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PREFACE.

On the publication of this, the first of a series of communications on the history of Ancient Cannon in Europe, I have great pleasure in recording the obligations which I am under to John Hewitt, Esq. the author of "Ancient Armour and Weapons of Europe," compiler of the official catalogue of the Tower Armouries, &c. at whose suggestion the work was first undertaken, and to whom I am indebted for many references to MSS. and printed works bearing on the subject, for the free use of his collection of unedited drawings, and for constant valuable aid and counsel.

I wish also to thank R. R. Holmes, Esq. F.S.A. of the British Museum, and Joseph Burtt, Esq. of the Public Record Office, for the kindness which they have shewn me, and the information which they have at all times readily given.

In case I should in any instance have failed to indicate by reference the sources from which I have drawn, I must here especially acknowledge the assistance derived from the works of the Emperor Napoleon III.,[1] Colonel Omodei,[2] Mr Hewitt,[3] and Sir Harris Nicolas,[4] and from the pamphlets of Mr Burtt,[5] and the Rev. Joseph Hunter.[6]

HENRY BRACKENBURY.

Royal Military Academy,
February, 1865.

[1] Etudes sur le passé et l'avenir de l'Artillerie.
[2] Dell' origine della Polvera da Guerra.
[3] Ancient Armour and Weapons of Europe.
[4] History of the Royal Navy, and other works.
[5] On the early use of gunpowder in England, published in the Archæological Journal.
[6] On the use of Gunpowder in the French Campaign of 1346–7, published in Archæologia.

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MEMOIR

OF

GENERAL SIR ROBERT WILLIAM GARDINER, G.C.B., K.C.H.

[COMMUNICATED BY THE SECRETARY, R.A.I.]

General Sir Robert Gardiner, G.C.B. of the Royal Artillery, was the second son of Captain John Gardiner (3rd Buffs) and Mary, daughter of Jonathan Allison, Esq., of Middleton, County Durham, and was younger brother of the late Lieut.-General Sir John Gardiner. He was born May 2, 1781, joined the Royal Military Academy, Woolwich, in 1795, and obtained his commission in the Royal Artillery April 7, 1797.

In October, 1797, Lieutenant Gardiner was sent to Gibraltar, then partially blockaded by the French and Spanish fleets, and remained there till November, 1798, when he embarked with the expedition under Sir Charles Stuart, and was present at the capture of Minorca. In May, 1799, he was appointed on the Staff in Minorca as Commandant of Mosquito Fort (the point where the Duke de Crillon had landed in 1782), and shortly afterwards became aide-de-camp to the general commanding, the Hon. Henry Fox, brother to the great Whig leader. He returned to England on the evacuation of Minorca at the peace of Amiens in 1802.

Promoted to second captain in 1804, Captain Gardiner in 1805 commanded 12 guns with the force under Lieutenant-General Don, forming the advanced corps of the army destined to serve under Lord Cathcart in the north of Germany, combined with the Russian army under Count Tolstoy. The allied armies advanced as far as Hanover, when the result of the battle of Austerlitz put an end to the campaign, and the British troops returned home, their unmolested embarkation being stipulated for by the treaty of Presburg. Captain Gardiner immediately effected an exchange in order to join Sir John Stewart's force employed against the French in Sicily, where he arrived shortly after the battle of Maida. On Sir John being relieved by General Fox, Captain Gardiner again joined the Staff of the latter, and, when General Fox returned home, was appointed aide-de-camp to Sir John Moore.

In 1807 the army left Sicily for the purpose of landing in Portugal, but being detained by contrary winds, only reached Lisbon to find that the Royal family, whose cause it was to have assisted, had sailed for the Brazils, and the force returned to England. Early in 1808, when Sir John Moore was named to the command of the expedition to Sweden, he repeatedly applied to Lord Chatham, then Master-General of the Ordnance, to be allowed to take Captain Gardiner on his personal Staff, but the regulations of the Corps at that time not allowing artillery officers from home stations to be employed on the Staff, these applications did not meet with success, and on Sir John's departure for Sweden Captain

Gardiner again exchanged for active service, and joined the army assembling at Cork under Sir Arthur Wellesley. Landing with it at Mondego Bay, and advancing from Lavaos on the 10th of August, in command of a half-battery, he was engaged at Roleia on the 17th, and in the crowning success against Junot at Vimiera on the 21st, followed by the capture of Lisbon on the convention of Cintra.

Sir John Moore having relieved Sir Arthur Wellesley in Portugal, Captain Gardiner was called to head-quarters as Brigade-Major of Artillery, and participated in the prolonged struggle called the Corunna retreat, which commenced on the 24th of December, at Benavente, and ended on the 15th January, 1809, at Lugo. After witnessing the death of his much loved friend and General, he returned to England, and was immediately appointed Brigade-Major to the Artillery commanded by Brigadier-General John Macleod, with Lord Chatham's army of the Scheldt. He was present at the capture of Middleburg and Flushing, and returned with the expedition to England in 1810, having been prostrated by the Walcheren fever. Three months later he effected a third exchange for active service, and joined the division of the Peninsular Army under Sir Thomas Graham. The monotonous defence of Cadiz was relieved by the expedition to Tarifa, terminating in the battle of Barrosa, in which his battery bore a conspicuous part.

