powder.	Range in Yards.																
	lbs.	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1800	2000
10-inch Gun, 86 cwt.	12	¼° ..	½° 1″	¾° 1¼″	1° 1½″	1¼° 2″	1¾° 2½″	2° 3″	2¼° 3¼″	2¾° 3¾″	3° 4″	3¼° 4¼″	3¾° 4½″	4° 4¾″	4½° 5¼″	5° 5¾″	6° 6¾″	7¼° 7¾″
For all 8-inch Guns, with these Charges.	10	.. ..	¼° 1″	½° 1¼″	¾° 1½″	1° 2″	1¼° 2¼″	1¾° 2½″	2° 3″	2¼° 3¼″	2¾° 3½″	3° 4″	3¼° 4¼″	3¾° 4¾″	4° 5¼″	4½° 5½″	5¼° 6½″	6° 7½″
	8	¼° ..	½° 1″	¾° 1½″	1° 1¾″	1¼° 2¼	1½° 2½″	2° 2¾″	2¼° 3¼″	2½° 3½″	3° 3¾″	3¼° 4½″	3½° 4½″	4° 5″				
	5	½° 1″	¾° 1¼″	1° 1¾″	1½° 2¼″	1¾° 2½″	2¼° 3″	2¾° 3½″	3° 3¾″	3½° 4¼″								
For 32-pounder 56 cwt. Guns, with these Charges, *see* Note.	10	..	..	¼°	½°	¾°	1°	1¼°	1½°	1¾°	2°	2¼°	2½°	2¾°	3°	3½°	4½°	5½°
	8	.. ..	¼° 1″	½° 1¼″	¾° 1½″	1° 1¾″	1¼° 2″	1½° 2¼″	1¾° 2½″	2° 3″	2¼° 3¼″	2½° 3½″	2¾° 4″	3° 4½″				
	6	¼° ..	½° 1″	¾° 1¼″	1° 1½″	1¼° 2″	1¾° 2¼″	2° 2½″	2¼° 2¾″	2¾° 3¼″	3° 3½″	3½° 4″						
32-pounder Gun, 25 cwt.	2½	½° 1″	¾° 1¼″	1° 1½″	1½° 2″	2° 2¼″	2½° 2¾″	3° 3″	3½° 3½″	4° 4″								

Note.—The Ranges for the 32-pounder 56 cwt. gun will answer for 32-pounder guns having the same windage, though of different lengths. And the Ranges, with the 10, 8, and 6 lbs. charges for the 32-pounder 56 cwt. gun may be taken as an approximation for the Ranges with 8, 6, and 4 lb. charges respectively for 32-pounder guns having less windage.

under him accordingly. And you are also to give such furt directions and assistance as you may deem necessary or advisa for the more perfect accomplishment of the objects explained ; you are to cause Captain . . . . . . to make a weekly return to of each day's transactions and practice, not the number and descriptions of persons attend on board each day ; to which also is to be added remarks the Captain may deem it right to o relative to the occurrences or details; and t weekly returns are to be regularly transmi by you to me for their Lordships' informatio

[f] Certificates of qualification, founded upon the register before mentioned, should be given to each man, according to his merit and proficiency on completing his instruction; and copies of the same transmitted to the Admiralty.

IV.—A Table of Charges and Times of Flight for dropping a Shell over the Parapet of a Battery, or for dislodging an Enemy from behind an Embankment.

Nature of Gun.	Elevation by Tangent-Sight.	Ranges in Yards, with Charges and Time of Flight.				
		400	500	600	700	800
10-inch, 86 cwt.	15°	15 ounces 4¾″	19 ounces 5¼	22 ounces 5¾″	25 ounces 6¼″	28 ounces 6¾″
10-inch, 86 cwt.	10°	20 ounces 4″	24 ounces 4½″	28 ounces 5″	32 ounces 5½′	36 ounces 6″
8-inch, 86 cwt.	10°	14 ounces 4″	18 ounces 4½″	22 ounces 5″	25 ounces 5½″	28 ounces 6″
32-pounder, 56 cwt.	10°	7 ounces 4″	8½ ounces 4½″	10 ounces 5″	12 ounces 5½″	14 ounces 6″

Note.—When firing Shells on the water for practice with the above charges and elevations, the fuzes must be fitted half a second shorter than the time of flight given in this Table, otherwise they will strike the water and be extinguished, as shells with that flight are intended to burst *immediately after* striking the ground.

II.—Ranges with Sea-Service Iron Mortars at 45°, obtained by Marine Artillery, in 1806, at Landguard Fort.

13-inch Sea-service Mortar, 100 cwt. Shell loaded, 200 lbs. Bursting-charge, 10½ lbs.

Charge....	1 lb.	2 lbs.	3 lbs.	4 lbs.	5 lbs.	6 lbs.	7 lbs.	8 lbs.	9 lbs.	10 lbs.	12 lbs.	14 lbs.	16 lbs.	18 lbs.	20 lbs.
Range	Yds. 420	Yds. 620	Yds. 980	Yds 1240	Yds. 1650	Yds. 1940	Yds. 2180	Yds. 2480	Yds. 2800	Yds. 2960	Yds. 3330	Yds. 3620	Yds. 3850	Yds. 4100	Yds. 4200
Time of Flight	″ 9	″ 11·25	″ 14·12	″ 16·36	″ 18·06	″ 20·56	″ 21·9	″ 23·4	″ 24·25	″ 25·3	″ 26·9	″ 28·1	″ 29·1	″ 29·8	″ 30·4

III.—10-inch Sea-service Mortar, 52 cwt. Shell loaded, 92lbs. Bursting-charge, 5½ lbs.

Charge....	1 lb.	2 lbs.	3 lbs.	4 lbs.	5 lbs.	6 lbs.
Range	Yds. 1030	Yds. 1690	Yds. 2180	Yds. 2560	Yds. 2890	Yds. 3090
Time of Flight	″ 15	″ 19	″ 21·8	″ 24	″ 25·5	″ 26·55

IV.—A TABLE of CHARGES and TIMES of FLIGHT for dropping a Shell over the Parapet of a Battery, or for dislodging an Enemy from behind an Embankment.

NATURE OF GUN.	ELEVATION BY TANGENT-SIGHT.	RANGES IN YARDS, WITH CHARGES AND TIME OF FLIGHT.				
		400	500	600	700	800
10-inch, 86 cwt.	15°	15 ounces 4¾"	19 ounces 5¼	22 ounces 5¾"	25 ounces 6¼"	28 ounces 6¾"
10-inch, 86 cwt.	10°	20 ounces 4"	24 ounces 4½"	28 ounces 5"	32 ounces 5½'	36 ounces 6"
8-inch, 86 cwt.	10°	14 ounces 4"	18 ounces 4½"	22 ounces 5"	25 ounces 5½"	28 ounces 6"
32-pounder, 56 cwt.	10°	7 ounces 4"	8½ ounces 4½"	10 ounces 5"	12 ounces 5½"	14 ounces 6"

Note.—When firing Shells on the water for practice with the above charges and elevations, the fuzes must be fitted half a second shorter than the time of flight given in this Table, otherwise they will strike the water and be extinguished, as shells with that flight are intended to burst ***immediately after*** striking the ground.

V.—Ranges with Sea-Service Iron Ordnance obtained on board Her Majesty's Ship "Excellent."

Elevation by Tangent-Sight.

Nature of Gun.	Length.	Weight.	Diameter of Bore.	Windage.	Weight of Shot or Shell.	Charge.	The Elevation and Range in Yards, with corresponding Times of Flight.																				
							¼	½	¾	1	1½	2	2½	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	Ft. In.	Cwt.	In.	In.	lbs.	lbs.																					
10-inch	9 4	86	10·	·16	Shot Shell 84	12	140	260 ¾"	380	500 1½"	650 2¼"	800 3"	950 3½"	1100 4"	1400 4¾"	1600 5¾"	1780 6¾"	1940 7½"	2100 8¼"	2240 9"	2380 9¾"	2520 10¾"	2660 11½"	2800 12¼"	2930 13"	3060 14"	3180 15"
8-inch	9 0 8 10	65 60	8·05	·125	Shot 56	10	160	300	430	550	750	900	1050	1200	1500	1760	1980	2160	2340	2520	2700	2850	3000	3120	3240	3340	3440
,,	,,	,,	,,	,,	Shell 51	10	200	350 1"	480 1½"	600 2"	800 2½"	950 3"	1100 3½"	1240 4¼"	1500 5¼"	1760 6¼"	1980 7¼"	2160 8¼"	2340 9¼"	2500 10"	2660 10¾"	2780 11½"	2900 12¼"	3000 13"	3100 13½"	3200 14"	3300 14½"
8-inch	9 0 8 10 8 0	65 60 54	8·05	·125	Shot 56	8	140	260	380	500	680	830	980	1130	1430	1660	1880	2060	2240	2420	2600	2760	2900				
,,	,,	,,	,,	,,	Shell 51	8	150	300 1"	430 1½"	550 2"	730 2½"	880 3"	1020 3½"	1160 4"	1430 5"	1660 6"	1880 7"	2060 8"	2240 9"	2400 9¾"	2560 10½"	2680 11¼"	2780 12"				
8-inch	9 0 8 10	65 60	8·05	·125	Shot 56 Shell 51	5	120	220 1"	300 1¼"	370 1¾"	510 2¼"	650 2¾"	770 3¼"	890 3¾"	1120 4¾"	1300 5¾"											
8-inch	8 0	54	8·05	·125	Shot 56 Shell 51	5	100	180	260 1"	330 1½"	470 2"	600 2½"	720 3"	830 3½"	1020 4½"	1170 5½"											

Remarks.—The Experiments with 8-inch Shells made on board the "Excellent" in the Autumn of 1838, and on which the tables for Shell-practice were formed, were corroborated by experiments made at Woolwich on the 5th November, 1838. From which it appeared that at 1250 yards 10 lbs. of powder forced the Shell through one side, and fixed it in the other side of a section of a Line-of-Battle Ship at the lower deck, and with 8 lbs. of powder the Shell passed through the first side and rebounded from the second. At 900 yards, with charges of 8 and 10 lbs. of powder, the Shell passed through the first side and lodged in the second. At 660 yards, with a charge of 5 lbs. of powder, the Shell passed through the first side and lodged in the second. At 300 yards, with charges of 8 and 7 lbs. of powder, the Shell passed through both sides. With the 56 lbs. Hollow Shot and 10 lbs. of powder, the Shot at 1250 yards passed through the first side and buried itself in the second. From that practice it was recommended that the lowest charge should be used which would give

V.—*continued.*—

								¼	½	¾	1	1½	2	2½	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
68-pr.	10 0	95	8·12	·198	Shot	68	16	220	340 ½"	500 1"	640 1½"	860 2¼"	1060 3"	1240 3¾"	1400 4¼"	1700 5¼"	1960 6¼"	2180 7¼"	2380 8¼"	2560 9¼"	2720 10¼"	2880 11½"	3040 12"	3200 12⅞"	3340 13¾"	3480 14⅝"	3620 15½"	3740 16⅜"	3860 17¼"	3980 18⅛"
,,	,,	,,	,,	,,	Shell	51	16																							
,,	,,	,,	,,	,,	Shot	68	12	200	300	400	510	730	940	1160	1330	1590	1830	2060	2270	2470	2640	2790	2940	3070	3200	3330	3460	3580		
,,	,,	,,	,,	,,	Shell	51	12	400 1"	510 1½"	620 1⅝"	730 2"	930 2¾"	1090 3¼"	1230 3¾"	1340 4"	1560 5"	1770 6"	1970 7"	2170 8"	2360 9"	2530 10"	2690 11"	2850 12"	2990 13"	3130 14"	3260 15"	3380 16"	3500 17"	3600 18"	3700 19"
,,	,,	,,	,,	,,	Shot	68	8	170	250	330	410	570	720	870	1020	1270	1500	1690	1870	2050	2230	2400								
,,	,,	,,	,,	,,	Shell	51	8	250	330 1"	420 1¼"	500 1½"	650 2"	800 2½"	940 3"	1070 3¼"	1310 4½"	1530 5¾"	1710 6½"	1890 7½"	2060 8¼"	2220 9"	2380 10"								
32-pr.	9 6	58	6·375	·198	Shot	32	10	320	460	600	720	930	1140	1320	1500	1740	1980	2200	2380	2560	2720	2880	3020							
,,	,,	,,	,,	,,	Shell	24	10	440 1⅛"	600 1½"	710 1¾"	820 2"	1000 2¾"	1140 3⅛"	1280 3¾"	1400 4¼"	1630 5½"	1840 6½"	2030 7½"	2200 8¾"	2360 9"	2500 9¾"	2640 10¾"	2770 12"	2880 14"						
,,	,,	,,	,,	,,	Shot	32	8	270	420	540	660	850	1060	1240	1400	1640	1880	2100	2280	2460	2620	2780								
,,	,,	,,	,,	,,	Shell	24	8	380 1"	520 1¼"	640 1⅝"	740 1⅞"	910 2¼"	1070 3"	1220 3½"	1340 4¼"	1580 5½"	1790 6½"	1970 7¼"	2140 8¼"	2310 9"	2470 10"	2620 11¼"	2760 12½"							
,,	,,	,,	,,	,,	Shot	32	6	210	360	490	600	780	960	1120	1280	1500	1700	1880	2060	2240	2420	2580								
,,	,,	,,	,,	,,	Shell	24	6	290 1"	440 1½"	570 1¾"	680 2"	870 2½"	1040 3¼"	1200 4"	1330 4¾"															

Note.—It is better, as a rule, not to fire 6-inch Shells with a higher charge than 8 lbs., as, when fired with 10 lb. charges, they sometimes burst prematurely. In firing Spherical Case from heavy Guns, the Charges, Elevations, and Times of Flight may be taken as for Common Shell.

V.—*continued.*—RANGES with SEA-SERVICE IRON ORDNANCE obtained on board Her Majesty's Ship "Excellent."

Elevation by Tangent-Sight.

Nature of Gun.	Length.		Weight.	Diameter of Bore.	Windage.	Weight of Shot or Shell.		Charge.	The Elevation and Range in Yards, with corresponding Times of Flight.																				
									¼	½	¾	1	1½	2	2½	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	Ft.	In.	Cwt.	In.	In.		lbs.	lbs.																					
32-pr.	9	6	56	6·41	·233	Shot	32	10	300	440	570	700	900	1100	1280	1460	1700	1900	2100	2280	2460	2620	2780	2920	3060	3180	3300	3420	3540
,,	,,		,,	,,	,,	Shell	24	10	430 1⅛"	570 1½"	700 1¾"	800 2"	960 2¼"	1100 3"	1230 3½"	1350 4"	1570 5"	1760 6"	1940 7"	2100 7¾"	2250 8½"	2400 9½"	2530 10"	2660 11"	2780 12"	2880 13"	2970 14"		
,,	,,		,,	,,	,,	Shot	32	8	250	380	500	600	800	1000	1200	1380	1620	1820	2020	2200	2340	2480	2620	2760	2900				
,,	,,		,,	,,	,,	Shell	24	8	350 1"	500 1½"	620 1¾"	720 2"	880 2½"	1040 3"	1180 3½"	1320 4"	1520 5"	1720 6"	1920 7"	2080 7¾"	2220 8½"	2360 9½"	2500 10"	2620 11"	2740 12"	2840 13"	2940 14"		
,,	,,		,,	,,	,,	Shot	32	6	150	280	400	500	660	820	950	1080	1340	1540	1720	1900	2060								
,,	,,		,,	,,	,,	Shell	24	6	200	340 1¼"	460 1½"	580 1¾"	740 2¼"	900 2¾"	1040 3¼"	1180 3¾"	1420 4¾"	1640 5¾"	1820 6¾"	1980 7½"	2100 8½"	2200 9"	2300 9¾"						

V.—*continued.*

									¼	½	¾	1	1½	2	2½	3	4	5	6	7	8	9	10	Remarks.
32-pr(A)	9	0	50	6·375	·198	Shot	32	8	300	440	580	700	900	1100	1280	1460	1680	1900	2100	2280	2460	2620	2780	
,,	,,	,,	,,	,,	,,	Shell	24	8	380 1"	520 1¼"	640 1⅝"	740 1⅞"	910 2¼"	1070 3"	1220 3½"	1340 4¼"	1580 5½"	1790 6½"	1970 7¼"	2140 8¼"	2310 9"	2470 10"	2620 11¼"	
32-pr(B)	8	6	45	6·35	·173	Shot	32	7	260	400	520	640	840	1020	1200	1380	1600	1820	2020	2200	2360	2520	2680	
,,	,,	,,	,,	,,	,,	Shell	24	7	300 ⅞"	460 1⅛"	600 1½"	700 1¾"	860 2⅛"	1020 2¾"	1180 3¾"	1300 4¼"	1500 5¼"	1700 6¼"						
32-pr(C)	8	0	42	6·35	·173	Shot	32	6	240	360	480	600	800	960	1120	1280	1500	1700	1880	2060	2240	2420	2580	
,,	,,	,,	,,	,,	,,	Shell	24	6	200	360 1⅛"	500 1¼"	600 1⅝"	800 2¼"	960 2¾"	1120 3½"	1240 4¼"	1460 5¼"	1660 6¼"						When the Reduced charges of the heavier guns are similar to the Full charges of the lighter guns having the same windage though of different lengths, the Ranges obtained with the lighter guns may be used as an approximation for the heavier guns.
32-pr.	6	6	32	6·3	·123	Shot Shell	32 24	5	180	280 1¼"	380 1⅜"	480 1⅝"	660 2⅛"	820 2¾"	960 3¼"	1080 4"	1300 5"	1500 6"	1680	1860	2020	2180	2340	
32-pr.	6	0	25	6·3	·123	Shot Shell	32 24	4	160	260 1⅛"	360 1⅜"	460 1⅝"	620 2"	760 2¼"	900 3¼"	1020 3¾"	1220 4¾"	1420 5¾"	1620	1800	1980	2140	2300	
,,	,,	,,	,,	,,	,,	,,	,,	2½	100	200 1¼"	280 1½"	360 1⅝"	500 2"	620 2¼"	740 2¾"	820 3¼"	1000 4¼"	1160 5"						These Ranges also answer for the Reduced charge of the 32-cwt. gun and for the 32-pounder carronade.

Note.—It is better, as a rule, not to fire 6-inch Shells with a higher charge than 8 lbs., as, when fired with 10 lb. charges, they sometimes burst prematurely. In firing Spherical Case from heavy guns, the Charges, Elevations, and Times of Flight may be taken as for Common Shell.

VI.—Ranges with Guns that are nearly obsolete, single shotted, obtained on board Her Majesty's Ship "Excellent."

Elevation by Tangent-Sight.

Nature of Gun.	Length.	Weight.	Diameter of Bore.	Windage.	Charge.	Elevation and Range in Yards, with corresponding Times of Flight.																			
						½°	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	11°	12°	13°	14°	15°	16°	18°	20°	24°	25°
	Ft. In.	Cwt.	In.	In.	lbs.																					
68-pr.	10 10	113	8·12	·198	20	500 ⅞"	780 1⅞"	1200 3⅜"	1500 4⅝"	1760 5¾"	2020 6¾"	2240 7¾"	2420 8¾"	2600 9⅝"	2760 10½"	2920 11⅝"	3080 12¼"	3240 13⅛"	3380 14"	3520 14⅞"	3660 15¾"	3780 17"	4020 17¾"			
68 ,,	9 8	91	8·12	·198	15	320 ½"	620 1¼"	1040 3"	1380 4¼"	1680 5¼"	1940 6¼"	2160 7¼"	2360 8½"	2540 9¼"	2700 10¼"	2860 11⅛"	3020 12"	3180 12⅞"	3320 13¾"	3460 14⅝"	3600 15½"	3720 16⅝"	3960 18⅛"	4160 19⅞"	4540	4820
68 ,,	9 6	87	8·12	·198	14	300 ¼"	600 1½"	1020 3"	1360 4¼"	1660 5¼"	1920 6¼"	2140 7¼"	2320 8¼"	2480 9⅛"	2620 10"	2760 10⅞"	2900 11¾"	3040 12⅝"	3180 13½"	3320 14⅝"	3460 15¼'	3580 16¼"	3820 17⅞"			
56 ,,	11 0	97	7·65	·175	16	370 1"	660 1¾"	1200 3"	1600 4¼"	1900 5½"	2120 6½"	2320 7½"	2500 8¼"	2660 9¼"	2820 10½"	2980 11⅜"	3120 12¼"	3260 13⅛	3400 14"	3520 14⅞"	3640 15¾"					
56 ,,	10 0	87	7·65	·175	14	450 1⅛"	740 2"	1180 3"	1480 4⅛"	1740 5¼"	1980 6¼"	2200 7¼"	2400 8¼"	2580 9¼"	2760 10¼"	2920 11¼"	3080 12⅛"	3220 13"	3360 13⅞"	3480 14¾"	3600 15⅝"					
42 ,,	10 0	84	6·97	·208	14	420 1"	720 2"	1120 2⅞"	1460 4⅛"	1740 5¼"	2000 6⅜"	2220 7¼"	2420 8¼"	2600 9¼"	2760 10¼"	2900 11¼"	3020 12⅛"	3140 13"	3260 13½"	3360 14½"	3460 15½"	3560 16½"	3720	3880	4150	4300
42 ,,	10 0	75	6·97	·208	12	400 1"	700 2"	1100 2⅞"	1420 4⅛"	1680 5⅛"	1940 6⅜"	2160 7¼"	2340 8¼"	2520 9¼"	2680 10¼"	2820 11¼"	2960 12"	3080 12¾"	3200 13¼"	3300 14¼"	3400 15"	3500 15¾"	3660	3820	4100	4320

VI.—*continued.*

						Elevation by Spirit Level. Height above Plane 5 ft. 4 in.										
						½°	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°
24-pr.	9 6	50	5·82	·211	8	500	750	1120	1420	1640	1820	1980	2120	2260	2380	2500
18 ,,	9 0	42	5·29	·193	6	430	680	990	1270	1500	1710	1890	2020	2130	2220	2310
18 ,,	7 0	42	5·17	·071	3	330	540	850	1100	1320	1540	1670	1760	1840		
Carronades.																
8-inch	5 4	36	8·05	·125	5	270	500	730	940	1100	1260					
42-pr.	4 6	22	6·84	·078	3½	230	430	700	900	1050	1200					
32 ,,	4 0	17	6·25	·073	2½	220	380	600	800	970	1140					
24 ,,	3 9	13	5·68	·068	2	200	360	580	770	950	1120					
18 ,,	3 4	10	5·16	·061	1½	180	340	550	740	920	1050					
12 ,,	2 8	6	4·52	·056	1	150	310	520	720	890	970					

VII.—RANGES WITH BRASS ORDNANCE.

Elevation by Tangent-Sight.

Nature of Gun.	Diameter of Bore.	Windage	Weight of Shot or Spherical Case.	Charge.	Elevation and Range in Yards, with corresponding Lengths of Fuze.												
					¼°	½°	¾°	1°	1½°	2°	2½°	3°	3½°	4°	4½°	5°	6°
Howitzer.	In.	In.	Sph.Case	lbs.													
24-pr. 4 ft. 8 in. 12½ cwt.	5·72	·12	20 lbs.	2½	250	300	350	400	500	600	700	800	900	1000	1100	1200	1350
			No. of Balls.	Burster.													
			100	3 ozs.		·1	·1	·15	·2	·25	·35	·45	·55	·65	·75	·85	1·0
					These Ranges may also be used for the Hollow Shot and Shell.												
					⅝°	⅞°	1⅛°	1½°	2°	2½°	3°	3½°	4°	4½°	5°	6°	7°
Howitzer.			Shot.														
12-pr. 4 ft. 6 in. 10 cwt.	4·58	·12	12 lbs.	2 lbs.	200	300	400	500	650	800	950	1050	1150	1250	1350	1550	1700
				Burster.													
				1 oz. 12 drs.	·1	·15	·2	·25	·35	·5	·6	·7	·8	·9	1·0		
					These Ranges may also be used for the Spherical Case and Common Shell												

VII.—*continued.*

					½°	¾°	1°	1½°	2°	2⅝°	3°	3⅜°	3¾°	4⅛°	4½°	5°	6°
Howitzer. 12-pr. 3 ft. 9 in. 6½ cwt.	4·58	·12	Sph.Case 10 lbs.	1¼ lbs.	250	300	350	450	550	650	700	750	800	850	900	950	1050
			No. of Balls. 75	Burster. 1 oz. 12 drs.	·1	·1	.15	·2	·3	·4	·45	·5	·6	·6	·65	·7	·8
					These Ranges may also be used for the Hollow Shot and Shell.												
					¼°	½°	¾°	1°	1½°	2°	2½°	3°	3¼°	4½°	5¼°	6°	
Gun. 6-pr. 5 ft. 6 cwt.	3·67	·12	Sph.Case 5 lbs.	1½ lbs.	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	
			No. of Balls. 30	Burster. 12 drs.	·1	·15	·2	·25	·3	·4	·5	·6	·7	·8	·9	1·0	
					These Ranges may also be used for the Shot.												

Note.—In firing Spherical Case from heavy guns, the Charges, Elevations, and Times of Flight may be taken as for Common Shell.

VIII.—Ranges, by Ricochet, with Sea-Service Iron Ordnance, single-shotted, obtained on board Her Majesty's Ship "Excellent."

Elevation by Spirit Level.

Nature of Guns.	Weight.	Length.		Diameter of Bore.	Charges.	Height above the Plane.		Elevation.	First Graze.	Extreme Graze before Deflection.	No. of Grazes.	Remarks.
	Cwt.	Ft.	In.	Inches.	lbs.	Ft.	In.	°	Yards.	Yards.		
10-inch ..	84	9	4	10	12	12	6	¼	280	2850	16	The ricochet ranges were generally obtained when the water was perfectly smooth. It has been observed that a slight ripple diminishes the range considerably.
								1	658	2700	14 Hollow Shot 84 lbs.	
								2	770	2680	18	
8-inch ..	65	9	0	8·05	10	12	6	¼	340	2900	32	Ricochet ranges are not given for Shells, because the Time-fuzes are always extinguished when so used.
	60	8	6					1	626	2766	23 Hollow Shot 56 lbs.	
								2	970	2576	14	
8-inch ..	50	6	8	8·05	7	5	4	¼	331	2150	14	
								1	653	2017	14 Hollow Shot 56 lbs.	
								2	933	2333	9	
32-pounder	56	9	6	6·41	10	12	6	¼	350	2850	24	
								1	800	2900	15	
								2	1220	2650	12	

VIII.—*continued.*

32-pounder	50	9 0	6·375	8	5 6	..	346	3183	33	
						1	747	3033	26	
						2	1173	2490	13	
32-pounder	45	8 6	6·35	7	5 6	..	333	2450	15	It has been observed in ricochet firing that the nearer the gun is placed to the water (other circumstances being alike) the greater is the range of the shot. It might, therefore, in some cases, be advisable to heel the ship over, by running in the opposite guns.
						1	716	2150	8	
						2	1040	2260	8	
32-pounder	42	8 0	6·35	6	5 6	..	326	2366	19	
						1	700	2100	8	
						2	1026	2480	16	
32-pounder	39	7 6	6·35	6	12 6	..	333	2003	9	
						1	637	1867	8	
						2	857	2007	18	
32-pounder	32	6 6	6·3	5	12 6	..	300	1980	15	
						1	580	1800	10	
						2	800	1950	15	
32-pounder	25	5 4	6·3	4	5 4	..	270	1980	21	
						1	480	2027	16	
						2	990	1670	6	

IX.—RANGES with SEA-SERVICE IRON ORDNANCE, with Double Grape, obtained on board Her Majesty's Ship "Excellent."

Elevation by Tangent-Sight.

Nature of Guns.	Weight.	Length.	Charge.	Elevation.	First Graze of Grape.	Extreme Range of Grape.	Spread of Grape at Yards.									Extreme Spread of Grape.
							500	450	400	350	300	250	220	200	150	
	Cwt.	Ft. In.	lbs.	°	Yards.	Yards.	Yards.	Yards.	Yards.	Yards.	Yards.	Yards.	Yards.	Yards.	Yards.	Yards.
32-pounder	56	9 6	6	½	40	1210	..	..	..	..	..	..	..	40	..	90
				1	60	1240	..	..	..	..	..	..	30	..	..	120
				2	230	1250	..	..	35	..	..	..	..	..	..	90
32-pounder	50	9 0	5	½	130	1450	..	..	..	..	..	..	..	18	..	65
				1	110	1300	..	..	..	25	..	..	..	..	..	63
				2	130	1250	35	..	..	..	..	..	..	..	..	80
32-pounder	48	8 0	5	½	180	1110	..	..	..	..	..	..	..	..	8	100
				1	170	1320	..	..	..	..	30	..	..	..	..	120
				2	50	1150	..	..	35	..	..	..	..	..	..	100
32-pounder	39	7 6	4	½	190	1270	..	..	..	..	..	20	..	..	..	120
				1	100	1320	30	..	..	..	..	..	..	..	..	80
				2	250	1320	..	50	..	..	..	..	..	..	..	80
32-pounder	25	6 0	2½	½	140	770	..	..	..	..	15	..	..	..	..	55
				1	150	920	..	..	..	..	..	10	..	..	..	65
				2	200	620	..	..	60	..	..	..	..	..	..	50

The following Remarks were made on practice obtained with double Grape and Double Case, in December 1833 :—

The Gun (a 32-pounder 56 cwt.) was loaded with a 6 lb. charge and Double Grape and fired with 1½° of elevation, at the 400-yard target; they fell very close together at about 350 yards, two of the shot passing through the target, and the extreme range was about 1400 yards.

Two 32-pounders 56 cwt. were then loaded, the one with 6 lb. charges and Double Grape, the other with 6 lb. charges and Double Case, and fired at a section of a 74-gun ship's side, distant 300 yards.

The Case Shot grazed the water at about 100 yards' distance, and few of them appeared to reach the object, whereas the Grape

X.—Ranges with Sea-Service Iron Ordnance, with Single Grape, obtained on board Her Majesty's Ship "Excellent."

Elevation by Tangent-Sight.

Nature of Guns.	Weight.	Length.		Charge.	Elevation.	First Graze of Grape.	Extreme Range of Grape.	Spread of Grape at Yards.						Extreme Spread of Grape.
								550	400	380	300	150	100	
	Cwt.	Ft.	In.	lbs.	°	Yards.	Yards.	Yards.	Yards.	Yards.	Yards.	Yards.	Yards.	Yards.
32-pounder	56	9	6	6	½	90	950	..	12	..	..	..	..	60
					1	100	1250	50	..	..	..	..	..	80
					2	100	1450	..	..	..	25	..	..	90
32-pounder	50	9	0	5	½	100	1350	..	..	..	..	..	18	90
					1	120	1400	..	20	..	..	..	..	35
					2	50	1500	..	..	..	..	60	..	120
32-pounder	48	8	0	5	½	80	1010	..	15	..	..	..	..	110
					1	250	1120	..	10	..	..	..	..	85
					2	410	1250	20	..	..	..	..	..	100
32-pounder	39	7	6	4	½	130	1450	..	15	..	..	..	..	100
					1	160	1400	..	8	..	..	..	..	80
					2	230	1400	10	..	..	..	..	..	70
32-pounder	25	6	0	2½	½	290	770	..	25	..	..	..	..	70
					1	190	905	..	..	10	..	..	..	50
					2	190	906	..	40	..	..	..	..	70

June 1858.—Three rounds of Single Grape were fired from a 32-pounder 50 cwt. with 8-lb charges at the "Serpent" Brig, distant 750 yards; out of the 27 balls that were fired 10 struck in a space of 100 feet by 8 feet; 1 passed through the outer planking (4 in. oak); another through outer planking (4 in. fir, but rotten), and then through inner lining (3 inch oak); the remainder penetrating from 2 to 3 inches in oak.

XI.—RANGES with SEA-SERVICE IRON ORDNANCE, with Single Case-Shot, obtained on board Her Majesty's Ship "Excellent."

Elevation by Tangent-Sight.

Nature of Guns.	Weight.	Length.	Charge.	Elevation.	First Graze of Case.	Extreme Range of Case.	Spread of Case at Yards.						Extreme Spread of Case.
							500	450	400	300	200	80	
	Cwt.	Ft. In.	lbs.	°	Yards.	Yards.	Yards.	Yards.	Yards.	Yards.	Yards.	Yards.	Yards.
32-pounder	56	9 6	6	½	40	1150	..	..	..	..	15	..	140
				1	30	1080	..	..	20	..	..	..	160
				2	50	1090	70	..	..	..	..	..	130
32-pounder	50	9 0	5	½	60	1090	..	..	..	..	..	50	120
				1	40	1020	..	80	..	..	..	..	125
				2	120	1200	80	..	..	..	..	..	175
32-pounder	48	8 0	5	½	90	1000	..	..	60	..	..	..	120
				1	150	1000	..	..	35	..	..	..	130
				2	110	1000	..	..	30	..	..	..	130
32-pounder	39	7 6	4	½	100	1300	..	..	..	..	60	..	170
				1	110	1150	..	..	..	..	50	..	200
				2	100	1000	..	..	..	60	..	..	200
32-pounder	25	6 0	2½	½	160	750	..	..	45	..	..	..	75
				1	60	700	..	..	..	..	40	..	120
				2	100	950	..	..	..	60	..	..	125

XII.—PENETRATIONS OF SHOT AND SHELL WITH DIRECT FIRING.

Those at 1200 yards show the average penetrations, *in good oak*, obtained during the Experimental Firing against the "York" (old 74), in 1853.

Those at 2500 yards have been carefully calculated from the above and a few other penetrations, obtained at larger and shorter distances, and in the absence of any practice at this distance, they may be considered as a very good approximation.

Projectile.	Charge.	1200 yards.	2500 yards.
	lbs.	Inches.	Inches.
68-pounder .. shot	16	45	20
32-pounder .. ,,	10	30	12
10-inch .. .. shell	12	35	17
8-inch .. .. ,,	16	..	15
8-inch .. .. ,,	10	30	13
8-inch .. .. ,,	5	20	..
6-inch .. .. ,,	10	..	10
6-inch .. .. ,,	8	25	8
6-inch .. .. ,,	6	20	..

XIII.—The following penetrations, in a *mass* of seasoned White Oak, are extracted from Capt. Dahlgren's (U.S.N.) work on Shells and Shell-guns :—

Gun.	Projectile.	Charge.	Initial Velocity.	500 yards.	1000 yds.	1500 yds.	2000 yds.
		lbs.	Feet.	Inches.	Inches.	Inches.	Inches.
64-pr.	shot	16	1620	49.9	37.3	27.9	20.8
32-pr. (long) ..	,,	9	1700	38.7	26.5	18.2	12.5
,, 42 cwt.	,,	6	1450	32.0	22.0	15.0	10.3
,, 32 ,,	,,	4½	1250	26.4	18.5	12.7	8.8
10-inch, 86 cwt.	shell	10	1160	32.1	24.2	18.2	13.7
8-inch, 63 ,,	,,	9	1500	33.2	23.0	15.9	11.0
8-inch, 55 ,,	,,	7	1350	29.2	20.2	14.0	9.7

XIV.—Comparative Ranges of French 30-livre Guns, long and short, with English 32-pounders. The Ranges of the French Guns are taken from the general Table formed on the Experiments made at Gavre between 1830 and 1840, interpolated for the Charges and Elevations here given. The Weights and Dimensions are in English denominations. The Ranges of the English Guns are taken from the Table of Experiments carried on in the year 1845 on board the "Excellent."

Nature of Ordnance.	Weight of Gun.	Diameter of Bore in Inches.	Charge.	Weight of Shot (solid).	Elevations.									
					0° 15'	1°	2°	3°	4°	5°	6°	7°	8°	9°
					Ranges.									
	Cwts. qrs. lbs.	Inches.	lbs.	lbs. oz.	Yards.	Yards.	Yards.	Yards.	Yards.	Yards.	Yards.	Yards.	Yards.	Yards.
Fr. long gun, 30 liv. ..	58 3 17	6.48	10	33 13	230	620	1020	1315	1580	1830	2040	2257	2456	2648
Short ditto	49 0 0	6.48	10	33 13	259	630	975	1317	1572	1810	2016	2225	2426	2620
(Windage .2 in.)														
Eng. 32-pr.	56 0 0	6.41	10	..	343	700	1100	1513	1760	1930	2100	2300	2477	2622
(Windage .233 in.)	9 ft. 6 in. long.													
Fr. long, 30 liv.	58 3 17	6.48	8	33 13	231	590	940	1246	1400	1732	1947	2149	2345	2534
Short ditto	49 0 0	6.48	8	33 13	237	580	938	1231	1488	1715	1922	2118	2295	2532
(Windage .2 in.)														
Eng. 32-pr.	56 0 0	6.41	8	..	350	600	970	..	..	..	..	..	..	..
	9 ft. 6 in. long.													
Ditto	50 } 8 ft. long. 48 }	6.41	8	..	320	760	1116	1320	1516	1696	1835	2060	2246	2318
(Windage .233 in.)														
Fr. long, 30	58 3 17	6.48	7	33 13	218	581	955	1248	1492	1715	1939	2134	2329	2526
Short ditto	49 0 0	6.48	7	33 13	225	547	940	1213	1462	1685	1900	2099	2247	2510
(Windage .2 in.)														
Eng. 32-pr.	45 0 0	6.3	7	..	333	716	1040	1320	1600	1800	2026	2180	2340	2510
(Windage .173 in.)	8 ft. 6 in. long.													
Fr. long, 30	58 3 17	6.48	6	33 13	210	516	850	1255	1352	1604	1784	1935	2108	2360
Short ditto	49 0 0	6.48	6	33 13	220	512	828	1113	1345	1556	1755	1954	2134	2327
(Windage .2 in.)														
Eng. 32-pr.	40 0 0	6.3	6	..	326	700	1026	1300	1566	1710	1890	2105	2250	2440

XV.—Ranges, in Yards, of French Canons-obusiers of 80 (liv.), with 50-pounder and 36-pounder French Guns. From the Experiments at Gavre in 1846, 1847.—(Corrected.)

Nature of Ordnance.	Charge.	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	15°	20°	25°	30°	Remarks.
	lbs. oz.	Yards.	Yards.	Yards.	Yards.	Yards.	Yards.	Yards.	Yards.	Yards.	Yards.	Yards.	Yards.	Yards.	Yards.	
Canon-obusier 80, No. 1 (1842)	7 11.5	443	731	998	1201	1395	1580	1665	1840	2070	2195	..	..	..	..	Hollow Shot.
Ditto ditto 2	6 10	430	660	898	1060	1230	1390	1455	1625	1780	1900	..	..	..	..	Ditto.
50-pounder (Fr.) Gun	17 10	632	1051	1387	1669	1900	2129	2322	2504	2674	2831	3610	4288	4704	4923	Solid Shot.
36-pounder (Fr.) Gun	13 3.75	687	1083	1391	1647	1866	2072	2270	2456	2636	2811	3605	4245	4510	4543	Ditto.

XVI.—Ranges with "Shrapnel's Shells" for Sea-service Ordnance.