In November, 1811, Captain Gardiner was promoted to first captain, and in February 1812, he proceeded to join the main body of the army under Lord Wellington before Badajoz. He was mentioned in Lord Wellington's despatches for his services in the trenches, and received a brevet majority in April, 1812. In May he joined a field battery with the First Division, and commanded it through the campaign in the battle of Salamanca and at the capture of Madrid. At the siege of Burgos Major Gardiner volunteered with several of his men for the trenches, and took part in the operations till the siege was raised, when he resumed his field duties throughout the arduous movement and frequent engagements, known as the Burgos retreat, from the 28th October to the 19th of November. While in winter cantonments he was nominated to the command of 'E', afterwards 'D' troop, Royal Horse Artillery (now 'A' battery, 'B' brigade), which he immediately joined, and marched into Spain with Lord Dalhousie's division. In June, 1813, he was attached to the Hussar Brigade, and was engaged with them (and mentioned by Lord Wellington) at Morales. The chief actions in which he took part in the triumphal march through Spain and France were—Vittoria, the affairs in the Pyrenees from the 27th to the 30th July, Orthes (for which he received a lieutenant-colonelcy), Tarbes, and Toulouse. Proceeding through France after the peace, he embarked at Calais for England in June, 1814, and was shortly afterwards created Knight Commander of the Bath.

During the corn riots in 1815, Sir Robert Gardiner's troop was stationed in the gardens at Carlton House, and remained there till the mobs dispersed on the news of Napoleon's escape from Elba. Landing with his troop at Ostend in April, 1815, he was again attached to the Hussar Brigade. The troop was most severely pressed in covering the left of the army on the retreat from Quartre Bras on the 17th, and took part in the great battle of the 18th, and in the capture and occupation of Paris.

Returning home in January, 1816, Sir Robert was suddenly called upon to change the life of camps for that of a court. On the marriage of the Princess Charlotte of Wales with Prince Leopold of Saxe-Coburg he was selected for the post of principal equerry, retaining this appointment until his Royal Highness accepted the throne of Belgium in 1831, after which Sir Robert continued to reside at Melbourne, on the Claremont estate. He was military aide-de-camp to George IV., William IV., and to her Majesty until he attained general's rank in 1841. In 1848 Sir Robert Gardiner was appointed Governor and Commander-in-Chief of Gibraltar, and his public service terminated with that appointment in 1855. He became a Regimental Lieut.-Colonel 30th December, 1828; a Brevet Colonel 22nd July, 1830; Colonel 24th November, 1839; a Colonel Commandant 22nd March, 1853; a Major-General 23rd November, 1841; a Lieut.-General 11th November, 1851; and a General 28th November, 1854.

Sir Robert landed at Gibraltar in February, 1849, and his government of this important fortress was eminent for the broad and high principled views he always took of the onerous duty entrusted to him. Regarding Gibraltar as a first class English fortress, he deprecated the breach of the Treaty of Utrecht, in making its harbour a thorn in the side of a friendly nation as a smuggling depôt. In all other respects he would never consent to render the military, subordinate to commercial, interests, and this in the question of Quarantine produced serious complications. It had been customary to bow to the venal and absurd laws of Spain on this point, in order to keep open our communication with the neighbouring country. This he thought an undignified and unbefitting position for England, and the necessity of communicating with ships carrying troops to the Crimea (these vessels being considered in quarantine by Spanish law because there were a few cases of cholera in England !) gave him an opportunity of making a stand. Both these questions, however, embroiled him with the mercantile community.

Sir Robert's hospitality during his command was unbounded, and those who served under him could not fail to observe that whilst, guided by an ever zealous sense of duty combined with untiring pluck and energy, his ruling motive was to do thorough justice to his work, he never failed to bring prominently forward that the governor of Gibraltar was a Gunner. He never wore any uniform but blue, and even after his return from Gibraltar attended court in a regimental tunic as Colonel Commandant of the 4th Brigade. The same spirit showed itself about his honors, orders, &c.; he cared little for them personally, but valued them as bringing credit *to the Corps*, and whenever distinction befell any member of it, he always showed the same feeling of gratification.

He had become Colonel Commandant of the 4th Battalion, Royal Artillery, in 1853, and was advanced to the Grand Cross of the Bath in 1855. In April, 1864, he was appointed Colonel-Commandant of the 'B' Brigade, Royal Horse Artillery. He received the order of the Guelph for his services in Hanover, and the Russian Order of St Anne for Waterloo. When at Gibraltar Her Majesty the Queen of Spain sent him the Grand Cross of Carlos III., but the regulations of the service precluded his wearing the decoration. He held a distinguished service pension, and had the gold medal and clasps for Barrossa, Salamanca, Vittoria, Orthes, and Toulouse; the silver war medals for Roleia, Vimiera, Corunna, and the Waterloo medal and clasp. He married in 1816 Caroline, eldest daughter of Lieutenant-General Sir John and Lady Emily Macleod, of which marriage two children survive —Colonel Lynedoch Gardiner, and Emily, married to Major George Frend.

Sir Robert's intellect remained unclouded almost to the last, notwithstanding that he endured much suffering and exhaustion in his last days; he died at Melbourne Lodge, Claremount, on the 26th June, 1864.

The mastery of mind over matter was always most remarkable with Sir Robert Gardiner. A strong instance of this occurred on the occasion of the first Corps dinner, when, although suffering from fever and gout, he left his bed (at the age of 80), to fulfil what he conceived a duty in meeting the Duke of Cambridge as Colonel of the Regiment, and in his weak state bore the brunt of representing the Regiment on this occasion.

The following General Regimental Order which was published after Sir Robert Gardiner's death, by command of His Royal Highness the Duke of Cambridge, is a just tribute to Sir Robert's memory, and recognises the high chivalrous feeling which was so striking a feature in his character.

HORSE GUARDS, S.W.,
8th November, 1864.

GENERAL REGIMENTAL ORDER.

His Royal Highness the Field Marshal Commanding-in-Chief, with the concurrence of the Right Honorable the Secretary of State for War, has been pleased to give instructions that the name of GENERAL SIR ROBERT WILLIAM GARDINER, G.C.B., K.C.H., be added to the names inscribed on the Memorial Pillar in the Rotunda at Woolwich.

His Royal Highness deems it unnecessary to recite to the Royal Artillery, the special actions in which this distinguished Officer, in the great Wars of the commencement of the present century, acquired his own Military reputation, and contributed with many gallant comrades to raise the fame of the British Artillery; but it is the desire of His Royal Highness that services so well remembered, a long period of service subsequently devoted to strenuous exertions for the benefit of his Corps, a personal character conspicuous for its dignity and chivalry, should be permanently and publicly commemorated among those of other departed Artillerymen, whose brilliant military services or scientific reputation has led to their selection for a similar honor.

By Command of

FIELD MARSHAL H.R.H THE DUKE OF CAMBRIDGE, K.G.,
Colonel of the Royal Artillery;

G. GAMBIER,
Deputy Adjutant-General.

No memoir of Sir Robert Gardiner, however short, would be complete without some allusion to his writings. They number eighteen in all, the last, which is a posthumous work on the subject of the Holy Communion, being left as a farewell offering to the officers and men of the army and navy. The majority of his writings had but one object; they were written in the interest of the Corps, with which he so thoroughly identified himself, and whose welfare was his constant thought up to the latest hour.

The first pamphlet was written in 1834, and is a military memoir of the late Lieutenant-General Sir John Macleod, G.C.H., the first staff officer of artillery and Deputy Adjutant-General from 1795 to 1825, during all the large operations in which the corps took part. This memoir was written just after Sir John Macleod's death (which occurred in 1833), and was published in the U. S. Journal, No. LXVIII. The next pamphlet was also a biographical sketch, being a memoir of Admiral Sir Graham Moore, G.C.B., an intimate friend of Sir Robert's, and brother to his old friend and General, Sir John Moore. We now come to the time when Sir Robert put himself forward in the interest of the corps, and those who knew his devoted *esprit de corps* were not surprised at this determination, considering the miserable plight to which the Regiment was, at that time, reduced owing to the mistaken economy of successive governments. With a view, therefore, to interest Government in the cause of the Regiment, Sir Robert Gardiner in 1848, published a Report of the numerical deficiency, want of instruction, and inefficient equipment of the Royal Artillery, which he addressed to Lord Seymour and the Committee of the House of Commons then sitting on the Army, Navy, and Ordnance Estimates. Many of the leading statesmen were astounded at the revelations therein contained, but although the publication, by an officer of the corps, of this pamphlet giving details to support his statement was a bold measure, and only undertaken at some personal risk, it had a most beneficial effect and led to the almost immediate removal of one of the grievances therein complained of, by the appointment of Sir Robert himself to the Governorship of Gibraltar.

This appointment which gave very great satisfaction to the Royal Artillery, had but one drawback, that owing to the necessity of Sir Robert's departure to Gibraltar, he was unable to give evidence before Lord Seymour's Committee, he, therefore, in the midst of his preparations, drew up the fourth pamphlet suggesting such enquiry as was likely to be made to him and the answers he was prepared to give.

On his return from Gibraltar in 1856, after drawing up a Report to Lord Palmerston, demonstrating the evils and dangers of governing the fortress as a Colony, Sir Robert again turned his mind to the necessities of the Corps, and addressed a pamphlet to Lord Panmure (then Secretary of State for War), bringing forward the defective system of enlisting men for the combined duties of gunners and drivers, and the necessity for the reorganization of the driver corps; also the inadequate General and Regimental Staff, the numerical deficiency of the Horse Artillery, and lastly drawing attention to a subject in which he took the deepest interest, viz. the establishment of an Artillery of the Guard. Sir Robert pointed out that "the guard in every army in Europe, save alone that of England, is composed of Artillery, Cavalry and Infantry" and that "on the amalgamation of the Artillery with the Cavalry and Infantry, of the army, hopes long since cherished immediately revived, that a portion of the Corps would be attached to the Household troops..." These hopes are, however, still deferred.