Nature of Gun.				Description of Shell.						Lengths of Fuzes (Fuze-Composition) with the Corresponding Elevations and Ranges.																		
Carronade.	Weight	Charge.	Calibre.	Diameter.	Weight empty.	Weight filled.	Number of Balls.	Bursting Charge.	Lengths of Fuze-Composition, in Inches or Decimals of an Inch.	B .2	C .3	D .4	E .5	F .6	G .7	.8	.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0
	Cwt.	lbs.	In.	In.	lbs.	lbs.	No.	Oz.																				
8-inch ..	36	..	8.05	7.9	32	59¼	395	15	Elevations in Degrees ..	2⅛	3¼	4¼	5⅛	5⅞	6¼	7⅛	7¾	8⅜	9	9¼	10¼	11⅛	11¾	12¼	13¼	14	15	
									Range in Yards	500	750	950	1100	1225	1350	1475	1600	1700	1800	1900	2000	2100	2200	2300	2375	2450	2525	
42-pounder	22	..	6.84	6.762	19¼	35¾	240	7½	Elevations in Degrees ..	2⅛	2¾	3⅜	4	4⅝	5⅛	5¾	6⅜	6⅞	7¼	8⅛	8⅞	9⅝	10⅝	11⅛	12	12¾	13¼	14¼
									Range in Yards	500	700	850	975	1100	1220	1330	1440	1550	1650	1750	1840	1930	2020	2110	2200	2280	2360	2440
32-pounder	17	2 10/16	6.25	6.177	15	27¼	178	7	Elevations in Degrees ..	2¼	2⅞	3¼	3⅞	4¼	5⅛	5¾	6⅜	6⅞	7¼	8⅛	8⅞	9⅝	10⅝	11	11⅝	12⅛	13	14¼
									Range in Yards	500	700	850	975	1100	1200	1300	1400	1500	1590	1680	1770	1860	1950	2040	2120	2200	2280	2360

The letters B, C, &c., designate the fuze for the various times of flight, or rather length of fuze. This is necessary in the field, where the distances vary rapidly. After .7 fuze or G you must cut your fuze accordingly.

XVII.—Ranges with "Shrapnel's Shells" for Field Ordnance.

Nature of Gun.				Description of Shell.					Lengths of Fuze-Composition, in Inches of Decimals of an Inch.	Lengths of Fuzes (Fuze-Composition) with the Corresponding Elevations and Ranges.														
Field Howitzer.	Weight.	Charge.	Calibre.	Diameter.	Weight empty.	Weight filled.	Number of Balls.	Bursting Charge.		A .1	B .2	C .3	D .4	E .5	F .6	G .7	.8	.9	1.0	1.1	1.2	1.3	1.4	1.5
	Cwt.	lbs.	In.	In.	lbs.	lbs.	No.	Oz.																
24-pounder	12½	2½	5.72	5.565	11 1/16	21¼	128	6	Elevations in Degrees	1	1½	2	2½	3	3½	4	4½	5	5⅝					
									Ranges in Yards	450	550	650	750	850	950	1050	1125	1175	1225					
5⅝-inch New Gun for Boats .. .	10	2	5.62	5.595	11 1/16	21¼	128	6	Elevations in Degrees	1¾	2¼	2¾	3¼	4⅛	4⅝	5⅛	6¼	6⅞	7½	8⅛	8¾	9⅜	10	10⅝
									Ranges in Yards	350	475	600	700	800	900	1000	1100	1200	1300	1400	1475	1550	1625	1700
12-pounder	6½	1¼	4.58	4.454	5 10/16	10.82	63	4½	Elevations in Degrees	1¼	1¾	2¼	2¾	3¼	3¾	4¼	5	6						
									Ranges in Yards	450	550	650	750	850	950	1025	1100	1200						

XVIII.—Heights in English Measure, above the Water, of the different parts of French Ships of War and their Masts, according to the following Rates (1850).

	Line-of-Battle Ships.										Frigates.				Corvettes.		Brigs.	
	120 Guns.		100 Guns.		90 Guns.		86 Guns.		82 Guns.		60 Guns.		44 Guns.		24 Guns.		18 Guns.	
	Ft.	in.	Ft.	in.	Ft.	in.	Ft.	in.	Ft.	in	Ft.	in.	Ft.	in.	Ft.	in.	Ft.	in.
Portsills of lower deck..	5	3	7	10	6	7	5	8	5	8								
,, middle ,, ...	13	1																
,, upper ,, ...	19	4	15	1	14	9	12	9	12	9	6	6¾	6	11	5	10	4	3
,, quarter ,, ...	25	7	21	3	19	8	19	2	19	2	13	9	13	4	12	0		
After part of poop plank sheer	35	5	29	2	29	6	25	4	25	4								
MAINMAST :—																		
Upper side of mainyard	79	0	77	1	76	5	71	0	66	0	67	0	59	0	41	0	39	0
Under side of maintop	93	6	91	10	90	2	84	0	78	0	79	0	70	0	49	0	47	0
Upper side of cap to mainmast	109	6	109	10	108	3	101	0	94	0	95	0	84	0	59	0	56	0
,, main topsail yard	148	7	140	9	141	0	139	0	130	0	131	0	114	0	79	0	72	0
,, crosstrees to main topmast	158	5	150	11	150	11	148	0	138	0	139	0	121	0	85	0	77	0
,, cap to main topmast ..	166	4	161	8	158	9	156	0	147	0	148	0	128	0	89	0	81	0
Head of topgallant rigging	190	7	185	4	185	4	183	0	170	0	171	0	151	0	104	0	96	0
Truck	219	9	212	7	201	9	205	0	192	5	187	9	168	6	120	7	112	0
FOREMAST :—																		
Upper side of foreyard	72	10	72	2	71	2	64	0	61	0	67	0	51	0	34	0	34	0
Under side of foretop	86	7	84	11	83	7	77	0	72	0	73	0	63	0	43	0	41	0
Upper side of cap to foremast	103	0	101	8	100	0	92	0	87	0	88	0	76	0	53	0	50	0
,, fore topsail yard	136	5	128	11	129	7	128	0	117	0	118	0	101	0	70	0	66	0
,, crosstrees to fore topmast	145	8	139	1	137	9	136	0	126	0	127	0	109	0	76	0	70	0
,, cap to fore topmast.. ..	153	6	148	11	145	0	144	0	135	0	136	0	116	0	81	0	75	0
Head of topgallant rigging	173	10	170	3	169	7	168	0	156	0	157	0	136	0	95	0	89	0
Truck	200	1	194	10	184	8	188	0	176	0	172	1	152	0	109	6	103	6
MIZENMAST :—																		
Upper side of crossjack yard	73	1	71	10	70	2	64	0	61	0	62	0	52	0	32	0		
Under side of mizentop	83	4	83	7	81	4	75	0	71	0	72	0	62	0	39	0		
Upper side of cap to mizenmast	93	6	96	5	93	9	85	0	82	0	83	0	71	0	47	0		
,, mizen topsail yard	121	4	116	9	117	1	110	0	107	0	108	0	94	0	56	0		
,, crosstrees to mizen topmast	127	11	125	11	122	4	117	0	112	0	113	0	99	0	61	0		
Head of topgallant rigging	154	2	150	11	145	8	143	0	136	0	137	0	120	0	74	0		
Truck	177	9	171	7	158	9	160	0	153	0	150	0	133	6	85	0		

XIX.—ANGLES subtended by the Mainmasts of French Ships of War, between the Water Line and the Truck, with the corresponding Distances.

The observer is supposed to be 20 feet above the level of the water.

Yards.	Line-of-Battle Ships.			Frigates.		Corvettes.	Brigs.	Yards.
	120 Guns.	90 Guns.	82 Guns.	60 Guns.	44 Guns.	24 Guns.	18 Guns.	
	Truck to the Water Line, 220 ft.	Truck to the Water Line, 202 ft.	Truck to the Water Line, 192 ft.	Truck to the Water Line, 188 ft.	Truck to the Water Line, 168 ft.	Truck to the Water Line, 120 ft.	Truck to the Water Line, 112 ft.	
	° '	° '	° '	° '	° '	° '	° '	
200	20 20	18 47	17 54	17 33	15 46	11 22	10 37	200
300	13 48	12 42	12 6	11 51	10 37	7 37	7 7	300
400	10 25	9 35	9 7	8 55	7 59	5 43	5 20	400
500	8 21	7 41	7 18	7 9	6 24	4 34	4 16	500
600	6 59	6 25	6 6	5 58	5 20	3 49	3 34	600
700	5 59	5 30	5 14	5 7	4 35	3 16	3 3	700
800	5 14	4 49	4 35	4 29	4 0	2 52	2 40	800
900	4 40	4 17	4 4	3 59	3 34	2 33	2 22	900
1000	4 10	3 51	3 40	3 35	3 12	2 17	2 8	1000
1100	3 49	3 30	3 20	3 16	2 55	2 5	1 57	1100
1200	3 30	3 13	3 3	2 59	2 40	1 54	1 47	1200
1300	3 14	2 58	2 49	2 46	2 28	1 46	1 39	1300
1400	3 0	2 45	2 37	2 34	2 17	1 38	1 31	1400
1500	2 48	2 34	2 26	2 23	2 8	1 32	1 25	1500
1600	2 37	2 24	2 17	2 14	2 0	1 26	1 20	1600
1700	2 28	2 16	2 9	2 7	1 53	1 21	1 15	1700
1800	2 20	2 8	2 2	2 0	1 47	1 16	1 11	1800
1900	2 13	2 2	1 56	1 53	1 41	1 12	1 7	1900
2000	2 6	1 56	1 50	1 48	1 36	1 9	1 4	2000
2200	1 55	1 45	1 40	1 38	1 27	1 2	0 58	2200
2400	1 45	1 36	1 31	1 30	1 20	0 57	0 53	2400
2600	1 37	1 29	1 24	1 23	1 14	0 53	0 49	2600
2800	1 30	1 23	1 19	1 17	1 9	0 49	0 46	2800
3000	1 24	1 17	1 13	1 12	1 4	0 46	0 43	3000
3200	1 19	1 12	1 8	1 7	1 0	0 43	0 40	3200
3400	1 14	1 8	1 5	1 3	0 57	0 40	0 38	3400
3600	1 10	1 4	1 1	1 0	0 53	0 38	0 35	3600
3800	1 6	1 1	0 58	0 57	0 51	0 36	0 34	3800
4000	1 3	0 58	0 55	0 54	0 48	0 34	0 32	4000

XX.—Angles subtended by the Mainmasts of French Ships of War, between the Water Line and the Topmast Crosstrees, with the corresponding Distances.

The observer is supposed to be 20 feet above the level of the water.

Yards.	Line-of-Battle Ships.			Frigates.		Corvettes.	Brigs.	Yards.
	120 Guns.	90 Guns.	82 Guns.	60 Guns.	44 Guns.	24 Guns.	18 Guns.	
	Topmast Crosstrees to the Water Line, 158 ft.	Topmast Crosstrees to the Water Line, 151 ft.	Topmast Crosstrees to the Water Line, 138 ft.	Topmast Crosstrees to the Water Line, 139 ft.	Topmast Crosstrees to the Water Line, 121 ft.	Topmast Crosstrees to the Water Line, 85 ft.	Topmast Crosstrees to the Water Line, 77 ft.	
	° ′	° ′	° ′	° ′	° ′	° ′	° ′	
200	14 52	14 13	13 2	13 7	11 28	8 5	7 20	200
300	9 59	9 33	8 45	8 48	7 41	5 24	4 54	300
400	7 31	7 11	6 34	6 37	5 46	4 3	3 40	400
500	6 1	5 45	5 16	5 18	4 37	3 14	2 56	500
600	5 1	4 48	4 23	4 25	3 51	2 42	2 27	600
700	4 18	4 7	3 46	3 47	3 18	2 19	2 6	700
800	3 46	3 36	3 18	3 19	2 53	2 2	1 50	800
900	3 21	3 12	2 56	2 57	2 34	1 48	1 38	900
1000	3 1	2 53	2 38	2 39	2 19	1 37	1 28	1000
1100	2 45	2 37	2 24	2 25	2 6	1 29	1 20	1100
1200	2 31	2 24	2 12	2 13	1 55	1 21	1 13	1200
1300	2 19	2 13	2 2	2 2	1 47	1 15	1 8	1300
1400	2 9	2 3	1 53	1 54	1 39	1 9	1 3	1400
1500	2 0	1 55	1 45	1 46	1 32	1 5	0 59	1500
1600	1 53	1 48	1 39	1 39	1 26	1 1	0 55	1600
1700	1 46	1 42	1 33	1 34	1 21	0 57	0 52	1700
1800	1 40	1 36	1 28	1 28	1 17	0 54	0 49	1800
1900	1 35	1 31	1 23	1 24	1 13	0 51	0 46	1900
2000	1 30	1 26	1 19	1 20	1 9	0 49	0 44	2000
2200	1 22	1 19	1 12	1 12	1 3	0 44	0 40	2200
2400	1 15	1 12	1 6	1 6	0 58	0 40	0 37	2400
2600	1 9	1 6	1 1	1 1	0 53	0 37	0 34	2600
2800	1 5	1 2	0 56	0 57	0 50	0 35	0 31	2800
3000	1 0	0 57	0 52	0 53	0 46	0 32	0 29	3000
3200	0 56	0 54	0 49	0 49	0 43	0 30	0 27	3200
3400	0 53	0 51	0 46	0 47	0 40	0 29	0 26	3400
3600	0 50	0 48	0 44	0 44	0 38	0 27	0 24	3600
3800	0 47	0 45	0 41	0 42	0 36	0 25	0 23	3800
4000	0 45	0 43	0 39	0 40	0 35	0 24	0 22	4000

XXI.—Penetrations into Oak. (From the 'Aide Mémoire Navale.')

The Initial Velocities were obtained from Experiments with the Ballistic Pendulum, and the Velocities at the instant of Impact were computed.

Solid Shot. Density, 7.15 (water = 1).

Nature of Ordnance.	Charge.	Initial Ve-locity.			Distance of the object from the mouth of the Gun in Yards.					
					109	219	438	656	875	1094
	lbs. oz.									
Canon de 36..	13 3.7	1578	Velocity at Impact	Yards ..	1476	1384	1223	1089	974	876
			Penetration	Feet, &c.	4 6.8	4 0.7	3 5.8	2 11.4	2 6.4	2 1.6
	9 15.8	1482	Velocity at Impact	Yards ..	1391	1305	1158	1033	928	836
			Penetration	Feet, &c.	4 1.2	3 9.2	3 2.5	2 9.	2 3.6	2 0.
	6 9.9	1302	Velocity at Impact	Yards ..	1227	1154	1030	761	833	754
			Penetration	Feet, &c.	3 1.9	3 2.5	2 9.1	2 4.	2 0.	1 8.4
Canon de 30 (long)	11 0.5	1591	Velocity at Impact	Yards ..	1482	1384	1217	1076	958	856
			Penetration	Feet, &c.	4 1.9	3 10.1	3 3.	2 8.6	2 3.6	1 11.2
	8 4.3	1492	Velocity at Impact	Yards ..	1394	1305	1151	1020	912	817
			Penetration	Feet, &c.	3 10.4	3 6.5	3 0.2	2 6.2	2 1.4	1 2.4
	5 8.2	1305	Velocity at Impact	Yards ..	1223	1151	1020	912	814	738
			Penetration	Feet, &c.	3 3.4	3 0.2	2 6.2	2 1.5	1 9.6	1 6.5
Canon de 24 (long)	8 13.2	1610	Velocity at Impact	Yards ..	1489	1384	1200	1050	925	820
			Penefration	Feet, &c.	3 10.4	3 6.5	2 11.4	2 5.2	2 0.4	1 8.
	6 9.9	1505	Velocity at Impact	Yards ..	1397	1299	1132	994	879	780
			Penetration	Feet, &c.	3 6.8	3 3.4	2 8.6	2 3.1	1 10.4	1 6.8
	4 6.4	1305	Velocity at Impact	Yards ..	1217	1138	997	882	784	699
			Penetration	Feet, &c.	2 11.8	2 8.6	2 3.1	1 10.4	1 6.8	1 3.7
Canon de 18 (long)	6 9.9	1630	Velocity at Impact	Yards ..	1496	1374	1174	1013	882	774
			Penetration	Feet, &c.	3 6.5	3 2.2	2 7.1	2 1.2	1 8.4	1 4.8
	4 15.4	1519	Velocity at Impact	Yards ..	1397	1286	1165	958	840	735
			Penetration	Feet, &c.	3 3.	2 11.	2 4.7	1 3.4	1 6.8	1 3.4
	3 4.9	1309	Velocity at Impact	Yards ..	1210	1122	971	946	741	656
			Penetration	Feet, &c.	2 8.6	2 5.2	1 11.6	1 7.3	1 1.2	1 6.
Canon de 12 (short)	4 6.4	1640	Velocity at Impact	Yards ..	1479	1341	1118	945	807	675
			Penetration	Feet, &c.	2 10.9	2 8.6	2 4.6	1 8.	1 3.7	1 1.2
	3 4.9	1532	Velocity at Impact	Yards ..	1387	1263	1056	925	767	662
			Penetration	Feet, &c.	2 9.8	2 5.9	1 11.6	1 6.4	1 2.5	0 11.5
	2 3.3	1325	Velocity at Impact	Yards ..	1207	1105	925	767	685	597
			Penetration	Feet, &c.	2 4.3	2 1.2	1 7.7	1 3.4	0 11.8	0 9.5
Hollow Shot, diameter = 16 centi. = 6.3 inch. Density 4.93 (water = 1).										
Canon de 30 (long)	8 4.3	1742	Velocity at Impact	Yards ..	1578	1423	1183	1000	853	735
			Penetration	Feet, &c.	3 0.96	2 9.6	2 1.9	1 8.4	1 4.	1 0.6
			Velocity at Impact	Yards ..	1420	1292	1082	918	787	682

XXII.

Tangent-Practice with 8-inch Guns, weighing 65 and 60 cwt., carrying a single shot weighing 56 lbs., or a shell weighing 51 lbs., and charged with 10 lbs. of powder. The line of sight is parallel to the axis of the bore, and the Gun is 5 feet 4 inches above the level of the water.

Elevations.			Distances.	Heights of the parts aimed at above the Water.		The points aimed at.	
						In a Line-of-Battle Ship of 82 Guns.	In a 44-Gun Frigate.
°	'	"	Yards.	Ft.	in.		
0	22	20	330	11	10	One foot below the port-sills of the main-deck.	One and a half foot below the port-sills of the quarter-deck.
0	35	0	435	18	7	Seven inches below the port-sills of the quarter-deck and forecastle.	Five feet above ditto.
0	47	30	535	27	6	Two feet above the after part of poop plank sheer.	Twice the height from the water to ditto.
1	0	0	630	38	4	About midway between the water-line and the under side of the maintop.	Three times ditto.
1	20	0	756	58	0	Three feet below the upper side of the fore-yard.	Upper side of the main-yard.
1	40	0	879	82	0	Upper side of cap to mizenmast; or four feet above the under side of the maintop.	Two feet below the upper side of the cap of the mainmast.
2	0	0	1000	110	0	Two feet below the crosstrees of the mizentopmast.	One foot above the upper side of the crosstrees of the foretopmast.
2	20	0	1078	137	0	One foot below the crosstrees of the maintopmast.	One foot above the head of the top-gallant rigging, foremast.
2	40	0	1153	166	0	Four feet below the head of top-gallant rigging.	Two feet below the truck of the mainmast.
3	0	0	1225	198	0	Six feet above the truck of mainmast.	

Tangent-Practice with 32-pounder Guns, weighing 56 cwt., carrying one solid shot, charge 10 lbs. The line of sight being parallel to the axis of the bore, and the Gun 5 feet 4 inches above the water.

Elevations.			Distances.	Heights of the parts aimed at above the Water.		The points aimed at.	
						In a Line-of-Battle Ship of 82 Guns.	In a 44-Gun Frigate.
°	'	"	Yards.	Ft.	in.		
0	15	0	343	9	10	Three feet below the port-sills of the upper deck.	Three feet above the port-sills of the upper deck.
0	30	0	435	16	9	Four feet above ditto.	Three feet above the port-sills of the quarter-deck.
0	41	0	525	24	0	One foot below the after part of poop plank sheer.	About midway between the water and the under side of fore-yard.
0	52	0	613	33	0	Midway between the water and the upper side of main-yard.	One-third of distance from the water to the crosstrees of mizentopmast.
1	0	0	700	42	0	About midway between the water and the upper side of the cap of the mizenmast.	Midway between the water and cap of mainmast.
1	20	0	835	63	8	About two feet below the upper side of the main-yard.	The under side of foretop.
1	40	0	968	90	0	Four feet below the upper side of the cap of the mainmast.	Four feet under the mizen topsail-yard.
2	0	0	1100	120	0	Three feet above the upper side of foretopsail-yard.	One foot below the upper side of the crosstrees of maintopmast.
2	20	0	1240	157	0	One foot above the head of top-gallant rigging, foremast.	Five feet above the truck of foremast.
2	40	0	1378	198	0	Five feet above the truck of mainmast.	