The subsequent pamphlets were called forth by the events of the day—in which he continued, in spite of failing health, to take the warmest interest—but two of these were strictly Artillery pamphlets. The first,—addressed to Lord Derby and the Members of the House of Lords and House of Commons—pointed out in forcible terms the disadvantageous relative position of our Artillery to the other arms of the service, as compared with the Artillery of first class foreign powers, and also drew attention to the non-realization of benefits that were expected to accrue to the Corps from its amalgamation with the Cavalry and Infantry of the army under Horse Guards rule. The second,—addressed to the Duke of Cambridge—reiterated the statements advanced in the previous pamphlet, and invited His Royal Highness' attention to the requirements of the Corps, in consequence of the interruption that had occured in the investigation by a Committee of the House of Commons, into the effects of the military changes in the Ordnance Department, concluding with suggestions on the training and uses of Volunteer Artillery.

None could read these pamphlets without admiring the unflinching constancy with which Sir Robert continued to point out the disabilities under which the Regiment at that time suffered, and all must feel that in his death the Royal Artillery has lost not only one of its brightest ornaments, but also one who was unwearied in exerting all his powerful influence for that Corps of which he was so devoted and so distinguished a member.

FROM SHORE BATTERIES ON ELEVATED POSITIONS, TO FIND THE DISTANCES OF OBJECTS AT SEA, BY THE AID OF THE ARMSTRONG GUN.

By Captain A. W. DRAYSON, R.A.

There are several instruments by the aid of which the distances of objects may be obtained, but to supply every coast battery with any one of these, would be a very expensive proceeding. As in almost every coast battery an Armstrong gun is, or will be, placed, it may be of great practical use to show how distances may be obtained by its aid.

For all practical purposes the Armstrong gun would be as available, as a theodolite or any other instrument for measuring angles, and this is all that is necessary.

The method of proceeding is as follows :—

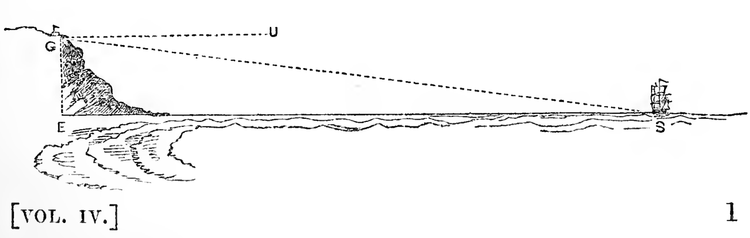
(1) Obtain by levelling, the accurate height in yards of the gun above low water mark. This has most probably been already done at all stations, so that we may assume that the height of the battery is known.

(2) By the aid of a common level placed in the bore of the gun, bring the axis of the piece exactly horizontal, and directed as nearly as possible towards the object whose distance is required.

(3) By the aid of the tangent scale and vernier, find the angle of depression of the object.

(4) Multiply the cosecant of the angle of depression by the number of yards representing the height of the gun in the battery, and the product will be the range in yards.

The principle brought to bear in this problem will be evident from the following diagram.



Suppose G the gun, and S an object at sea, GE the height of the object above the sea. Then if UGS be the angle of depression $= GSE$,

$$GS = GE \times \operatorname{cosec} GSE;$$

that is,

Range = height of gun above sea × cosec of angle of depression.

The practical application and use of this method will now be considered.

It is of course of the utmost importance that ranges should be rapidly determined, and although processes 1, 2, and 3, would occupy scarcely more than three quarters of a minute and to an expert observer not more than half as long, still the looking out, and multiplying the cosecant would be a work of time, and a proceeding by which errors *might* arise. To avoid this and also to shorten the process, a Table should be printed or written *and hung up in every battery, that is fifty feet, or more, above low water mark.*

By this means the range in yards could be instantly found by reference to the table.

For the purpose of levelling the gun, a common spirit-level should be used, and placed in the bore near the muzzle, so as to be easily seen; one gun number could watch this, whilst another moved the elevating screw.

In order to obtain the most correct results, allowance should be made for the state of the tide. This would merely require, three columns for range, instead of one, the heading for each of these three being,

Low Water.	Mean.	High Water.

These items would affect the multiplier GE merely.

In order to avoid any possible source of error when referring to this table, two lathes of wood might be suspended over the columns of range not being used. So that if practice were being carried on at high water, columns "Low water" and "Mean" would be hidden and high water only be that visible, and therefore to be used.

The vernier of the Armstrong gun enables an angle to be read to at least $\frac{1}{60}$th of a degree. If now we suppose that the battery were 100 ft. above the sea, we could actually obtain the range by the above method to within a few yards. Thus, one minute error would give only about 40 yds. in 2000. If, however, the batteries were higher, as they are in many places, the amount of error would be slighter. Thus a battery 200 ft. above the sea would enable us to obtain the range to within 14 yds. of a mile, an accuracy we believe not to be obtainable by any method as simple and practicable as the above.