Tangent-Practice with 32-pounder Guns, weighing 50 and 48 cwt., carrying one solid shot, charge 8lbs. The line of sight is parallel to the axis of the bore, and the Gun 5 feet 6 inches above the water.

Elevations.			Distances.	Heights of the parts aimed at above the Water.		The points aimed at.	
						In a Line-of-Battle Ship of 82 Guns.	In a 44-Gun Frigate.
°	'	"	Yards.	Ft.	in.		
0	15	0	320	9	8	Three feet below the port-sills of upper deck.	Three feet above the port-sills of upper deck.
0	26	0	437	15	5	Three feet above ditto.	Two feet above the port-sills of quarter-deck.
0	37	0	547	23	0	Two feet below the upper part of poop plank sheer.	One-third of the distance from the water to the under side of maintop.
0	48	0	655	33	0	Midway between the water and the upper side of main-yard.	One-third of the distance from the water to the upper sill of the crosstrees, mizentopmast.
1	0	0	760	45	0	About midway between the water and the upper side of the cap of mainmast.	One-third of the distance from the water to the head of the top-gallant rigging, foremast.
1	20	0	881	67	0	One foot above the upper side of main-yard.	Three feet below the under side of maintop.
1	40	0	999	93	0	One and a-half feet below the upper side of the cap of mainmast.	One foot below the upper side of mizen-topsail-yard.
2	0	0	1116	122	0	Four feet below the upper side of the crosstrees of foretopmast.	One and a-half feet above the upper side of the crosstrees, maintopmast.
2	30	0	1218	165	0	Five feet below the head of the top-gallant rigging, mainmast.	Three feet below the truck of the mainmast.
3	0	0	1320	213	0	Eighteen feet above the truck of the mainmast.	

XXIII.—Relative Strength of the English, French, and Russian Navies.

English Navy.

Class of Ship.	Steam.			Sailing.	Total of Steam and Sailing.
	Afloat.	Building or Converting.	Total.	Afloat.	
Liners	48	12	60	16	76
Frigates	34	16	50	13	63
Block Ships	9	..	9	..	9
Iron-cased Ships	..	4	4	..	4
Corvettes	16	5	21	3	24
Sloops	80	15	95	..	95
Small Vessels	27	..	27	..	27
Gun Vessels and Gun Boats	171	21	192	..	192
Floating Batteries	8	..	8	..	8
Transports	15	..	15	..	15
Mortar Vessels	4	..	4	..	4
Total	412	73	485	32	517

French Navy.

Class of Ship.	Steam.			Sailing.	Total of Steam and Sailing.
	Afloat.	Building.	Total.	Afloat.	
Liners	33	4	37	9	46
Frigates	34	13	47	28	75
Iron-cased Ships	2	3	5	..	5
Corvettes	17	2	19	13	32
Avisos, &c.	86	3	89	46	135
Gun Boats	39	29	68	..	68
Floating Batteries	5	4	9	..	9
Transports	31	..	31	..	31
Total	247	58	305	96	401

Russian Navy.

Class of Ship.	Steam.			Sailing.	Total of Steam and Sailing.
	Afloat.	Building.	Total.	Afloat.	
Liners	13	9	22	16	38
Frigates	18	3	21	..	21
Corvettes	11	11	22	..	22
Small Vessels	30	..	30	..	30
Gun Boats	112	25	137	..	137
Transports	8	..	8	..	8
Total	192	48	240	16	256

5*th May*, 1860.

TABLE XXIV.

List of Naval Ordnance in use for the British Navy.

	Nature.		Weight.	Length.		Diameter of Bore.	Windage.	Charge of Powder.		Whose Pattern.	Remarks.
	IRON :		Cwt.	Ft.	in.	Inches.	Inches.	lbs.	oz.		
1	Guns .	68-pr.	95	10	0	8.12	.2	16	0	Col. Dundas', new	These are for Steamers.
2			88	9	6			14	0		
3		56-pr.	98	11	0	7.65	.175	16	0	Mr. Monk's, new	These give place to the above when Ships at Sea are recommissioned.
4			87	10	0			14	0		
5		42-pr.	67	9	6	6.97	.2	10	8	Col. Dundas', new	Ditto Ditto.
6		10-in.	86	9	4	10.0	.16	12	0	Gen. Millar's modified Shell-Gun.	These are to be substituted, in Steamers, for the 68-pr. Guns. See observations, Art. 212, p. 226.
7			84							Gen. Millar's Shell-Gun ..	
8		8-pr.	65	9	0	8.05	.125	10	0	Gen. Millar's Shell-Gun ..	These are for large heavy vessels.
9			60	8	10			10	0		Frigates.
10			52	8	0			8	0		First Class 6th rates.
11		32-pr.	61½	9	6	..	.2 .175	10	0	Col. Dundas'.	
12			58[a]	9	6	..	..	10 8 & 5	0 0 0	Col. Dundas'.	
			56	9	6	6.41	.233	10	0	Sir Thos. Blomefield's ..	The old Gun, which will probably hereafter give place to one of 58 cwt.
			48 to 50	8	0			8	0	Dickson's and Millar's ..	A Gun of 9 ft. and 50 cwt. will take the place of this.
			41	8	0	6.35	.173	6	0	Bored up from Sir Thos. Blomefield's 24-pr.	Bored-up Guns, which, when unserviceable, will be replaced by the 32-pr. of 42 cwt. and 8 ft. in length.
			39	7	6			6	0		
			40	7	6			6	0	Do. Sir W. Congreve's do.	
			32	6	6	6.3	.123	5	0	Do. Blomefield's do. ..	Bored-up Guns used in brigs and some 1st rates,
			25	6	0			4	0	Do. do, 18-pr. ..	Bored-up, in general use.
			25	6	0			4	0	Col. Dundas', new	Gun made new.

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[a] 32-pr. Guns, 9 ft. 6 in. long, windage .2 inch, and weighing 58 cwt., are now in general use.

TABLE XXIV.—*continued.*

List of Naval Ordnance in use for the British Navy.

	Nature.		Weight.	Length.		Diameter of Bore.	Windage.	Charge of Powder.		Whose Pattern.	Remarks.
	IRON:		Cwt.	Ft.	in.	Inches.	Inches.	lbs.	oz.		
21	Guns	32-prs.	50	9	0	6·375	.198	8	0	New Gun A, Monk's new	These, which may be denominated Medium Guns, enter largely into the armament of the Navy.
22			45	8	6	6.35	.173	7	0	New Gun B	
23			42	8	0			6	0	New Gun C	
24		18-prs.	22	7	0	5.17	.071	3	0	Bored up from 9-pr. ..	These are made for the smaller class of brigs, and other small craft.
25			20	6	0			3	0	Do. light 12-pr.	
26			15	5	6			2	0	Do. light 9-pr.	
27	Carronades.	68-pr.	63	5	4	8.05	.125	5	0	Carron Company.	
28		42-pr.	22	4	6	6.84	.078	3	8		
29		32-pr.	17	4	0	6.25	.073	2	11		
30		24-pr.	13	3	9	5.68	.068	2	0		
31		18-pr.	10	3	4	5.16	.061	1	8		
32		12-pr.	6	2	8	4.52	.066	1	0		
33		6-pr.	4½	2	9	3.6	.05	0	10		
34	Mortars	13-in.	101	4	5	13.0	.16	20	0	Sir Thomas Blomefield's.	
35		10-in.	52	3	9½	10.0	.16	9	8		
	BRASS:										
36	Guns	9-pr.	13½	6	0	4.2	.1	3	0	.. ..	For Steam-packets.
37		6-pr.	6	5	0	3.668	.1	1	8	.. ..	One, mounted on a field-carriage, on board all large ships for land service.
38	Howitzers.	24-pr.	13	4	8½	5.72	.125	2	8	Gen. Millar's, new	For boat-service, and to be landed on field-carriages when required, 24-pr. (2) on board each 1st, 2nd, and 3rd rate; 12-pr. (2) 10 cwt., on board 4th and 5th rates, and 12-pr. (2) 6¼ cwt. on board 1st, 2nd, 3rd, 4th, 5th, and 6th rates, and 1 on board brigs and smaller vessels.
39		12-pr.	10	4	7	5.58	.125	2	0	Col. Dundas', new	
40			6¼	3	9¼	5.58	.125	1	4	Gen. Millar's, new	

Table XXIV.—*concluded.*

Land Service.—Iron Ordnance.

Nature.		Weight.	Length.		Diameter of Bore.	Windage.	Service Charge.		
		Cwt.	Ft.	in.	Inches.	Inches.	lbs.	oz.	
Guns.	56-pr.	98	11	0	7.65	.175	16	0	
	8-in.	65	9	0	8.05	.125	10	0	
		50	6	8½			8	0	
	32-pr.	56	9	6	6.41	.233	10	0	
		32	6	6	6.3	.122	5	0	Bored up from 24-pr. of 33 cwt.
	24-pr.	50 or	9	6	5.823	.211	8	0	
		48	9	0					
		20	6	0	5.75	.138	2	8	Bored up from 12-pr. of 21 cwt.
	18-pr.	42	9	0	5.292	.193	6	0	
		20½	6	0	5.17	.071	3	0	Ditto ditto.
	12-pr.	34	9	0	4.623	.1	4	0	
		21	6	0	4.623		3	0	
	9-pr.	17	5	6	4.2	.1	3	0	
	6-pr.	17	6	0	3.668	.1	2	0	
Howitzers.	10-in.	41	5	0	10.0	.16	7	0	
	8-in.	21	4	0	8.0	.14	4	0	
	5½-in.	15	3	4¾	5.62	.025	2	8	
Mortars	13-in.	36	3	0¾	13.0	.16	9	0	
	10-in.	16½	2	7½	10.0	.16	4	0	
	8-in.	8¼	2	1¼	8.0	.14	2	0	

Land Service.—Brass Ordnance.

Guns.	12-pr.	18	6	6	4.623	.1	4	0	With the new Shot this charge will be reduced probably to 3 lbs. 8 oz.
	9-pr.	13½	6	0	4.2	.1	2	8	
	6-pr.	6	5	0	3.668	.1	1	8	
	3-pr.	3	4	0	2.913	.09	0	12	
		2¼	3	0			0	10	
Howitzers.	32-pr.	17½	5	3	6.3	.125	3	0	
	24-pr.	13	4	8½	5.72	.123	2	8	
	12-pr.	6½	3	9¼	4.58	.122	1	4	
	4⅖-pr.	2½	1	10½	4.52	.066	0	8	
Mortars	10-in.	12¾	2	3	10.0	.16	4	0	
	8-in.	6½	1	9½	8.0	.14	2	0	
	5½-in.	1¼	1	3	5.62	.025	0	8	
	4⅖-in.	¾	1	0¾	4.52	.066	0	4	

APPENDIX (C.)

Observations on the Naval Operations in the Black Sea, November, 1854.

Brought down to the present Edition.

At the beginning of the year 1854 there remained little hope tl the peace of Europe would be preserved, and it was soon afterwar judged necessary to send a British army to the East, in order to operate with one from France. By great exertions, upwards 20,000 troops, infantry and cavalry, were shipped and sent off; t guns, military stores, and provisions, were to be despatched proportion as they could be collected. A few field-batteries onl affording, on an average, scarcely one gun for every thousand me were sent. Gunner-drivers and horses for the train, waggons carry ammunition, spring-carts for the sick or wounded, sappers a miners with their intrenching-tools, and bridge equipments, with the other indispensable requisites for an army in the field, we scantily supplied, and some were altogether wanting.

Thus, on a small peace establishment, the country was caught a political storm, and involved in a mighty war. There exist some good regiments of infantry, and a few over-officered squadro —they could not be called regiments—of well-appointed cavalr but all were totally unprovided with the means necessary f enabling them forthwith to take and keep the field. In this sta a military force, constituting nearly the whole of our effecti strength, was despatched with wonderful promptitude to the co templated seat of war; but, lacking the establishments which shou have given it vitality, it is not surprising that it was not prepar to enter on a campaign till the season propitious for military ope tions was near its termination.

These deficiencies and disabilities could not, however, with a justice, be charged to the Government of that day, nor could they l provided at the eleventh hour by any administrative talent on tl part of the new Department of War. The evils were too deep seated to be removed on a sudden; all that zeal, energy, and abili could accomplish, was done by the Government to repair the evi and supply the deficiencies which had resulted from the persisten of Parliament, at and after the conclusion of the war in 181 in measures dictated by a reckless spirit of economy, to abolish reduce the military establishments of the country, as if war were never again to overtake the nation.[a] All the establishments indis-

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[a] The army had been greatly reduced in strength; the infantry of the service had been overworked in Colonial service, no camps of instruction had been formed during the whole of the 40 years' peace; that most excellent and efficient operative corps the Staff Corps, which had rendered eminent services throughout the Peninsular War, was reduced; the Waggon Corps, the land-service Transport Corps in the Peninsula, was abolished; the Gunner-driver Corps, "le Train" of the French Service,—which, in the Peninsular War, was appropriated to the service of the Artillery in the field, and to the Park of Artillery, to the conveyance of provisions, ammunition, and stores, and other services in the field, had been annihilated; the permanent Staff Corps of officers was discontinued; military education was discouraged and neglected, and the military educational establishments of the Crown neglected, discouraged, and in the main subverted, by diminution of the Parliamentary grants from year to year—and ultimately the withdrawal of the whole, so that the Royal Military College might become self-sustaining,—thus violating the engagements on which that seminary had been established by the King's Warrant and provided for by Parliament: all gratuitous education in that institution for the orphans of officers who had been killed or died in the service, being withdrawn, as well as that other original regulation which provided that the sons of officers serving should be educated at reduced rates, according to their respective ranks. Then again, the Staff School of the British Army (the Senior Department of the Royal Military College), during the great war had supplied the General Staff of the army in the Peninsula with well-qualified officers; which General Staff was acknowledged to be the most efficient in Europe; and was so considered by the French in particular, when they instructed Baron Charles Dupin to visit this country in 1816, to examine and report upon our Naval and Military Institutions, and specially directed him to visit, inspect, and report upon the British Staff School. On the receipt of M. Dupin's Report, L'Ecole d'Application d'Etat Major was established at Paris. Extended, encouraged, and fostered to the utmost, that establishment has succeeded in forming the Corps d'Etat Major of scientific skilful officers; and, whilst that most important establishment has acquired great practical efficiency and renown, its prototype, the British Staff School, has been reduced, discouraged and neglected. Indeed so nearly had it expired, that, when the foundation stone of the new Staff College was recently laid, near the Royal Military College at Sandhurst, the event was alluded to, by the speakers on the occasion, as if an entirely new institution were being originated; instead of its being the revival and restoration of one which in its day had done good service to the country: its pre-existence was absolutely ignored, and the good it had accomplished was consigned to oblivion.

In the minutes of evidence taken before the Select Committee of the House of Commons in May, 1855, the reader will find, in the evidence given by the author, full statements of this decadence of the Royal Military College in both its departments, and from which evidence he copies the following, to substantiate what he has stated in the previous part of this note:—

"*General Sir Howard Douglas*, G.C.B., 15th May, 1855.

"2230. Colonel NORTH.—Do you know the proportion that the country paid when the expense was 34,000*l.*?—It was all paid by the country at that time. In 1817 it was 27,764*l.* In 1818 it was 24,774*l.* In 1819 the Parliamentary grant was 23,028*l.* In 1820 it was 21,471*l.* 16*s.* 9*d.* In 1821 it was 18,738. In 1822 it was 15,687*l.* In 1823 it was 13,760*l.* In 1824 it was 13,294*l.* In 1825 it was 18,833*l.* In 1826 it was 13,135*l.* In 1827 it was 13,229*l.* In 1828 it was 12,917*l.* In 1829 it was 10,029*l.* In 1830 it was 7,656*l.* In 1831 it was 5,627*l.* In 1832, up to March, 1833, it was 2,638*l.*, when the Parliamentary votes entirely ceased, and the College became self-sustaining. In proportion, as these reductions went on, it became neces
to diminish more and more, first, the orphan establishment, and then the number
who did not pay anything like the cost of their education; afterwards to incr
the number of the sons of private gentlemen, and to augment their rates of
to a great deal more than the education of their sons individually cost. Sc
to make the College self-sustaining, the chief expense of the establishmer
by the sons of private gentlemen, who pay about one-half more thar
actually costs, and the excess is carried to the aid of the College funds

pensably necessary to enable the army to take the field, of which in vain lamented the want in 1854, had to be restored and

who cannot afford to pay the cost of their education. No one can doubt that, as lon it continues to be a military establishment, the original endowment ought to have respected; and, instead of calling upon the sons of private gentlemen to pay more the cost of their education, and to apply that excess to those who could not afford to the expense of their education, the Government, and not the third establishment, sh have provided the necessary funds, and continued to charge the noblemen and gentle whose sons form the third class, with the real cost of their education, and nothing mo

"2232.—Do you think that the fact of charging, in round numbers, double the cos the education of a gentleman's son, tends to exclude from the benefits of a military ed tion the sons of gentlemen of smaller means?—Certainly, by so much.

"2233.—In fact, it throws the military education into the hands of the very wea class, and not into the class of orphans and the sons of officers of subordinate stati who receive an education partly gratuitously from the surplus funds furnished by sons of the wealthy gentlemen?—Applying that with respect to the College, it is c that the effect of the pecuniary economy was to introduce the sons of a great numbe persons who could afford to pay that high price for their education, and to exclud so much those who could not so well afford it, but who had been admitted under former plan. In consequence of this, the College has really less hold upon the consi ation of the country, in the state in which it is, than it would have had if we had ke firm on the foundation on which it was originally placed; that is, as a place of educa for the sons of officers at moderate rates, for orphans gratuitously, and for the son private gentlemen at cost rates, instead of discontinuing the reception of youths who h the greatest possible claim on the service, and on the country.

"2289.—Can you give the Committee any information as to the number of officer the Senior Department who have passed the final examination, and obtained certificates the qualification for the general staff since the formation of the department?—Tl hundred and twelve; of whom 240 obtained certificates in the period from 1820 to 18 these last obtained certificates after the Senior Department had been removed fi Farnham.

"2290.—How many have obtained certificates up to the time when the three cla of certificates were introduced?—Two hundred and sixteen.

"2292.—How many officers have received certificates from that time in the th different classes of certificates?—Two hundred and sixteen.

"2293.—Can you state to the Committee how many officers who have received ce ficates of qualification for the general staff are now employed in the duties of the staff In 1852 there were seven; in May 1854 there were fifteen.

"2308.—When did the British army first begin to be efficient with regard to the du of the general staff?—I think it was made highly efficient in the course of the Penins War, and very much so in consequence of the number of officers who were appointe that time, after having passed their examination at High Wycombe, and obtained ce ficates. They were thereupon employed on the staff in the Peninsula: a great part of Quartermaster-general's staff was composed of officers who had been educated at H Wycombe.

"2310.—You attribute that a great deal to the College at High Wycombe?—Yes. I h here a list of the names of officers who had been at the Senior Department, who served the staff in the Peninsula:—Sir George Murray, Sir Henry Bunbury, Sir Benja D'Urban, Sir Richard Bourke, General Birch Reynardson, Sir James Bathurst, Gene Samuel Brown, Sir Richard Jackson, Lord Aylmer, Lord Hardinge, General Sir J Wilson, General L'Estrange, Sir William Herries, Sir Nathaniel Thorne, Sir Geo Scovell, Sir William Gomm, Sir William Waarre, Sir Thomas Brotherton, Sir Geo Bowles, Sir James Douglas, Sir Robert Harvey, Sir James Hope, Colonel Muter Stratt General Macgregor, Colonel Drake, General Bainbrigge, Colonel Cameron, Sir Sa ford Whittingham, Colonel Nisbet, Sir William Eustace, Earl Cathcart, General G L'Estrange, Sir Charles Napier, Sir William Napier, Sir Jeremiah Dickson, General J Coffin, Sir Neil Campbell, Sir Octavius Carey, Colonel Riddell, Colonel John Freeman Sir George Brown, Sir William De Lancey, Colonel the Hon. Alexander Abercroml Colonel Robert Waller, Colonel Edward Fitzgerald, Major Algernon Langton, Colo John Thornton, Colonel Thomas Fraser, Hon. Sir Edward Cust, Sir George Wether organised. For this, much time had necessarily to be lost, and precious opportunities let slip, ere England could collect and organise her neglected military resources, and be again prepared to buckle on her armour and exert the plenitude of her military strength, whether for defending her own territories, or to resist aggressions directed against those of her allies.

The author feels himself justified in making public these sentiments, because they are consonant with what he had written, published, and on some occasions spoken, since the termination of the Waterloo campaign, up to the breaking out of the late war with Russia. The evil predicted having once overtaken us, the country must take warning, having become convinced that something more than numerical strength and personal bravery is required to render an army efficient in the field; and that a nation which had so neglected her military establishments as to have permitted her army to fall into such a state of inefficiency for immediate service, could scarcely be counted upon as a military power capable of promptly taking part in a great territorial war, and of immediately sustaining and vindicating the lofty tone which, without reflecting upon our very limited military means, the

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Sir James Simpson, Sir Richard Dogherty, Major-General Rumley, Colonel A. Stirling, Sir George Grey, Governor of the Cape of Good Hope, and many others. Then White, Osborn, Patrick, Lemesures, Bradford, Collins, and many others who were killed in the Peninsula. Since the war, many officers who afterwards distinguished themselves, studied at the Senior Department, and were engaged subsequently in other wars.

"2329.—Are you acquainted with the Corps de l'Etat Major in France?—Yes, I am.

"2330.—When was that organized and made a special corps?—It was organized in 1816. Soon after the Peace, a great part of the army was in fact disbanded; and when the Royal armies were reformed, a commission of very eminent officers was named to regulate the reorganization of the army and of the staff. I had access to all the discussions that took place at that time at Paris, and I think it might be serviceable now to produce to the Committee copies of the discussions that took place upon the question, whether or not, in reorganizing their staff, they should form it into a special corps, or leave it as it was, the officers being connected with the troops. Various discussions took place on the question of forming a separate staff corps, as to what the effect might be in discouraging the line; how the relative promotions should be regulated; how the staff should be educated; whether the staff should be recruited by drawing competent officers occasionally from the regiments, as they might be selected for their intelligence and military acquirements; or whether to establish some special school for the education of the officers of the staff. It was decided, upon the whole (not unanimously, however), that the staff should be formed into a separate corps; that it should not be kept up by indraughts of officers from the troops, to be interpolated into the several ranks of the staff, but that it should be recruited at the bottom, by *elèves* from the special school of St. Cyr and the Polytechnic School, who should then become students at L'Ecole d'Application. That the students should then be sent for two years to do duty with a regiment of infantry; the [illegible]
to act as regimental officers, and the second year to act as aides-de-camp [illegible]
for there are three battalions in a French regiment, and the colo [illegible]
brigade. It was further decided, that, after a student shall [illegible]
tion in the service of the infantry, he should be sent to a [illegible]
and then to L'Ecole Spéciale at Metz, the great engin [illegible]
thus acquired a competent knowledge of all the arms [illegible]
well-qualified and accomplished staff officer, he shou [illegible]
lieutenant to the staff corps."

Government of this country so nobly assumed, and the spirit nation so generously and congenially re-echoed, at the breaki of hostilities.

Under these very disadvantageous and inauspicious circums with respect to the small amount of our effective military forc the late period of the season at which it was so far equippe be able to take the field, the allied army, deeply impregnate the seeds of disease, and, had it even been in an efficient sa state, not numerically strong enough, particularly in ca to ensure success, entered on the arduous task of besi capturing, and destroying the great fortress and naval arse Sevastopol.

There never was a case in which a siege required to be under with greater regard to the relative strength of the besiege besieging armies, and to the quantity as well as quality of siege artillery—never one in which a great superiority o investing army over the forces forming the garrison of the plac so imperative. In estimating the amount of force requir besiege and capture Sevastopol, regard should have been had t important fact that, in its local character as a military position town is a vast fortress situated on both sides of a long ha resembling a very broad river, and of which the northern occupied by the citadel, is elevated above the southern part. place belongs, therefore, to the category of a fortress divided two portions by an unfordable river,[a] in which case the divisi the investing corps would be prevented from mutually assi each other. To invest such a place would require an army twi strong as would suffice, if no such obstruction to intercommunic and mutual support existed. In this case, also, the enemy ke the field with a numerous army of observation, a strong and extensive line of circumvallation was necessary.

With respect to the means of defence, with which it is well k that Sevastopol was plentifully provided.—Here was a vast arsenal already well fortified, and capable, from the time of menaced with an attack, of being greatly strengthened in its v and its garrison: it possessed enormous quantities of ordnance ammunition, which had been accumulated in its magazines; exclusive of the artillerymen attached to the ordnance of the pla had the power of drawing from the fleet in the harbour vast nun of well-trained naval gunners, all of whom could be rendered able for manning the artillery during the progress of the siege.

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[a] ' Une place partagée par une rivière non guéable, exige le double plus de forc son investissement qu'une place autour de laquelle des communications faciles perm à tous les corps qui en forment l'investissement de s'entre-secourir prompteme *Bousmard*, ' Essai Général de Fortification,' liv. i. chap. ii. p. 65.

No operation in war may be depended upon with so much certainty as the siege of a fortress, provided it be undertaken with sufficient means and be skilfully conducted;[a] but no measure is so disastrous as the undertaking of a siege, as was the case with that of Burgos, at which the author served, in 1812,[b] without the requisite strength in men and materials. The attacking force should be sufficiently numerous to invest the place on every accessible side, so that nothing may be able to get in or out, and it should be equal in amount to about five, and never less than three, times the garrison: there should be, moreover, in the field a covering army, of which a large portion should be cavalry, in order to protect the operations of the siege, and prevent them from being interrupted by an army of observation, which the enemy may bring up while they are being carried on. The allied army in the Crimea found itself manifestly inadequate to the accomplishment of the object in view, and even the victory on the Alma rendered it still less able to compete with the overwhelming power of its opponents. The allied commanders were then compelled to come to a determination on which side, the northern or the southern, Sevastopol should be attacked: on both at once they could not act. The northern side was strongly fortified, the Russians held a formidable position on the Belbec River, and no shelter for the ships could be afforded on that part of the coast; there was no place, in fact, convenient for landing the siege-train, or for establishing a secure point of communication between the army and the fleet, which at that late season could not be expected long to lie at anchor on the open sea. On these accounts, it was promptly determined to abandon the precarious base of operations north of Sevastopol; and to turn the enemy's positions on the Belbec and the northern heights, by a flank march to the south, in order to establish in Balaklava Bay a new base, from which the attack might be made on the southern heights.

To invade the Crimea,—an integral portion of the Russian empire,—and lay siege to Sevastopol at that late period of the season, and, as has been already observed, with an army deeply impregnated with the seeds of disease, was, in the opinion of the author, a desperate and dangerous operation. It was undertaken, too, contrary to the judgment of an eminent engineer, whose opinion should have ruled, but who, when that determination was take
did all in his power to meet the difficulties of the case by r
mending, as a matter of necessity, to abandon the base
Sevastopol, whose communications with the sea had
period of the year become precarious, and to seize up
south of the place, in which a secure base might be

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[a] *Napier*, 'History of the Peninsular War,' vol. iv. p. 476.

[b] Ibi

a change of position which, under the difficulties in which the alli army was placed from insufficiency of force, was apparent the best measure that could be adopted under such circumstance and this very critical movement was gallantly and successful accomplished by a somewhat hazardous march of the whole army.

It is, however, much to be regretted that, from want of sufficie force, it should have been necessary to abandon the line of ope tions by which the place was at first approached, and on whic at the Alma, the army covering Sevastopol in that direction w defeated. That battle was a brilliant deed of arms, most honoura to the allies; but, in consequence of the change of plan, it must allowed that, except in its moral effects, it was fruitless, and some important respects disadvantageous. In laying siege Sevastopol, it may safely be asserted, that the most advantageo point of attack was the northern side; the ground there being m elevated, and the large octagonal work on its summit its citadel a the key of the place. This taken, the Telegraph and Wa batteries on the northern heights, Fort Constantine and the fo below, being commanded and attacked in reverse, must have so fallen: while the town, docks, arsenal, and barracks on the sou side of the harbour would have been at the mercy of the allies, w by the fire of their batteries, might have entirely destroyed the all; whereas, by attacking the place from the south, the ene holding the northern heights, although the works on the crest of t southern heights should be breached and taken, the town, the bo of the place, with its docks and arsenals, would not be tena by the besiegers till the great work on the northern side, and all i defensive dependencies, had been taken; and these, were great strengthened before the allies were in a condition to direct th attacks against them.

The flank march of the whole army to the south abandon at once to the enemy a perfectly free communication between t place to be besieged and his army of observation in the field, a left open the line of operation from their base at Perekop; disclosed the alarming fact that, from want of sufficient for Sevastopol could not be invested on every side; that the m advantageous point of attack was not to be attacked, but turne that the enemy's communication with the strongest portion of t town—its citadel, its keep, and the key of the whole position—w to be left open to him; and that, instead of besieging Sevastop the allied army was only to attack an intrenched position on t southern heights, supported in its rear by the strongest feature a most formidable works of the place, and open to receive succour reinforcements to any extent; also that the attack of the place w to be carried on without a covering army, distinct from t besieging force, to protect it from being disturbed in its operations by the enemy in the field, who was thus left in direct and immediate communication with a *tête* which he might support with all his force. The flank march of the whole army to the south was therefore an error in strategical science, imposed of necessity upon the allied commanders by want of numerical strength to render the attack of Sevastopol safe and successful; and such error can only be justified by the absolute inability of the army to fulfil the conditions on which the siege of a fortress, with a large army of observation in the field, can be successful.

Had the allied army been strong enough to follow up its success on the Alma by the occupation of Duwankoi and Khuton, or Bakchi Sarai, and to invest the place on the north with the large reserve force which assuredly should have been at hand, a successful attack on the small intrenched camp established by the Russians to prevent a landing being made good at the mouth of the Belbec River, would have materially affected the progress of the operations in the Crimea. However formidable the defences of that camp might have been seaward, it could easily have been taken by land, while a part of the allied force moved round and gained possession of Balaklava, so as to open its port to the fleet, the latter having on board a sufficient *reserve* to invest the place on that side also. To this it may be said, we sent to the intended seat of war the whole of our effective military force, and could do no more. This unhappily is true; but if as the author always maintained, and subsequent events proved, "our all" was then clearly insufficient to do our part to effect the purposes in view, all that can be said is, that so great an operation should not have been undertaken until ample means had been provided, and not on any account at so late a period of the year. But, moreover, if the whole of our very limited means was not sufficient to enable us to provide a contingent adequate, in the stipulated proportions, to form with our allies an army sufficiently strong to enter on a great territorial war in an enemy's country with any fair prospect of success, how was it then—and, till too late—with respect to reinforcements? Where were *our* reserves? No such operation should ever be undertaken without large reserves either at hand or immediately forthcoming.

The very first principle in strategical science is to keep a retreat open in the event of a failure in the object of an operation; another is, not to undertake any military measure without well considering both the unsuccessful and the successful issue. No thought appears to have been bestowed on either of these maxims in regard to the Crimean expedition; complete and speed[illegible] was deemed certain: that Sevastopol was doomed to [illegible] to doubt; and failure in this object was prom[illegible] The sad disappointment of this expectation was attributed to caus which, it is said, could not have been foreseen—the strength of tl place, its abundant means of defence, and the determined resistan opposed by the Russian forces: yet all this should have be anticipated; it was, in fact, foretold by the author, whose co victions were founded on what military science and experience h taught him respecting an enterprise attempted in such circu stances. The following extracts from a work published by t author in 1819[a] will serve to show what, at various times since t invention of gunpowder, have been the consequences of attempti to besiege fortified places with insufficient means:—

"When Beauvais was besieged by Charles the Bold, in 1472, t place not being completely invested, succours were thrown into and the king, who discovered his error when it was too late, w obliged to raise the siege." The like error was committed, and t like result followed, when Haarlem was besieged by the Spaniar in 1573.[b] "When, in 1674, M. Rabenhaupt, with an army 11,000 men, besieged Grave, in which there was a garrison 4000 men, the sorties from the place were so frequent, th according to M. Quincy, in his 'Histoire Militaire de Louis XIV vol. i. p. 387, it was difficult to pronounce whether M. Rabenhau was the assailant or the defender; a circumstance which prov that an error had been committed in undertaking the siege with small a force."[c]

The investing force required to attack such a place as Grav should not be less than 21,000 men. The proportion required f camp and other duties cannot well be less than one-tenth of t whole army, which for 11,000 men, at three reliefs, is 3300 me the strength of the working parties, at three reliefs, is 3600; the would remain, therefore, only 4100 men as the guard of the trenche which, at three reliefs, would furnish only 1366 men to oppose t sorties; and these were no doubt made with 3000 men. In th calculation, no allowance is made for sickness or casualties; a all the duty is supposed to be performed with three reliefs, whic no troops could support except for a very short time and in fi weather.

Numerous other instances of failures arising from this error m be found in military history, nor is it necessary to go far back. I the year 1854, the Russians attacked Silistria without having i vested it, and tried to carry the place by assault, but were repuls with great loss. Omar Pacha succeeded in throwing reinforcemen into the fortress, with assurances that he would speedily come

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[a] 'Observations on the Motives, Errors, and Tendency of M. Carnot's "Principles Defence," p. 79. [b] Ibid., p. 80. [c] Ibid., p. 157, *et seq.*

its relief. The Russians made another desperate assault, hoping to take it before it should be relieved; but the Turks, strengthened by the reinforcements thrown in, repulsed the attack, and the Russians were compelled to raise the siege, with a loss of 10,000 men, who had fallen during the forty days that it had lasted.

How the troops before Sevastopol endured their labours, and service in the trenches, is a miracle in war. The men on duty in the lines were very nearly half the effective strength of the division that furnished them; and a very large portion of those who so heroically repulsed the attack of the 5th of November, had just left their night's duty in the trenches.

The force required for guarding the trenches should not be less than three-fourths of the strength of the garrison; and, unless this proportion be observed, the operations and works of a siege will be continually exposed to be disturbed or destroyed by the sorties. Frequent sorties from a besieged place, are strongly condemned,[a] particularly in the early stages of the attack, when its works are yet distant; because, even if partially successful, the loss of one man in a place completely invested, is more serious to the besieged than six or seven would be to the besiegers. But when the garrison is strong, and the besieging army inadequate to the enterprise (which was the case in the attack of Sevastopol, it not having been invested), this maxim is reversed: the loss of one man to the allied army was far more serious to it than a much greater loss to the defenders of a position which might be strengthened to any extent commensurate with its force in the field. Under these circumstances, the Russians did right to make frequent sorties, and to resort to operations of active defence which they could not have done had the place been invested. In these attacks, though most gallantly repulsed, the allied army sustained far greater loss than in prosecuting the operations of the siege; and this was a penalty paid in precious blood, for having undertaken a siege with means so inadequate as to invite, and admit of, as we experienced to our cost, those *retours offensifs*, which under usual circumstances are as condemnable as impracticable.

Nothing could justify the attack of Sevastopol at so late a period of the year but the certainty of taking it by a coup-de-main; and that this was believed possible, and urged on accordingly, is clear from the general tone of the organs of public opinio [illegible]
commencement and throughout the operations c [illegible]
the serious error of underrating the force [illegible]
and of exaggerating our own. The au [illegible]
the place having been taken could r [illegible]

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[a] *Vauban*, 'Traité de la Défense des P [illegible]

power to discredit statements which raised the expectations of the people of this country to the highest pitch, thereafter to occasion the most bitter disappointment.

Viewed strategically, the operation of laying siege to Sevastopol commenced inauspiciously: the place was not invested, its communications with the country, with the army in the field, and with its base, were free; succours and supplies to any amount could be thrown in, or taken out; the defensive force in the place was in direct communication with the offensive force in the field. The besiegers knew not what force they were fighting.

The bombardment of the 17th October satisfied, to some extent, the desire of the commanders, officers, and seamen of the fleets to have an active share in the labours and dangers of the attack of Sevastopol, and to gratify popular clamour against the reserved position in which the Admirals wisely kept their fleets, as at Bomarsund; but that bombardment contributed nothing to the reduction of the place. The co-operation of the fleet could only be useful as a diversion in favour of the land-attack, when the army should be prepared to assault the enemy's position at the same time; but under the then existing circumstances it could produce no such effect, and the severe damage and loss sustained by the ships and their gallant crews was very inadequately compensated by the little injury they inflicted on the enemy's forts and seaward batteries, which, not being faced with granite, appeared to be more severely damaged than at Bomarsund. The safety of the whole operation depended very materially on the presence of the fleets, and on their ability to keep the sea. The ships were greatly short of guns and of hands. The entrance to the harbour was blocked up by the sunken ships, so that the batteries which the fleets engaged could neither be approached sufficiently near, nor turned by forcing an entrance. The effects produced by the ships' guns on the stone forts were far from justifying an opinion that the fleet could have attacked the place with any prospect of reducing it, had not land-forces been employed (Art. 360, p. 368): it shows rather that an attack made by the fleet alone on the seaward batteries, however gallant and successful it might have been in damaging some of the defences, and dismounting some of the guns, would have produced no results commensurate with the losses sustained; the ships would have been vastly more crippled than they were in the attack which actually took place, and there can be no doubt that some ships would have been entirely destroyed and many disabled. The severe effects produced by the plunging fire of the Telegraph batteries and the Wasp Fort, situated on a cliff, upwards of 100 feet above the level of the sea, and the very little damage they sustained by the fire of the ships, may well be cited as a practical illustration of what is stated in Art. 346 on the "command" which coast batteries should have over the surface of the sea; for, although the elevations for the distances of the several ships from the batteries were not greater than from 1° to 3°, it required the greatest elevation the ports admit of, to bring the guns of the ships to bear on the parts of the enemy's batteries that could be seen; whilst the ships were wholly exposed to a destructive plunging fire from the forts. The action terminated by nearly all the vessels engaged in that quarter, slipping their chains, and retiring out of fire.

The French ships were drawn up in line against the forts on the south side of the harbour, and partly across its mouth; the British ships were in line opposite the forts on the north side; and the Turkish ships were drawn up between them. The ships were so much *underhanded*, in consequence of no less than 4000 seamen and marines having been landed from the fleet to serve at the siege, that the gallant Admiral would not allow any men to be exposed on the upper deck of the "Britannia" but his staff, signal-men, &c., and walked his poop, dictating signals for the arrangement of the ships in the order of battle. During the action, a shell from one of the enemy's batteries exploded close to him. It was a dead calm, and great difficulty was experienced, as well as time lost, in moving the heavy sailing line-of-battle ships, by steamers lashed to their sides. This mode of propulsion was preferred to traction or towing, in order to protect the steamer from the danger of being crippled by the enemy's fire; but in avoiding the danger incidental to towing, other difficulties were incurred, which, together, show that no vessels should be employed in attacking land-batteries but such as possess steam power inherent in themselves: for it took an hour to turn the "Britannia" into the proper position to advance after her anchor had been weighed! (Art. 348).