In many of our coast batteries at home and abroad, the height of the gun above the sea is considerable, and therefore this process might be there available. In England, there are batteries at Devonport, Folkestone, Shorncliffe, Dover, &c.; and abroad at Malta, Gibraltar, and other places, all of which are sufficiently above low water for the range to be obtained as above.

The following is the form of table recommended for use in Batteries:

Station.........................

Name of Battery ....

Height above Low water...

Angle of Depression.	Range at Low Water.	Range at Mean Tide.	Range at High Tide.

The calculation of these tables requires merely a knowledge of common multiplication; any master gunner, or non-commissioned officer might make them out, and as it is not likely that ranges would be required beyond three miles, or within five hundred yards, merely ninety lines of ranges would be required if *every* angle were given; but as 1′ of a degree would only cause a difference in the range of about 5 yds. when the angle was greater than 2° and the battery 100 ft. high, every 5′ might be there calculated and the proportion allowed for by estimation. Thus the Table would scarcely exceed 50 lines, and its practical use would be well worth the trouble.

SOME CONSIDERATIONS RESPECTING THE PRACTICAL VALUE OF SHELLS OF THE SHRAPNEL CLASS.

BY CAPTAIN VIVIAN DERING MAJENDIE, R.A.
CAPTAIN INSTRUCTOR, ROYAL LABORATORY.

In a former paper* I discussed the validity of General Shrapnel's claim to the invention of the shell which bears his name; I propose now to discuss briefly, *and in a general way*, the merits and alleged demerits of that invention. I shall not in the present paper touch upon the particular form of Shrapnel shell known as the Diaphragm, for I am anxious first to establish the merits of the Shrapnel *class* of shells, reserving for another paper an enquiry into the character and value of individual shells of that class.†

There has always existed, and still exists, much difference of opinion as to the practical value of Shrapnel shell; but it appears to me that the testimony borne to their efficiency on their first introduction, and during their employment in the Peninsula campaign is so overwhelming as to admit of no doubt on the subject on the part of those who choose to examine this testimony carefully and dispassionately; my chief difficulty in dealing with the matter consists in the selection of authorities in support of my views, from the large mass at my disposal. The Duke of Wellington, in a letter to Sir John Sinclair, dated 18th October, 1808, says, "I shall have great pleasure in testifying at any time to the great benefit which the army lately under my command derived from the use of the spherical case shot, in two actions with the enemy—a benefit which I am convinced, will be enjoyed wherever they will be judiciously and skilfully used."

Colonel Robe, commanding the Royal Artillery, says, in a letter to General Shrapnel, "It is admirable to the whole army .... its accuracy perfect and its effect dreadful, *as acknowledged by the French officers themselves at a conference with ours after the action of the* 21*st*. .... the artillery has been complimented both by them and by all our own general officers in a way highly flattering to us; and I should not do my duty to the service were *I not to attribute this good fortune to a good use of that weapon with which you have furnished us.* I told Sir Arthur Wellesley I meant to write to you, and asked if it might be with his concurrence, his answer was 'You may say anything you please, you cannot say too much.'"—*Ordnance Select Committee Report on Shrapnel Shells*, p. 14.

"D'après le Général Foy, les Anglais se seraient servis avec beaucoup d'avantage contre nous de ce projectile à la bataille de Vimiera en Portugal."—*Instruction d'Artillerie*, p. 299.

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* See Vol. III. p. 398.

† It will not be possible altogether to avoid allusion to the Diaphragm shell, but I shall only allude to it where it is absolutely necessary, to make more clear some point which I may be seeking to establish, or to anticipate and reply to some objection which no longer holds good against the Shrapnel class of shells.

"En 1808, les shrapnels etaient employés contre les Français à la bataille de Vimiera et, suivant les Anglais, concourent beaucoup au gain de cette première bataille livrée dans la Péninsule, par Sir Arthur Wellesley."—*Expériences sur les Shrapnels.* Avant-Propos. III.

It would be easy to multiply authorities to prove that the effect produced by these shells at Vimiera, and subsequently throughout the Peninsula campaign, was very great; and to those who would wish to investigate the subject more at length I would recommend a perusal of Major Seton's *Observations on Shrapnel Shells*,* particularly chapters i. and iii. Major Seton is one of those who think the effect of Shrapnel very questionable, and that although on their first employment they seemed to have done good service, this service was rather apparent than real, the novelty of the projectile contributing in no small measure to increase the admiration with which it was first regarded, and to cause its effect to be exaggerated. Now, respecting this, and other, adverse opinions which have been expressed upon the subject, I must remark that no case against these shells seems to me to have been made out.†

It appears to me, in the first place, on weighing the favourable against the unfavourable opinions, as collected and recorded by Major Seton, and some few others which I have met with elsewhere, that the balance is largely in favour of the shells; and this any reader who chooses to take the trouble may determine for himself by referring to Major Seton's work.