Notwithstanding the diversion caused by the fire of the besiegers' land-batteries, considerable loss, according to Admiral Dundas's Report, was sustained by the British ships; besides the damage to their hulls from shells and red-hot shot, the masts, yards, and rigging were, more or less, cut away.

The damage sustained by the combined fleets was caused chiefly by the Russian shells, which were fitted with time-fuzes, as those were which they used in the affair at Sinope (Art. 314). The "Albion" received several shells close to the water-line; three entered her cockpit, and she was once or twice on fire. Having ceased firing, in consequence of being [illegible] fire, to close the magazine, and having sig[illegible] steamer, the "Albion" was towed [illegible] the "Firebrand," in effecting [illegible] damaged. The "Arethu[illegible]

severely damaged by the Russian shells. One burst on the m
deck, and knocked down a considerable number of men of
adjoining guns'-crews; another shell burst on the lower deck,
set fire to some material close to 200 live-shells, placed there
immediate use! Another shell blew out portions of several pla
in the bends, and had there been any sea the ship must have su
A shell lodged and burst in the timbers at the water-line.
officer and five out of seven men, standing together on the up
deck, were dangerously wounded by the bursting of a shell. A
having retired out of fire, it was found necessary to keel the shi
plug shot-holes below the water-line. The "Sans Pareil" suffe
severely in men and spars. The "London" suffered considerab
in her hull, from shot and shells, fired from the Telegraph Batte
and was three times on fire, within two hours. The "Queen" a
was forced to withdraw, a red-hot shot having set fire to her. T
"Agamemnon" lay near Fort Constantine, at 800 yards' distan
and suffered severely. The French ships appear also to ha
suffered greatly. The "Ville de Paris," while engaging t
Quarantine Battery, received a shell which blew away part of h
poop-deck, and killed and wounded a great number of men. The
facts, extracted from the general reports of damages, are sufficie
to show that the shells fired by the Russians were fitted with tim
fuzes. Shells which struck, penetrated into the ships, and th
exploded; and others which exploded over the ships witho
striking, could only be time-fuzed shells. Percussion-fuzes cou
not burst their shells without hitting a sufficiently resisting part
the ship to cause explosion; nor could they explode after havi
penetrated. It is therefore evident that a great error will
committed if we persist in preferring percussion to time fuzes,
shell-firing against ships;[a] against forts they are utterly useles
and the result of this bombardment fully bears out what has be
constantly asserted by the author (Art. 314).

It is stated that, to the last moment, the Russian guns (upwar
of 300) kept up their fire. The effect produced on the mason
works is said to have been very small: the archings of two cas
mated embrasures were shaken, and these were at once repaire
From Admiral Hamelin's despatch to the French Government,
appears that, after the firing from the French ships had continu
about an hour and a half, that of the Russian batteries opposed
them slackened, and the Quarantine Battery was silenced. On t

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[a] The author was informed by letters written by a naval officer of high rank, and a d
tinguished artillery officer, who were present in the action on board a line-of-battle sh
that the observations contained in Art. 347, p. 355, of this work, on the severe effects
shell-firing with time-fuzed shells upon ships, were remarkably verified in the attack
the Russian forts at Sevastopol.

British side, we learn that towards dusk the Russians returned to their guns, and that these batteries re-opened their fire with considerable effect upon the allied fleet. In consequence of the little impression made, apparently, on the forts, when darkness was coming on, the fleets retired to their anchorage.

The artillerymen were several times driven from their guns, many of which were dismounted, but as often they resumed their stations: they appeared to have served their guns well, and fired bar-shot, rockets, red-hot shot (Art. 311, p. 309), and shells, with great precision.

The observations which the author frequently had occasion to make on the subject of the expedition to the Crimea were fully borne out by all that took place in the operations against Sevastopol. In order to understand the actual position of the belligerent armies, it is necessary to observe that, on the side attacked, the town was fortified with a double *enceinte* of earthworks terminating on the east at the head of the inner harbour, from whence a strong redan line extended north-westward, ending on the careening bay. This line enclosed the docks, and the camp of that part of the Russian army which was in immediate co-operation with the garrison of the town.

The besieging army occupied a development of not less than twelve miles—the French, British and Turkish troops extending from Streletska Bay on the west to the river Chernaya on the east, and crossing the Balaklava and Woronzoff roads. The only ground on which the approaches could be carried on, was an open plain about 2200 yards broad, between two ravines, one leading to the Quarantine Bay, and the other to the inner harbour, which forms the eastern side of Sevastopol. Stretching across this plain, at 1300 yards from the outer line of the ramparts of the place, the first parallel was formed; the second parallel was scarcely 400 yards in advance of the first.

A chain of batteries extending over a line four miles in length formed a sort of countervallation, which was within 600 yards of the ramparts of the town and the fortifications of the intrenched camp; and several of these batteries were armed with the heaviest ordnance.

The presence of a Russian army of observation in the field rendered it necessary to form a chain of redoubts and batteries, which constituted a line of circumvallation: these were nearly four miles distant from the works of the town; and immediately beyond them took place the actions of the 25th of October and the 5th of November, in which British gallantry was brilliantly display though under very unfavourable circumstances.

The task assigned to the besieging army was precisely th attacking a strongly-intrenched camp in connection with a powerfu fortress, open to receive supplies to an unlimited amount. Th allied army was in fact, situated between two forces, each apparentl as numerous as itself; and it had to contend with the most seriou difficulties, from the nature of the ground scarcely admitting o trenches being dug in it: its works were incessantly exposed to th fire of a powerful artillery in the massive casemated towers of th place, and to the numerous batteries established on the newly-constructed lines by which these points of defence were covered and connected, and harassed continually by the powerful army in it rear; while the brunt of action had to be borne by the French and English troops, who could place little dependence on their Turkish allies. After two months of open trenches, the besiegers had not even arrived within the distance at which a practicable breach could be made in the works of the place.

We are taught by a high authority,[a] and the precept was fully illustrated by what took place before Sevastopol, that the most effectual mode of retarding the operations of a siege, as well as of rendering them difficult and sanguinary for the besieging army, is to have the place so strongly garrisoned that the defenders may be able to make frequent sorties (*retours offensifs*), and to be, moreover, in immediate connection or to have secure communications with a strongly-intrenched camp. This was precisely the state of Sevastopol, which served as a *grand tête* to the northern position with its citadel and other numerous works; the whole being open towards the rear, by which reinforcements and supplies to any amount could arrive along the great road from Perekop.

Very different was the condition of the Russians at Sevastopol from that of the Austrian army at Ulm, in 1805: that city being in a position which admitted of being surrounded by the French, and far distant from the army which should have supported it, was compelled to surrender. Rather may their circumstances be compared to those of the Austrians at Olmütz, in 1758, when that city was besieged by the army of Frederick II. On that occasion General Theirheim connected the detached forts about the place by works of earth, so as to convert the city into a strongly-retrenched camp, by which the place was enabled to hold out till the king was obliged to retire from it.[b] The state of the allies before Sevastopol was nearly similar to that of Napoleon I. when, in 1796, he besieged Mantua. That great general, finding himself in danger of being immediately surrounded by the two armies which were advancing to relieve the place, did not hesitate to raise the siege, abandoning even his siege artillery. He threw his whole force on each of the

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[a] *Bousmard*, 'Des Camps Retranchés sous les Places,' chap. vii. p. 224.

[b] *Jomini*, ch. x.

Austrian armies in succession, and, in defeating them, he struck the decisive blow which rendered him master of the north of Italy.[a]

Active operations against the intrenched position on the southern heights of Sevastopol having been suspended, the safety of the allied army through the winter became a matter of painful interest. After an unopposed landing, most skilfully and gallantly conducted by Rear-Admiral Sir Edmund Lyons, under the orders of the Vice-Admiral Commanding in Chief, in the manner practised at Aboukir in 1802 (Art. 357 et seq.), and a series of brilliant exploits in the field, in a few short weeks the allied army, disappointed in its expectations of speedy and complete success, found itself shut up and besieged in a *cul-de-sac* in the remotest corner of Europe; while large portions of the fleets had to be employed throughout the winter, in a stormy sea and at all risks, in conveying to the beleaguered troops succours of the first necessity, and in which service many ships were lost.

No siege should ever be undertaken in any seat of war till the enemy in the field shall have been defeated, and completely driven back by the covering army of the besiegers, so that the operations of the siege may be carried on undisturbedly. This might have been done by the allies, had the descent on the Crimea been made at an earlier season, with a force larger and better provided with the means of more effectually carrying out the object of the expedition. An army of 70,000 men, of such troops as those of the allies proved themselves to be, might, as the Duke of Wellington said of his army in Spain, "have gone anywhere and done anything."

In reviewing the operations in the Crimea, at this distance of time (1860), the author cannot concur in the assertion, so often made, that the British military system was so badly adapted to real service that it broke down before Sevastopol. The British military system, which, during the Peninsular war, had been brought to the highest state of proficiency in the field, had been almost annihilated long previously to the Crimean war, as stated in pages 606, 607, and 608, of this Appendix. Its destruction commenced immediately after the termination of the great war, and continued during the whole of the ensuing peace for forty years: all the establishments which had been created and brought to perfection had been either rendered useless or broken up, and there remained nothing of the military system of England of former times but that relating to regiments; and we entered into the late war totally unprovided with the means by which only the organization of an army for service in the field can be called systematic. This was the true

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[a] *Jomini*, ch. xxx.

cause of the sufferings and disasters which the British troop endured. Nor was the termination of the operations in the Crime altogether satisfactory, nor the military operation in reality com pleted. Sevastopol was never taken, strictly speaking: the allie army never gained military possession of the place, nor the allie fleets possession of the harbour. The key of the intrenched positio on the south side having been carried by assault, the Russian abandoned that side, and retired in excellent order across a bridge admirably constructed, skilfully made, and most expertly withdrawn when the passage was effected to the North Fort—to capture which a real siege was required. A suspension of arms, proposed by th allies, thereupon took place, followed by a sudden peace; and th allied forces evacuated the Crimea without having obtained rea military and naval possession of the place, and left the Russian flag flying on the citadel and key of Sevastopol. True, the fleet ha been destroyed by the enemy himself, and the arsenal by the allies but the operation was never completed in a real military sense, a history will hereafter assert it should have been, and which th author still thinks it might have been, by commencing operations o the north side.

APPENDIX (D).

THE RELATIVE STRENGTH OF THE BRITISH AND FRENCH ARTILLERY.

BRITISH ARTILLERY.

Organisation of the British Royal Artillery (1860).

The Royal Artillery of the British Army is a force of about 27,000 men, distributed throughout the British Empire.

Of this force about 16,500 are serving at Home Stations, about 5200 in India, and the remainder in the Colonies.

The Royal Regiment of Artillery is at present organized in brigades of Field Artillery, and of Garrison or Siege Artillery. There is also a brigade for Coast defence, and a Depôt Brigade.

The *Field Artillery* comprises 1 Brigade of Horse Artillery, consisting of 10 batteries, and 6 brigades of Field Artillery, consisting of 50 batteries.

Of these 60 batteries, 30 are serving at Home Stations, 24 are in India, and 6 in China.

The *Garrison Artillery* consists of 9 brigades or 70 batteries, of which 40 are serving at Home, and 30 in the Colonies.

The *Coast Brigade* consists of 8 batteries, and, as its name implies, is dispersed on the coast of the United Kingdom.

The *Depôt Brigade* consists of 10 batteries, and serves as the receptacle for the recruits enlisted for the general service of the Artillery, and is the source from which the brigades on Foreign Service are supplied.

Two of its batteries are organized as Field Artillery for the instruction of recruit drivers, and the remainder as Garrison Batteries.

The Depôt Brigade also includes the majority of the non-effectives of the regiment.

Gunners and Drivers.—Early in 1858 the system, which had hitherto obtained, of combining the duties of gunner and driver in a single individual, was exchanged for one which separated those duties. The drivers of the Royal Artillery are therefore distinct from the gunners. These drivers are instructed in the ordinary duties of gunners, and the gunners of a field battery are also so instructed as to perform on an emergency all the duties of drivers.

The establishment of a battery of field artillery differs from of a battery of garrison artillery in the addition of the neces drivers and artificers (including the farrier, shoeing-smiths, co makers, and wheelers). Thus any of the brigades of Garr Artillery on Home Service could at the shortest notice be verted into field brigades by drafting drivers and artificers the Depôt Brigade at Woolwich.

Thus a battery of garrison artillery consists of 117 Non- missioned officers and men (gunners), while a battery of artillery consists of:—

117	Non-commissioned officers and men (gunners).
85	Non-commissioned officers and men (drivers).
12	Non-commissioned officers and men (artificers).
214	Non-commissioned officers and men.
104	Horses for peace establishment.
210	Horses for war establishment.

The establishment of officers is the same in each case, vi battery officers.

Materiel.—Each battery of field artillery is composed of 6 pi viz., 4 9-pounder guns of 13 cwt., and 2 24-pounder howitze nearly the same weight.

The carriages which accompany a battery of field artiller active service comprise 6 ammunition-waggons for the guns, a ammunition-waggons for the howitzers, a rocket-carriage, a s gun-carriage, a store limber-waggon, a forge, 2 forage-waggo water-carts, a store-cart, and a medicine-cart. Making a tota 28 carriages, necessitating 210 horses. The whole under the mand of a captain.

Ammunition.—Each battery of field artillery carries into the 176 rounds of ammunition for each gun, and 174 rounds for howitzer, together with 100 rockets (12-pounders).

The batteries of the *Royal Horse Artillery* are equipped with 6-pounders of 6 cwt., and 12-pounder howitzers of the same wei With these guns the Horse Artillery are enabled to accomp Cavalry in their most rapid movements.

The force of field artillery in the United Kingdom is, there 180 guns, fully equipped in every particular, and ready for im diate service.

The same number of guns are now attached to the Royal Artil in India and in China.

NOTE.—It has been deemed advisable to make no mention in the text of the Arms rifled field-gun of 8 cwt., which has been very recently introduced into the service. I course of the present summer (1860) the whole of the batteries of field artillery on service will be equipped with the new rifled gun. Two of the batteries now in Chin already so equipped, as are four of the batteries at present in the United Kingdom.

Detail of the Royal Horse Artillery Brigade.[a] *—Headquarters, Woolwich.*

ESTABLISHMENT.

Staff.—1 Serjeant-major; 1 Quartermaster Serjeant; 1 Trumpet Major; 1 Orderly-Room Serjeant; 1 Paymaster Serjeant; 1 Hospital Serjeant; 1 Armourer Serjeant; 1 Drill Serjeant; 24 Troop Serjeants; 1 Farrier; 1 Collarmaker; 1 Wheeler.

Troops.—96 Serjeants; 70 Corporals; 100 Bombardiers; 1,010 Gunners; 975 Drivers; 11 Trumpeters; 11 Farriers; 72 Shoeing-smiths; 33 Collarmakers; 33 Wheelers.

Total.—Men 2443. Horses 1190.

Detail of a 9-pounder Field Battery, Royal Artillery, for an Establishment of Six Guns.

Number of Carriages.	Equipment.	Men.			Horses.			Sets of Appointments.		Harness Sets, Double.	
		Gunners.	Drivers.	Total.	Riding.	Draught.	Total.	Officers.	Non-Com. Officers and Men.	Lead.	Wheel.
4	9-pounder Guns ..	40	12	52	..	24	24	..	..	8	4
2	24-pounder Howitzers	20	6	26	..	12	12	..	..	4	2
6	Ammunition-waggons	12	12	24	..	24	24	..	..	6	6
1	Store Limber-waggon	..	2	2	..	4	4	..	..	1	1
1	Forge	..	2	2	..	4	4	..	..	1	1
1	Store Cart	..	1	1	..	2	2	..	..	..	1
1	Hospital Cart	..	1	1	..	2	2	..	..	..	1
1	Light Forage-waggon	..	2	2	..	4	4	..	..	1	1
..	Officers' Horses ..	..	..	..	6	..	6	6	..	..	..
..	Staff-Serjeants and Mounted Non-Com. Officers	..	..	..	10	..	10	..	10	..	..
..	Trumpeter	..	..	..	1	..	1	..	1	..	..
..	Farrier	..	..	..	1	..	1	..	1	..	..
..	Shoeing-smith	..	..	..	1	..	1	..	1	..	..
..	Spare Men, Officers' Servants & Batmen, & Spare Horses ..	28	37	65	1	8	9	..	1	2	2
17	Total Carriages. Total	100	75	175	20	84	104	6	14	23	19

Officers.—1 Captain; 1 Second Captain; 3 Lieutenants; 1 Assistant-Surgeon.

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[a] Divided into 10 troops, which in May, 1860, were disposed as follows:—Woolwich, 2 troops and depôt; Aldershot, 1; Norwich, 1; Ireland, 2; India, 4.

Non-Commissioned Officers and Men.—2 Staff-Serjeants; 8 Serjeant 6 Corporals; 9 Bombardiers; 100 Gunners; 75 Drivers; 2 Tru peters.

Artificers.—1 Farrier; 6 Shoeing-smiths; 3 Collarmakers; Wheelers.

DETAIL of a 6-pounder Battery, Royal Horse Artillery, for an Establishme of Six Guns.

Number of Carriages.	Equipment.	Men.			Horses.			Sets of Appointments Non-Com. Officers and Men.	Harness Sets, Double.	
		Gunners.	Drivers.	Total.	Riding.	Draught.	Total.		Lead.	Wheel
4	6-pounder Guns	32	12	44	32	24	56	32	8	[illegible]
2	12-pounder Howitzers	16	6	22	16	12	28	16	4	[illegible]
4	Gun Ammunition-waggons	8	8	16	..	16	16	..	4	[illegible]
2	Howitzer Ammunition-waggons	4	4	8	..	8	8	..	2	[illegible]
1	6-pounder Rocket-carriage	2	3	5	..	6	6	..	2	[illegible]
1	Store Limber-waggon ..	..	2	2	..	4	4	..	1	[illegible]
1	Forge	..	2	2	..	4	4	..	1	[illegible]
1	Store Cart	..	1	1	..	2	2	..	..	[illegible]
1	Hospital Cart	..	1	1	..	2	2	..	..	[illegible]
1	Light Forage-waggon ..	..	2	2	..	4	4	..	1	[illegible]
..	For 2 Staff-Serjeants, 1 Trumpeter, 1 Farrier, and 3 Shoeing-smiths	..	..	..	7	..	7	7	..	..
..	Spare Men, Officers' Servants and Batmen, &c., and Spare Horses	18	29	47	5	8	13	5	2	[illegible]
18	Total Carriages. Total	80	70	150	60	90	150	60	25	[illegible]

Officers.—1 Captain; 1 Second Captain; 3 Lieutenants; 1 Assi ant-Surgeon.

Non-Commissioned Officers and Men.—2 Staff-Serjeants; 8 Serjeant 6 Corporals; 9 Bombardiers; 80 Gunners; 70 Drivers; 1 Tru peter.

Artificers.—1 Farrier; 6 Shoeing-smiths; 3 Collarmakers; Wheelers.

Detail of a 9-pounder Battery, Royal Horse Artillery, for an Establishment of Six Guns.

Number of Carriages.	Equipment.	Men.			Horses.			Sets of Appointments Non-Com. Officers and Men.	Harness Sets, Double.	
		Gunners.	Drivers.	Total.	Riding.	Draught.	Total.		Lead.	Wheel.
4	9-pounder Guns	40	16	56	40	32	72	40	12	4
2	24-pounder Howitzers	20	8	28	20	16	36	20	6	2
4	Gun Ammunition-waggons	8	8	16	..	16	16	..	4	4
2	Howitzer Ammunition-waggons	4	4	8	..	8	8	..	2	2
1	12 pounder Rocket-carriage	2	3	5	..	6	6	..	2	1
1	Store Limber-waggon ..	..	2	2	..	4	4	..	1	1
1	Forge	..	2	2	..	4	4	..	1	1
1	Store Cart	..	1	1	..	2	2	..	..	1
1	Hospital Cart	..	1	1	..	2	2	..	..	1
1	Light Forage-waggon ..	..	2	2	..	4	4	..	1	1
..	For 2 Staff-Serjeants, 1 Trumpeter, 1 Farrier, and 3 Shoeing-smiths	..	..	..	7	..	7	7	..	..
..	Spare Men, Officers' Servants and Batmen, and Spare Horses ..	16	38	54	7	12	19	7	5	1
18	Total Carriages. Total	90	85	175	74	106	180	74	34	19

Officers.—1 Captain; 1 Second Captain; 3 Lieutenants; 1 Assistant-Surgeon.

Non-Commissioned Officers and Men.—2 Staff-Serjeants; 8 Serjeants; 6 Corporals; 9 Bombardiers; 90 Gunners; 85 Drivers; 1 Trumpeter.

Artificers.—1 Farrier; 6 Shoeing-smiths; 3 Collarmakers; 3 Wheelers.

FRENCH ARTILLERY.

Organisation of the French Artillery (1860).

On the 20th February, 1860, the Emperor of the French issued a decree which entirely changed the organisation of the French Artiltillery. The following is the present organisation of that Force:—

The Depôt Staff of the hitherto existing 17 Regiments has been abolished, as well as the 30 Batteries which formed the "park," and the four companies of gunner-drivers which were attached to the first 6 Regiments of Artillery.

Twenty new Batteries of Foot Artillery were authorised, and are equally distributed between the first 5 Regiments of the Artillery.

The 105 Batteries of Field Artillery which had hitherto dispersed among the 7th, 8th, 9th, 10th, 11th, 12th, and 13th ments, are by the new system reduced to 100, which are orga in 10 Regiments of Field Artillery. This necessitated the add of 3 Regiments to those (7th to 13th) which had previously incl the Batteries of Field Artillery. These Regiments are numb 14, 15, and 16.

Four Regiments of Horse Artillery (17, 18, 19, and 20) are retained.

An Artillery Train is re-established. It consists of 6 squad each squadron composed of a Staff, a section of non-combatants, 5 companies. There is also in addition a headquarter Regi Staff.

The foregoing constitute the Artillery of the Line.

The Artillery of the Guard is of a distinct establishment.

The 2 cadres de depôts which have hitherto existed have suppressed.

In the guard there is one Battery of Foot Artillery, and a pany of Bridgemen (ouvriers-pontonniers) under the command chef d'escadron and a special staff.

The hitherto existing Regiment of Foot Artillery has bee organized as a Regiment of Field Artillery consisting of 8 Batte Of these 8 Batteries 2 are newly raised, and the remaining 6 formed by the attaching to the existing Batteries of Foot, the teries hitherto composing the "park."

Attached to the Guard is a squadron of the Artillery Train, u the orders of a chef d'escradon. This squadron is composed companies, each of a distinct establishment.

By the recent arrangements, each of the Batteries or Compa of the several branches of the Artillery Service has a fixed (cadre). The only alteration in this particular consequent on would be the addition of one Lieutenant to each Battery.

The companies of the Train (both with the Line and with Guard) may be "dedoublé." This is to be done by adding extra lieutenant to the officers, and then dividing the officers two subdivisions; each subdivision to be completed in rank file equal to the original division. Of the officers, the senior Captain) and the second senior Lieutenant are attached to the subdivision, and the senior Lieutenant and the junior subaltern the second.

In time of war a depôt and staff may be established for the sev Regiments of Artillery and squadrons of the Artillery Train.

It is intended that the six squadrons of the Artillery Train s be stationed in the same garrisons with the first six Regiment

Foot Artillery, and shall undergo all the instruction necessary for the management of horses.

In time of war the Regiments of Foot Artillery combined with the squadrons of the Train will compose mixed Batteries, on which will devolve the management of mountain Batteries and of rockets, as also of part of the reserve Batteries.

The following gives in a tabular form the present strength of each of the French Regiments of Artillery.

Line.

1st	Foot Artillery	16	Batteries	
2nd	do.	16	do.	
3rd	do.	16	do.	
4th	do.	16	do.	
5th	do.	16	do.	
6th	Bridgemen	12	do.	
7th	Field Artillery	10	do.	60 Guns.
8th	do.	10	do.	60 do.
9th	do.	10	do.	60 do.
10th	do.	10	do.	60 do.
11th	do.	10	do.	60 do.
12th	do.	10	do.	60 do.
13th	do.	10	do.	60 do.
14th	do.	10	do.	60 do.
15th	do.	10	do.	60 do.
16th	do.	10	do.	60 do.
17th	Horse Artillery	8	do.	48 do.
18th	do.	8	do.	48 do
19th	do.	8	do.	48 do.
20th	do.	8	do.	48 do.
				792

with an Artillery Train of six squadrons corresponding to the first 6 Regiments of Artillery. Each squadron being composed of 5 Companies of effectives in addition to the Squadron Staff and supernumeraries and Regimental Staff.

Guard.—1 Regiment of Field Artillery, consisting of 8 Batteries with 48 Guns; 1 Regiment of Horse Artillery, consisting of 6 Batteries with 24 Guns; with a squadron of Artillery Train—making a total of 864 Guns.

Personnel.—The general duties of the Artillery Service are carried on by a "general" staff. This general staff comprises the following officers:—32 Colonels; 38 Lieut.-Colonels; 84 Chefs d'escadron; 215 Captains.

There is also a staff of "Employés Militaires" (including Gardes, Artificiers, Ouvriers d'etat, and Gardiens de Batteries) to the number of 862, and a staff of 147 "Employés Civils," including the superintendents of the foundries and officers charged with the manufacture and issue of Arms.

In addition to the foregoing, each Regiment, both of the Line and of the Guard, has an organisation as follows:—

1st. A Regimental Staff consisting of all Officers other than
pany Officers, and including—1 Colonel; 1 Lieut.-Colonel; 8
d'escadrons; 1 Major; 1 Riding-Master; 1 Adjutant; 1 Payma
1 Assistant-Paymaster; 3 Medical Officers; 1 Veterinary Surg
1 Band-Master; 3 Staff Serjeants; 5 Artificers; 21 Musici
2 Trumpeters.

2nd. A "Peloton hors rang," or detachment of non-combat
including Armourers, Clerks, Tailors, Bootmakers, Farriers, &
the number of about 57 to each Regiment.

3rd. A Battery of Artillery of a fixed establishment.

The following are the establishments of the various Batteries,
of the Regiments of French Artillery:—

	Peace.			War.	
	Officers.	Non Com. Officers and Men.	Horses.	Officers.	Non-Com. Officers and Men.
Line:—					
Foot Artillery Battery	4	100	..	4	200
				when employed sieges, &c.	
				4	100
				if a battery of res of 12-pounders	
				4	90
				if attached to a m tain battery.	
Field Artillery Battery	4	135	65	5	234
				or 5	198
Horse Artillery Battery	4	135	106	5	204
Artillery Train Company ..	3	68	43	3	180
Ditto Dedoublé	1st division			2	178
	2nd do.			2	178
				when with the A lery park.	
	do.			2	144
				reserve battery pounder).	
	do.			2	104
				mountain (4-poun or rocket batte	
Artillery of the Guard:—					
Foot Battery	4	120	6	4	150
Field Battery	4	156	104	5	198
Horse Artillery	4	160	160	5	204
Artillery Train (Squadron) ..	10	200	162	10	360
Ditto Dedoublé	..	..	..	12	712

The French Artillery therefore consists of

		Peace.			War.		
		Officers.	Non-Com. Officers and Men.	Horses.	Officers.	Non-Com. Officers and Men.	Horses.
Line ..	20 Regiments	1330	28,653	11,668	1462	45,215	28,512
	12 Companies of Artificers .. .. .. 2 Companies of Armourers	56	1040	..	56	1400	140
Imperial Guard.	1 Division of Foot .. 2 Regiments	108	2657	1967	122	3389	3133
Artillery Train	Line 6 Squadrons ..	144	2250	1392	144	5610	8568
		10	200	162	10	360	571
	Total	1648	34,800	15,189	1794	55.974	40,924

The above is exclusive of Headquarter Staff and Veterans.

The 12-pounder (canon obusier) which formed the great feature in the systême de l'Empereur, was done away with previous to the late Italian war. During that campaign, all the batteries attached to the divisions had 4-pounder rifled guns. The batteries of reserve retaining the 12-pounder howitzer-guns, but only because a sufficient number of the 4-pounder rifled guns and ammunition for them were not rifled. Some 12-pounder rifled guns were attached to the army, but considered only as siege guns.

The Gun.

	Inches.
Length of Base Ring	1.97
Do. 1st Reinforce	15.55
Do. 2nd Reinforce	12.01
Do. Chase	21.85
Do. Swell of the muzzle and face of Piece	5.12
Total length from Base Ring to face of Piece	56.50

N.B. Rear of gun to centre of button 3·9 (French measure). Length of muzzle mouldings ·7; neck ring ·4; as these are given in French measure only, and not in English, they are not included in the above length of Piece.

	Inches.
Length of Trunnions	3.15
Diameter of do.	3.14
Diameter of Base Ring	9.65
Do. Neck Ring	6.69

Six semicircular grooves ·630 in. diameter at bore; pitch 59 in. (1·50 m. French measure), or about very nearly one revolution in

the bore. In French measure, length of bore 1·59 m.;]
1·50 m.

The Shell.

	Inches.
Length of cylindrical part	3.11
Do. ogival top	3.39
Total length	5.5

The base rounded off.

	Inches.
Diameter of cylindrical part	3.35
Do. chamber	2.40
Thickness of shell at cylindrical part	.47
Length of fuze-hole	.98
Diameter of face of shell	1.41
Do. fuze-hole	.63
Thickness of shell at face	.39

Six buttons placed in two rows of 3 each. The centre of the l
ones being ¼ of the length of the cylindrical part of shell or ·7
from the base, and the centre of the top row being ¾ of the le
of the cylindrical part on 2·33 in. from the base of shot.

But this expedient did not always answer, and could not be r
upon. The buttons came off, or were stripped off, and the
were far from being perfect. Both these questions are under c
deration, and there is now under trial a gun loading at the br
but the result has not been disclosed.

APPENDIX (E).

ARMAMENT OF THE BRITISH NAVY.

SCREW STEAM-SHIPS.

First Rates. "*Victoria*" *Class.*—1000 *H.-P.*

Lower Deck	32	8-in. guns,	65 cwt., 9 feet.
Middle Deck	30	8-in. guns,	65 cwt., 9 feet.
Main Deck	32	32-prs.	58 or 56 cwt., 9 ft. 6 in.
Upper Deck	26	32-prs.	42 cwt., 8 feet.
	1	68-pr. pivot,	95 cwt., 10 feet.
	121	guns.	Total complement, 1150 men.

First Rates. "*Duke of Wellington*" *Class.*—700 *H.-P.*

Lower Deck	10	8-in. guns,	65 cwt., 9 feet.
	26	32-prs.	58 or 56 cwt., 9 ft. 6 in.
Middle Deck	6	8-in. guns,	65 cwt., 9 feet.
	30	32-prs.	58 or 56 cwt., 9 ft. 6 in.
Main Deck	38	32-prs.	42 cwt., 8 feet.
Upper Deck	20	32-prs.	25 cwt., 6 feet.
	1	68 pr. pivot,	95 cwt., 10 feet.
	131	guns.	Total complement, 1120 men.

First Rates. "*Royal Albert*" *Class.*—500 *H.-P.*

Lower Deck	32	8-in. guns,	65 cwt., 9 feet.
Middle Deck	32	32-prs.	58 or 56 cwt., 9 ft. 6 in.
Main Deck	32	32-prs.	42 cwt., 8 feet.
Upper Deck	24	32-prs.	42 cwt., 8 feet.
	1	68-pr. pivot,	95 cwt., 10 feet.
	121	guns.	Total complement, 1070 men.

Note.—The supply of shells is only limited by the size of the shell-rooms, provided that the whole supply of both shot and shell does not exceed 180 rounds for each pivot-gun, and 80 rounds for each broadside-gun, except in the case of 10-inch broadside-guns, which have a total supply of 100 shot and shell. 20 per cent. of the number of shells supplied are Diaphragm Shrapnel.

The usual proportions of shot and shell are as follows:—

	Shot.	Shell.
For all bow and stern pivot-guns	120	60
For all 10-inch broadside-guns	60	40
For 8-inch broadside-guns,—		
1st six	40	40
2nd six	60	20
Remaining number	70	10
32-pr. guns	70	10

Screw Steam-Ships—*continued.*

ARMAMENT FOR BOATS.

Brass Ordnance......	Howitzers	24-pr.	12½ cwt.,	2 in number.
		12-pr.	6½ cwt.,	2 „
	Guns......	6-pr.	6 cwt.,	1 „

Second Rates. "Conqueror" Class.—800 H.-P.

Lower Deck	36	8-in. guns,	65 cwt., 9 feet.
Main Deck............	36	32-prs.	58 or 56 cwt., 9 ft. 6 in.
Upper Deck	28	32-prs.	42 cwt., 8 feet.
	1	68-pr. pivot,	95 cwt., 10 feet.

101 guns. Total complement, 950 men.

Second Rates. "Renown" Class.—800 H.-P.

Lower Deck	34	8-in. guns,	65 cwt., 9 feet.
Main Deck............	36	32-prs.	58 or 56 cwt., 9 ft. 6 in.
Upper Deck	20	32-prs.	45 cwt., 8 ft. 9 in.
	1	68-pr. pivot,	95 cwt., 10 feet.

91 guns. Total complement, 880 men.

Second Rates. "Agamemnon" Class.—600 H.-P.

Lower Deck	34	8-in. guns,	65 cwt., 9 feet.
Main Deck............	34	32-prs.	58 or 56 cwt., 9 ft. 6 in.
Upper Deck	22	32-prs.	45 cwt., 8 ft. 6 in.
	1	68-pr. pivot,	95 cwt., 10 feet.

91 guns. Total complement, 880 men.

Second Rates. "Neptune" Class.—500 H.-P.

Lower Deck	32	8-in. guns,	68 cwt., 9 feet.
Main Deck............	34	32-prs.	56 cwt., 9 ft. 6 in.
Upper Deck	22	32-prs.	42 cwt., 8 feet.
	2	68-pr. on rear chocks,	95 cwt., 10 feet.

90 guns. Total complement, 880 men.

Second Rates. "Princess Royal" Class.—400 H.-P.

Lower Deck	32	8-in. guns,	65 cwt., 9 feet.
Main Deck............	34	32-prs.	58 or 56 cwt., 9 ft. 6 in.
Upper Deck	24	32-prs.	42 cwt., 8 feet.
	1	68-pr. pivot,	95 cwt., 10 feet.

91 guns. Total complement, 880 men.

Second Rates. "Exmouth" Class.—400 H.-P.

Lower Deck	32	8-in. guns,	65 cwt., 9 feet.
Main Deck............	32	32-prs.	58 or 56 cwt., 9 ft. 6 in.
Upper Deck	26	32-prs.	42 cwt.

tal cor n.

Screw Steam-Ships—*continued.*

Second Rates. "*Nile*" *Class.*—500 *H.-P.*

Lower Deck	18	8-in. guns,	65 cwt., 9 feet.
	14	32-prs.	56 cwt., 9 ft. 6 in.
Main Deck............	6	8-in. guns,	65 cwt., 9 feet.
	28	32-prs.	56 cwt., 9 ft. 6 in.
Upper Deck	24	32-prs.	42 cwt., 8 feet.

90 guns. Total complement, 850 men.

Third Rates. "*Colossus*" *Class.*—400 *H.-P.*

Lower Deck	10	8-in. guns,	65 cwt., 9 feet.
	18	32-prs.	58 or 56 cwt., 9 ft. 6 in.
Main Deck............	4	8-in. guns,	65 cwt., 9 feet.
	24	32-prs.	50 cwt., 9 feet.
Upper Deck	24	32-prs.	42 cwt., 8 feet.

80 guns. Total complement, 770 men.

Third Rates. "*Blenheim*" *Class.*—450 *H.-P.*

Lower Deck	28	32-prs.	56 cwt., 9 ft. 6 in.
Main Deck............	26	8-in. guns,	52 cwt., 8 feet.
Upper Deck	2	68-pr. pivot,	95 cwt., 10 feet.
	4	10-in. guns,	85 cwt., 9 ft. 4 in.

60 guns. Total complement, 615 men.

Third Rates. "*Pembroke*" *Class.*—200 *H.-P.*

Lower Deck	24	32 prs.	56 cwt., 9 ft. 6 in.
	4	8-in. guns,	65 cwt., 9 feet.
Main Deck............	26	32-prs.	50 cwt., 9 feet.
Upper Deck	2	68-pr. pivot,	95 cwt., 10 feet.
	4	10-in. guns,	85 cwt., 9 ft. 4 in.

60 guns. Total complement, 615 men.

SCREW STEAM-FRIGATES.

Fourth Rates. "*Emerald*" *Class.*—600 *H.-P.*

Main Deck............	30	8-in. guns,	65 cwt., 9 feet.
Upper Deck	20	32-prs.	58 or 56 cwt., 9 ft. 6 in.
	1	68-pr. pivot,	95 cwt., 10 feet.

51 guns. Total complement, 570 men.

Fourth Rates. "*Euryalus*" *Class.*—400 *H.-P.*

Main Deck............	8	8-in. guns,	65 cwt., 9 feet.
	22	32-prs.	58 or 56 cwt., 9 ft. 6 in.
Upper Deck	2	8-in. guns,	65 cwt., 9 feet.
	18	32-prs.	45 cwt., 8 ft. 6 in.
	1	68-pr. pivot,	95 cwt., 10 feet.

51 guns. Total complement, 540 men.

Screw Steam-Frigates—*continued.*

Fourth Rates. "*Mersey*" *Class.*—1000 *H.-P.*

Main Deck............	28	10-in. guns,	85 cwt., 9 ft. 4 in.
Upper Deck	12	68-pr. pivot,	95 cwt., 10 feet.

40 guns. Total complement, 600 men.

Fourth Rates. "*Doris*" *Class.* 800 *H.-P.*

Main Deck............	20	68-prs., with rear chocks[a]	95 cwt., 10 feet.
Upper Deck	10	32-prs.	58 or 56 cwt., 9 ft. 6 in
	2	68-pr. pivot,	95 cwt., 10 feet.

32 guns. Total complement, 487 men.

Fourth Rates. "*Arrogant*" *Class.*—360 *H.-P.*

Main Deck............	14	8-in. guns,	65 cwt., 9 feet.
	14	32-prs.	56 cwt., 9 ft. 6 in.
Upper Deck	2	32-prs.	50 cwt., 9 feet.
	10	32-prs.	32 cwt., 6 ft. 6 in.
	1	68-prs.	95 cwt., 10 feet.
	6	32-prs.	32 cwt., 6 ft. 6 in.

47 guns. Total complement, 487 men.

Fourth Rates. "*Ariadne*" *Class.*—1000 *H.-P.*

Main Deck............	24	10-in. guns,	84 cwt., 9 ft. 4 in.
Upper Deck	2	68-pr. pivot,	95 cwt., 10 feet.

26 guns.

Fifth Rates. "*Tribune*" *Class.*—300 *H.-P.*

Main Deck............	20	32-prs.	56 cwt., 9 ft. 6 in.
Upper Deck	10	32-prs.	42 cwt., 8 feet.
	1	10-in. pivot,	84 cwt., 9 ft. 4 in.

31 guns. Total complement, 350 men.

SCREW STEAM-CORVETTES.

Sixth Rates. "*Pearl*" *Class.*—400 *H.-P.*

Upper Deck	20	8-in. guns,	60 cwt., 8 ft. 10 in.
	1	68-pr. pivot,	95 cwt., 10 feet.

21 guns. Total complement, 270 men.