In the second place, it is certain that many of the adverse opinions prove upon investigation to be much less formidable than they at first sight appear. For instance, when the Duke of Wellington states, as he did in 1812, that his opinion in regard to these shells had been much shaken, (Gurwood's *Despatches*, Vol. VIII., p. 659), he explains wherein he thinks the shells defective,—"that they inflict trifling wounds, and kill no body,"—and in the following month we find him, not proposing to discontinue the supply of the shells, but suggesting "a remedy" for this "material defect," by the employment of larger bullets than those which had previously been placed in the projectile, (Gurwood's *Despatches*, Vol. IX., p. 281), a fact which in itself is strong proof that he thought the projectile only needed *improvement* to make it formidable. That this increase in the size of the bullets proved an effective remedy can hardly be doubted when we read the accounts given by the French of the effect which these projectiles produced when employed against them at St Sebastian in 1813. "Ces projectiles nous causèrent beaucoup de mal;" "Nous ne pumes lutter longtemps contre une masse aussi formidable d'artillerie;" "Ce projectile, que l'ennemie a trouvé le moyen de faire éclater à volunté, nous fait beaucoup de mal," (*Observations on Shrapnel Shell*, pp. 16, 17). Such are the terms in which these projectiles are spoken of by those who certainly did not want for opportunities of noticing their effects.

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* This work is in the Library of the Royal Artillery Institution.

† The evidence brought forward on both sides by Major Seton embodies nearly all that it is necessary to adduce to arrive at a correct opinion upon the subject, and in this way may be considered as practically exhaustive. In dealing with Major Seton's remarks, therefore, I shall virtually be dealing with the whole of the objections which have been urged against the Shrapnel shell by different writers.

In the third place, it should be noticed that the adverse opinions expressed often appear to have been formed upon imperfect or incomplete data: when we are told that these shells frequently inflicted wounds of a trifling description, we do not learn at the same time the conditions under which they were employed, whether at long ranges, beyond those at which Shrapnel shell could be efficiently employed, (and it must be remembered that the efficient range of the Shrapnel of that time was much less than that of the Diaphragm Shrapnel shell, in consequence of the impossibility of using high charges with them without danger of premature explosion); whether they exploded at the proper distance from the object fired at, or what was their "final" velocity—we know nothing, in short, of the circumstances under which these opinions came to be formed, and as much ignorance prevails even at the present day on the theory and practice of Shrapnel fire, it is not wonderful if on their first introduction they were not perfectly understood, and in consequence were sometimes improperly or injudiciously applied.

Fourthly, it has always appeared to me that writers who depreciate what I may designate the physical value of the Shrapnel shell, frequently, if not invariably, fail to take sufficiently into account their moral effect. I believe the moral effect of Shrapnel to be extremely great; as I am sure any one who has stood by during practice with these projectiles, or has been in any way exposed to their fire, will testify. And with respect to the wounds being sometimes of a trifling description, and not always fatal—this argument might upon occasion be applied to every other description of missile; moreover, if it could be shown, which I do not believe it can, that the Shrapnel wounds in the great majority of cases are not serious, I would reply that in an engagement the quantity of the wounds inflicted is of more account than their quality; for in the first place, it is difficult to persuade men standing under a whistling shower of fragments that if they are hit they will not be materially injured; in the second place, the sight of a large number of comrades becoming at least temporarily disabled will not tend to inspire confidence in those who are not hit, for men in the heat of action are not apt to balance chances so nicely, or to consider over-much the nature and extent of the injuries which they are liable to receive, and for the most part they find a fire in which six men are wounded harder to stand against than one by which two are killed; and, in the third place, it should never be forgotten that battles are decided, as has been well said, not by the number of men killed, but by the number frightened!

Much stress has also been laid by the opponents of the shell on the difficulty of judging correctly where the shell should be exploded; and though I believe that the force of this objection has been much overestimated,* I am quite prepared to assign to it a place in an investigation of

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* By General Shrapnel, indeed, it was affirmed that Shrapnel Shell have an *advantage* over other projectiles in this respect. He says, "The great advantage which pertains to spherical case shot over all other modes of firing is, that it is calculated and best adapted for unfixed distances and ranges merely estimated, or which cannot be correctly ascertained; the reason of which is self-evident from its covering or spreading over so much ground, that one and the same elevation will answer for a considerable number of contiguous ranges."—*Ordnance Select Committee Report on*

the merits of this description of projectile. Other objections, which perhaps held good against the original Shrapnel shell, such as the liability to premature explosion, and the comparatively short range at which they were effective, can certainly no longer be urged against the Diaphragm.

I cannot do better than conclude my remarks, and fortify my opinion, by a quotation from Col. Boxer's *Remarks on Diaphragm Shrapnel Shell:* "I am aware that various opinions are entertained by artillery officers in relation to the value of Shrapnel Shells as a military projectile; and, although it is not my intention in this paper to discuss the merits of this most destructive missile, I cannot refrain from making a few remarks upon what appears to me to be an extraordinary notion which has lately been advanced in relation to this point, namely,—that a round shot is, under all circumstances, a more efficient projectile than a Shrapnel shell, and that the latter ought to be removed from the field service. Let us consider for a moment what this opinion involves; no less than this—that round shot are more efficient than case and grape at very short ranges. But, in fact, there are even stronger reasons why Shrapnel should be more destructive than round shot at long ranges, than that case and grape should be superior to round shot at short ranges, when the irregularity in range of round shot, combined with the effect produced in the direction of their motion by grazing on irregular ground are duly considered.