Sixth Rates. "*Highflyer*" *Class.*—250 *H.-P.*

Upper Deck	20	8-in. guns,	52 cwt., 8 feet.
	1	10-in. pivot,	84 cwt., 9 ft. 4 in.

21 guns. Total complement, 250 men.

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[a] "Doris" and "Diadem" to carry on main deck twenty 10-inch, 86 cwt., 9 gun. A. O. 21 June, 1856.

Screw Steam-Corvettes—*continued.*

Sixth Rates. "*Cossack*" *Class.*—250 *H.-P.*

Upper Deck	18	8-in. guns,	60 cwt., 8 ft. 10 in.
	2	68-pr. pivot,	95 cwt., 10 feet.

20 guns. Total complement, 270 men.

Sixth Rates. "*Malacca*" *Class* —200 *H.-P.*

Main Deck............	16	32-prs.	40 cwt., 7 ft. 6 in.
Quarter Deck.........	1	10-in. guns,	84 cwt., 9 ft. 4 in.

17 guns. Total complement, 210 men.

Sixth Rates. "*Encounter*" *Class.*—360 *H.-P.*

Main Deck............	12	32-prs.	40 cwt., 7 ft. 6 in.
	1	10-in. pivot,	84 cwt., 9 ft. 4 in.
	1	68-pr. pivot,	95 cwt., 10 feet.

14 guns. Total complement, 180 men.

MORTAR-FRIGATES.

Sixth Rates. "*Eurotas*" *Class.*—200 *H.-P.*

Main Deck............	2	13-in. mortars,	100 cwt.,
	8	32-prs.	42 cwt., 8 feet.
Upper Deck	2	68-pr. pivot,	95 cwt., 10 feet.

12 guns. Total complement, 200 men.

FLOATING-BATTERIES.

Sixth Rates. "*Ætna*" *Class.*—200 *H.-P.*

Main Deck............	16	68-prs.	95 cwt., 10 feet.

16 guns. Total complement, 210 men.

SCREW STEAM-SLOOPS.

"*Cameleon*" *Class.* — 200 *H.-P.*

Main Deck............	16	32-prs.	32 cwt., 6 ft. 6 in. (on rear chock
	1	32-pr. pivot,	58 cwt., 9 ft. 6 in. [carriages).

17 guns. Total complement, 70 men.

"*Harrier*" *Class.*—100 *H.-P.*

Main Deck............	16	32-prs.	32 cwt., 6 ft. 6 in.
	1	33-pr. pivot,	56 cwt., 9 ft. 6 in.

17 guns. Total complement, 70 men.

Screw Steam-Sloops—*continued.*

"*Cordelia*" *Class.*—150 *H.-P.*

Upper Deck ....{ 10 32-prs. 25 cwt., 6 feet.
1 32-pr. pivot, 58 cwt., 9 ft. 6 in.

11 guns. Total complement, 125 men.

"*Swallow*" *Class.*—60 *H.-P.*

Upper Deck ....{ 8 32-prs 25 cwt., 6 feet.
1 32-pr. pivot, 56 cwt., 9 ft. 6 in.

9 guns. Total complement, 100 men.

"*Desperate*" *Class.*—400 *H.-P.*

Upper Deck ....{ 6 8-in. guns, 52 cwt., 8 feet.
1 68-pr. pivot, 95 cwt., 10 feet.

7 guns. Total complement, 165 men.

"*Plumper*" *Class.*—60 *H.-P.*

Main Deck ....{ 2 32-prs. 56 cwt., 9 ft. 6 in.
10 32-pr. carronades, 17 cwt., 4 feet.

12 guns. Total complement, 100 men.

"*Roebuck*" *Class.*—350 *H.-P.*

Main Deck ....{ 2 68-pr. pivot, 95 cwt., 10 feet.
4 32-pr. pivot, 25 cwt., 6 feet.

6 guns. Total complement, 110 men.

"*Wanderer*" *Class.*—200 *H.-P.*

Main Deck ....{ 2 68-pr. pivot, 95 cwt., 10 feet.
2 32-prs. 25 cwt., 6 feet.

4 guns. Total complement, 90 men.

SCREW STEAM GUN-VESSELS.

"*Arrow*" *Class.*—160 *H.-P.*

Main Deck ....{ 2 68-pr. pivot, 95 cwt., 10 feet.
2 12-pr. howitzers, 10 cwt.

4 guns. Total complement, 65 men.

SCREW STEAM GUN-BOATS.—First Class.

"*Charon.*"—60 *H.-P.*

Main Deck ....{ 1 68-pr. pivot, 95 cwt., 10 feet.
1 32-pr. pivot, 56 cwt., 9 ft. 6 in., on slides 1
available for the 95-cw

2 guns. Total complement, 36 men.

Screw Steam Gun-Boats—*continued.*

Second and Third Class.

" *Clown.*"—40 *H.-P.*

Main Deck	1 68-pr. pivot, 95 cwt., 10 feet. 1 32-pr. pivot, 56 cwt., 9 ft. 6 in.
	2 guns. Total complement, 36 men.

" *Cheerful.*"—20 *H.-P.*

Main Deck	2 32-pr. pivot, 56 cwt., 9 ft. 6 in.
	2 guns. Total complement, 30 men.

" *Algerine.*"—80 *H.-P.*

Main Deck	1 10-in. guns, 87 cwt. 2 24-pr. howitzers.
	3 guns.

SCREW STEAM-VESSELS.

" *Rifleman* " *Class.*—100 *H.-P.*

Main Deck	2 32-prs., 56 cwt., 9 ft. 6 in. 6 32-prs., 25 cwt., 6 feet.
	8 guns. Total complement, 90 men.

The following screw steam-ships, mentioned in the authorised Armament Book, have been omitted, either on account of their being so nearly like others that it was unnecessary to distinguish them as the representatives of a distinct class, or on account of their being the only ships of their kind in the Navy :—

Royal George .... 102 guns.

Cæsar	90 guns.	Sanspareil	70 guns.
Amphion	36 „	Dauntless	31 „
Termagant......	25 „	Brisk	16 „
Miranda.........	15 „	Glatton	14 „
Archer	13 „	Niger	13 „
Wasp	13 „	Conflict	7 „
Phœnix	6 „	Teazer	2 „

SAILING-SHIPS.

First Rates. " *Caledonia* " *Class.*

Lower Deck	8	8-in. guns,	65 cwt., 9 feet.
	24	32-prs.	56 cwt., 9 ft. 6 in.
Middle Deck	4	8-in. guns,	65 cwt., 9 feet.
	30	32-prs.	50 cwt., 9 feet.
Main Deck	34	32-prs.	42 cwt., 8 feet.
Quarter Deck and Forecastle	6	32-prs.	42 cwt., 8 feet.
	14	32-pr. carronades,	17 cwt., 4 feet.
	120 guns.	Total complement, 970 men.	

Sailing-Ships—*continued.*

Second Rates. "Princess Charlotte" Class.

Lower Deck	4	8-in. guns,	65 cwt., 9 feet.
	24	32-prs.	56 cwt., 9 ft. 6 in.
Middle Deck	2	8-in. guns,	65 cwt., 9 feet.
	28	32-prs.	48 cwt., 8 feet.
Main Deck	30	32-pr. rear chock carriage	32 cwt., 6 ft. 6 in.
Quarter Deck and Forecastle	6	32-prs.	45 cwt., 8 ft. 6 in.
	10	32-pr. carronades,	17 cwt., 4 feet.

104 guns. Total complement, 850 men.

Second Rates. "Asia" Class.

Lower Deck	6	8-in. guns,	65 cwt., 9 feet.
	24	32-prs.	56 cwt., 9 ft. 6 in.
Main Deck	2	8-in. guns,	65 cwt., 9 feet.
	30	32-prs.	48 cwt., 8 feet.
Quarter Deck and Forecastle	6	32-prs.	42 cwt., 8 feet.
	16	32-pr. carronades,	17 cwt., 4 feet.

84 guns. Total complement, 720 men.

Second Rates. "Superb" Class.

Lower Deck	8	8-in. guns,	65 cwt., 9 feet.[1]
	20	32-prs.	56 cwt., 9 ft. 6 in.
Main Deck	4	8-in. guns,	65 cwt., 9 feet.
	24	32-prs.	50 cwt., 9 feet.
Quarter Deck and Forecastle	24	32-prs.	42 cwt., 8 feet.

80 guns. Total complement, 720 men.

Third Rates. "Bellerophon" Class.

Lower Deck	4	8-in. guns,	65 cwt., 9 feet.
	26	32-prs.	56 cwt., 9 ft. 6 in.
Main Deck	2	8-in. guns,	65 cwt., 9 feet.
	30	32-prs.	45 cwt., 8 ft. 6 in.
Quarter Deck and Forecastle	6	32-prs.	42 cwt., 8 feet.
	10	32-pr. carronades,	17 cwt., 4 feet.

78 guns. Total complement, 650 men.

Third Rates. "Boscawen" Class.

Lower Deck	4	8-in. guns,	65 cwt., 9 feet.
	22	32-prs.	56 cwt., 9 ft. 6 in.
Main Deck	2	8-in. guns,	65 cwt., 9 feet.
	26	32-prs.	50 cwt., 9 feet.
Quarter Deck and Forecastle	16	32-prs.	42 cwt., 8 feet.

70 guns. Total complement, 650 men.

Fourth Rates. "Indefatigable" Class.

Main Deck	28	8-in. guns,	65 cwt., 3 feet.
Quarter Deck and Forecastle	22	32-prs.	45 cwt., 8 ft. 6 in.

50 guns. Total complement, 500 men.

Sailing-Ships—*continued.*

Fourth Rates. "Vernon" Class.

Main Deck	6	8-in. guns,	65 cwt., 9 feet.
	22	32-prs.	56 cwt., 9 ft. 6 in.
Quarter Deck and Forecastle	4	8-in. guns,	65 cwt., 9 feet.
	18	32-prs.	45 cwt., 8 ft. 6 in.

50 guns. Total complement, 480 men.

Fourth Rates. "Portland" Class.

Main Deck	8	8-in. guns,	65 cwt., 9 feet.
	22	32-prs.	50 cwt., 8 feet.
Quarter Deck and Forecastle	4	32-prs.	45 cwt., 8 ft. 6 in.
	16	32-prs.	25 cwt., 6 feet.

50 guns. Total complement, 44 men.

Fifth Rates. "Pique" Class.

Main Deck	6	8-in. guns,	60 cwt., 8 ft. 10 in.
	18	32-prs.	56 cwt., 9 ft. 6 in.
Quarter Deck and Forecastle	14	32-prs.	25 cwt., 6 feet.
	2	32-prs.	50 cwt., 9 feet.

40 guns. Total complement, 375 men.

Fifth Rates. "Africaine" Class.

Main Deck	2	8-in. guns,	60 cwt., 8 ft. 10 in.
	26	32-prs.	40 cwt., 7 ft. 6 in.
Quarter Deck and Forecastle	4	32-prs.	45 cwt., 8 ft. 6 in.
	12	32-pr. carronades,	17 cwt., 4 feet.

44 guns. Total complement, 340 men.

Fifth Rates. "Fisguard" Class.

Main Deck	2	8-in. guns,	52 cwt., 8 feet.
	22	32-prs.	39 cwt., 7 ft. 6 in.
Quarter Deck and Forecastle	4	32-prs.	45 cwt., 8 ft. 6 in.
	4	32-prs.	89 cwt., 7 ft. 6 in.
	10	32-pr. carronades,	17 cwt., 4 feet.

42 guns. Total complement, 340 men.

Fifth Rates. "Castor" Class.

Main Deck	4	8-in. guns,	60 cwt., 8 ft. 10 in.
	18	32-prs.	56 cwt., 9 ft. 6 in.
Quarter Deck and Forecastle	2	32-prs.	50 cwt., 9 feet.
	12	32-prs.	25 cwt., 6 feet.

36 guns. Total complement, 340 men.

Fifth Rates. "Diamond" Class.

Main Deck	20	32-prs.	40 cwt., 7 ft. 6 in.
Quarter Deck and Forecastle	2	8-in. pivot,	60 cwt., 8 ft. 10 in.
	6	32-prs.	25 cwt., 6 feet.

28 guns. Total complement, 300 men.

Sailing-Ships—*continued.*

Sixth Rates. "Trincomalee" Class.

Main Deck	8	32-prs.	56 cwt., 9 ft. 6 in.
	10	8-in. guns,	65 cwt., 9 feet.
Quarter Deck and Forecastle	6	32-prs.	40 cwt., 7 ft. 6 in.
	1	10-in. guns,	84 cwt., 9 ft. 4 in.

25 guns. Total complement, 275 men.

Sixth Rates. "Brilliant" Class.

Main Deck	10	32-prs.	50 cwt., 9 feet.
	6	8-in. guns,	52 cwt., 8 feet.
Quarter Deck and Forecastle	2	10-in. pivot,	84 cwt., 9 ft. 4 in.
	2	32-prs. on Hardy's carriage and slide	25 cwt., 6 feet.

20 guns. Total complement, 240 men.

Sixth Rates. "Vestal" Class.

Main Deck	2	8-in. guns,	52 cwt., 8 feet.
	16	32-prs.	40 cwt., 7 ft. 6 in.
Quarter Deck and Forecastle	2	32-prs.	42 cwt., 8 feet.
	6	32-prs.	25 cwt., 6 feet.

26 guns. Total complement, 230 men.

Sixth Rates. "Daphne" Class.

Main Deck	2	8-in. guns,	52 cwt., 8 feet.
	16	32-prs.	42 cwt., 8 feet.

18 guns.

Sloops.

"Arachne" Class ...	2	32-prs., 39 cwt., 7 ft. 6 in.
	16	32-prs., 25 cwt., 6 feet.

18 guns, Total complement, 145 men.

"Siren" Class	2	32-prs., 39 cwt., 7 ft. 6 in.
	14	32-prs., 25 cwt., 6 feet.

16 guns. Total complement, 135 men.

"Champion" Class	2	32-prs., 39 cwt., 7 ft. 6 in.
	12	32-prs., 25 cwt., 6 feet.

14 guns. Total complement, 135 men.

"Acorn" Class......	2	32-prs., 39 cwt., 7 ft. 6 in.
	10	32-prs., 25 cwt., 6 feet.

12 guns. Total complement, 135 men.

"Cygnet" Class ...	2	32-prs. pivot, 32 cwt., 6 ft. 6 in.
	6	32-prs. 25 cwt., 6 feet.

8 guns. Total complement, 80 men.

"Linnet" Class ...	2	32-prs. 32 cwt., 6 ft. 6 in.
	4	32-pr. carronades, 17 cwt., 4 feet.

6 guns. Total complement, 80 men.

Sailing-Ships—*continued.*

Brigs.

"Nautilus" Class...	2	32-prs.	32 cwt., 6 ft. 6 in.
	4	18-pr. carronades,	10 cwt., 3 ft. 4 in.

6 guns. Total complement, men.

The above are mentioned as representing the most important classes of sailing vessels still remaining in the navy.

PADDLE STEAM-FRIGATES.

Fifth Rates. "*Terrible*" *Class.*—800 *H.-P.*

Main Deck............	10	8-in. guns,	65 cwt., 9 feet.
	4	68-prs.	95 cwt., 10 feet.
Upper Deck	4	10-in. guns,	84 cwt., 9 ft. 4 in.
	3	68-pr. pivot,	95 cwt., 10 feet.

21 guns. Total complement, 310 men.

Fifth Rates. "*Penelope*" *Class.*—650 *H.-P.*

Main Deck............	10	8-in. guns,	65 cwt., 9 feet.
Upper Deck	4	8-in. guns,	52 cwt., 8 feet.
	2	10-in. pivot,	84 cwt., 9 ft. 4 in.

16 guns. Total complement, 310 men.

Fifth Rates. "*Retribution*" *Class.*—400 *H.-P.*

Main Deck............	18	32-prs.	50 cwt., 9 feet.
Upper Deck	1	68-pr. pivot,	95 cwt., 10 feet.
	9	8-in. guns,	65 cwt., 9 feet.

28 guns. Total complement, 310 men.

Fifth Rates. "*Leopard*" *Class.*—560 *H.-P.*

Main Deck............	12	32-prs.	56 cwt., 9 ft. 6 in.
Upper Deck	2	68-pr. pivot,	95 cwt., 10 feet.
	4	10-in. guns,	84 cwt., 9 ft. 4 in.

18 guns. Total complement, 310 men.

Sixth Rates. "*Furious*" *Class.*—400 *H.-P.*

Main Deck............	10	32-prs.	50 cwt., 9 feet.
Upper Deck	2	10-in. pivot,	84 cwt., 9 ft. 4 in.
	4	32-prs.	50 cwt., 9 feet.

16 guns. Total complement, 230 men.

Sixth Rates. Steam Sloop—"*Centaur*" *Class.*—540 *H.-P.*

Upper Deck	2	68-pr. pivot,	95 cwt., 10 feet.
	4	10-in. guns,	84 cwt., 9 ft. 4 in.

6 guns. Total complement, 195 men.

PADDLE STEAM-SLOOPS.

"*Bulldog*" *Class.—500 H.-P.*

Upper Deck	1 68-pr. pivot,	95 cwt., 10 feet.
	1 10-in. pivot,	94 cwt., 9 ft. 4 in.
	4 32-prs.	80 cwt., 8 feet.

6 guns. Total complement, 170 men.

"*Medea*" *Class.—350 H.-P.*

Upper Deck	2 10-inch pivot,	84 cwt., 9 ft. 4 in.
	4 32-prs.	25 cwt., 6 feet.

6 guns. Total complement, 135 men.

"*Ardent*" *Class.—200 H.-P.*

Upper Deck	1 32-pr. pivot,	45 cwt., 8 ft. 6 in.
	2 32-prs.	25 cwt.. 6 feet.

3 guns. Total complement, 100 men.

"*Trident*" *Class.—350 H.-P.*

Upper Deck	1 32-pr. pivot,	42 cwt., 8 feet.
	2 32-prs.	25 cwt., 6 feet.

3 guns. Total complement, 100 men.

PADDLE STEAM-VESSELS.

"*Medina*" *Class.—312 H.-P.*

Upper Deck .... 4 32-prs., 50 cwt., 9 feet.

4 guns. Total complement, 65 men.

"*Pluto*" *Class.—100 H.-P.*

Upper Deck	1 32-pr. pivot,	42 cwt., 8 feet.
	2 32-prs.	25 cwt., 6 feet.

3 guns. Total complement, 65 men.

"*Antelope*" *Class.—260 H.-P.*

Upper Deck	1 32-pr. pivot,	42 cwt., 8 feet.
	2 32-prs.	25 cwt., 6 feet.

3 guns. Total complement, 65 men.

"*Porcupine*" *Class.—132 H.-P.*

Upper Deck	1 18-pr. pivot,	20 cwt., 6 feet.
	2 18-pr. carronades,	10 cwt., 3 ft. 4 in.

3 guns. Total complement, 65 men.

Paddle Steam-Ships—*continued.*

"*Bloodhound*" *Class.*—150 *H.-P.*

Upper Deck ....{ 1 18-pr. pivot, 22 cwt., 7 feet.
2 24-pr. carronades, 13 cwt., 4 ft. 9 in.

3 guns. Total complement, 50 men.

"*Bann*" *Class.*

Upper Deck .... 2 32-prs., 25 cwt.

2 guns. Total complement, 40 men.

INDEX.

INDEX TO THE WORDS,

ALPHABETICALLY ARRANGED.

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AND CHARING CROSS.

PLATE I.

BALLISTIC PE

(Page 32, A

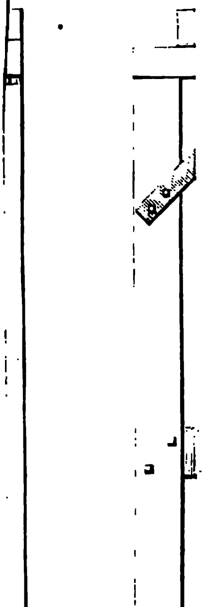

Fig. 3. (Page 34, Art. 55, Note.)