"Even on the sands at Shoeburyness, and more frequently on the marshes at Woolwich, a round shot will, after striking the ground, often ricochet at a considerable elevation, and pass over many hundred yards before it again touches the plain, and also be deflected considerably to the right or left of the object aimed at; and if the practice were carried on over the ordinary ground of any country, which was the seat of war, this irregularity would be greatly augmented.

"But, at short ranges, as the shot would seldom or never strike the ground until after it had taken effect upon the object fired at, there would be no injurious effect of irregularity, in its action from grazing; and, consequently, there is, as I have stated above, greater reason why a Shrapnel should, under a great variety of circumstances, be a more efficient missile in the field than a round shot at a long range, than that grape and case should be superior to round shot at a short range.

"There is one thing, however, in connexion with this point which must

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Shrapnel Shells, p. 16. I do not quite hold with General Shrapnel in this matter; but I go to the length of saying that the importance of the objection which has been urged against Shrapnel Shells on this account has been much overrated. Doubtless it is necessary to the full development of their efficiency that they should burst with tolerable correctness as regards the object aimed at; but it must not be supposed that their effect will be nullified if they do not burst at the *exact spot* required: no doubt their effect will be lessened in proportion as they explode further from the required spot, (may not this be said in a greater or less degree of all other projectiles?), but the limits of error in this respect are very large—larger perhaps than with any other projectile, except a solid shot. There is a passage in Col. Boxer's *Remarks on the Diaphragm Shrapnel Shell* which has a very direct and practical bearing on this subject, as showing the margin of error, allowable with shells of this class; it is quoted in the text, p. 8, "There is a point of much importance, &c." . . . down to end of quotation.

not be overlooked, namely, that with Shrapnel the fuze has to be regulated for a particular range, which is not the case with grape and case. But according to the present system, the operation of preparing the shell is of that simple character, that any man could, with proper instruction, be made thoroughly expert in a very short time, as compared with that which it is considered necessary to devote to far less important matters; *and, moreover, the rapidity with which this operation can be performed, with properly instructed men, is so great, that shells may be fired successfully as quickly as round shot, if it be considered desirable to do so.*

"There is a point of much importance, which has been well established by the results of the experiments lately carried on with Diaphragm shells at Woolwich, namely, that if the *elevation* be correct, it matters little whether the shell burst at 100 yds., or 20 yds., from the object fired at, so that, when the corresponding lengths of fuze and elevations have been determined by experiment, the practice with Shrapnel will become very simple."*

It will probably, however, always be a moot point as to whether the physical effects of Shrapnel fire are very great, and shells, of this class will probably always have their opponents,—but mainly, I believe, from the reason that men are apt to draw their conclusions hurriedly, and without perfectly knowing or sufficiently weighing *all* the circumstances of the cases on which these conclusions are founded.† For my own part, I must say that the solution of the question which a careful and dispassionate examination of the available data upon the subject has afforded me, is that which the foregoing pages have indicated, and which admits of a concise and general expression in the following terms: Certain conditions are necessary to the proper development of the efficiency of every missile; doubtless these conditions are somewhat more numerous in the case of Shrapnel shells than of other projectiles, but with the improvements which have been effected in these shells and their fuzes they are far from being impracticable or even difficult of fulfilment—while the effects, both physical and moral, of the shells are, under favourable conditions, probably greater than those of any other projectile.

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* Colonel Boxer's *Remarks on Diaphragm Shrapnel Shells*, pp. 42–44.

† As a proof that opinions *are* sometimes formed and expressed before the bearings of the subject have been sufficiently considered, I may mention that I have heard Shrapnel shell condemned and Armstrong's segment shells extolled in the same breath; now, it appears to me that whatever objections may be urged against Shrapnel shell, apply with increased force to Armstrong Segment Shells: where the velocity is the same it must be evident that the balance of disadvantages will be on the side of the segment shells. If spherical leaden bullets strike with insufficient force to inflict dangerous wounds, irregular shaped iron "segments," which from their shape and inferior density lose their velocity much more rapidly, will strike with even less force, and the wounds which they inflict will be even less formidable; if the dispersion of the bullets of Shrapnel shell is great enough to affect injuriously the efficiency of the projectile, how much greater must the dispersion necessarily be where the bursting charge is situated in the *centre* of the segments and where the centrifugal force to which the fragments of a rotating projectile are subjected tends to give to those fragments an increased lateral spread! I merely adduce this instance, without attempting to exhaust the instruction which may be derived from it, in support of my statement that condemnatory opinions respecting the efficiency of Shrapnel shells are sometimes advanced before the subject has been really studied, or even much thought over.

It will be observed that I have attempted to deal with the objections which have been urged against the Shrapnel class of shells in the aggregate, rather than separately and in detail, and this paper makes no pretence to the character of an exhaustive investigation of the subject; but perhaps the considerations and arguments which I have set forth, general though they be, may serve to guide officers to the salient points of a question which it is important every artilleryman should understand, and may help to clear away the doubts which embarrass the minds of some as to the practical value of Shrapnel fire.*

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* Those who care to pursue this subject at greater length should consult, in addition to Major Seton's little work the *Synopsis of Ordnance Select Committee Reports on Shrapnel Shell.* Decker's *Expériences sur les Shrapnels. Memoirs of Sir John Sinclair.* Col. Boxer's *Remarks upon Memo. of Ordnance Select Committee on Shrapnel Shell.* Bormann's *Shrapnel Shell in England and Belgium.* Delobel's *Révue de Technologie Militaire.*

ON TWO LARGE ENGLISH CANNON OF THE FIFTEENTH CENTURY,

PRESERVED AT

MONT S. MICHEL IN NORMANDY.

BY BRIGADIER-GENERAL LEFROY, R.A., F.R.S.

Readers of the learned *Etudes sur le passé et l'Avenir de l'Artillerie* of the Emperor Napoleon will recollect an allusion in Vol. III. p. 119 to "deux bombardes prises sur les Anglais au siége de Saint Michel, en 1423,[1] et qui sont encore actuellement dans cette ville." A drawing of these guns on a very small scale is given by Colonel Favé in Pl. v: a larger drawing, but by no means an accurate one, will be found in the *Recueil des Bouches à feu les plus remarquables* by General Marion and Captain Martin de Brettes, Plate lxxxi; and as we have no pieces in England of that early period whose date is so well established, they possess to the English military archæologist a very peculiar interest. In point of size the larger one is very little inferior to that "mickle-mouthed murtherer" Mons Meg, of whose history, however, nothing authentic is known before her first employment in 1489;[2] and it may be reasonably conjectured that like her they are the workmanship of those sturdy Flemish artizans who so early maintained their struggles for municipal independence, by their great mechanical skill.

The story of Froissart, as it is hardly necessary to say, does not extend to the year 1423; but it is remarkable that Monstrelet who relates the events of that year at some length, is silent as to the reverses of the English before Mont St Michel, although he relates the attempt of the French to take Avranches from the English by a *coup de main*, in which they were unsuccessful (Book II. ch. xiii.). It might lead one to suppose that guns of 15 or even 19 inches calibre were not of such extreme rarity in the 15th Century as to make their loss or their acquisition felt as a matter of great importance, did not Richard Grafton[3] assure us that such was not the case. The English had then, as they have usually had since, an advantage over their rivals in the mechanical perfection of their artillery, and the capture must have been a notable event. Thus, speaking of the siege of Maune (Le Mans) in 1424, he says:—"The Englishemen approched as nighe to the walles as they might without their losse and detriment, and shot against their walles great stones out of great Goonnes *whiche kinde of enginnes before that tyme, was very little seene or hearde of in Fraunce,* the strokes whereof

[1] "A la fin du mois d'Octobre, 1423."—*Recueil,* Part II. p. 3. This is however the date of the commencement of the siege, not of the end of it.

[2] Mr Hewitt in *Archæological Journal*, No. 37.

[3] *A chronicle at large and meere history of the affayres of Englande*, 1569.

so shaked, crushed, and riued the walles that within few dayes the Citie was dispoyled of all her toures and outward defences."[4] Even Holinshed writing as near the time as we are to the campaigns of Marlborough, does not find this campaign in Normandy worthy of any special notice. Perhaps the brilliant appearance of the Maid of Orleans on the stage, four or five years later, eclipsed the minor events of the period; or the vital interest at stake in the heart of the French monarchy caused the border warfare to sink into comparative insignificance; whatever be the cause, there is no allusion of this particular siege of Mont St Michel in any English work I have been able to consult.[5] Fortunately a learned and enthusiastic local historian has related the events in a way which leaves little to be desired.

It was, according to the Abbé Desroches,[6] "a period of frightful calamity. Attacks, surprises and combats followed in rapid succession, the vanquished of to-day being often the victor of to-morrow." The country immediately around Mont St Michel was more particularly the theatre of these exploits and of these disasters. The Count d'Aumale made frequent excursions. One day he learnt that the English captain, Jean de la Pole, had started from Normandy with two thousand five hundred men to pillage Anjou. Desirous of cutting off his retreat, d'Aumale summoned his fighting men from all parts. Jean de Lahage, baron de Coulonces, brought him a goodly company, and they were not long before they lighted upon the English, who following as it appears the instincts of their nature, were in the act of driving off great herds of beeves, (*d'immense troupeaux de bœufs*). "Quand les batailles dudit comte d'Aumale et dudit la Poule Anglais" says a contemporary historian quoted by the Abbé, "furent près l'une de l'autre comme un trait d'arc les Anglais marchaient fort, et en marchant ils piquaient devant eux de gros paux. . . It y eut de grandes vaillances d'armes faites mais les dites Anglais ne purent soutener le faix que leur baillaient les Français et furent défaits et les chefs furent près." Not long after these events the English set siege to Mont St Michel by sea and land; it was towards the end of

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[4] See also Camden's *Remaines*.

[5] Robert Fabyan records the burning of a Lollard, and even gives us a glimpse of Whittington thrice Lord Mayor of London, but is very brief in his notice of the events in France. "The first day of Marche (1423) was of his preesthod deregradyd an herytike, named William Tayllour and brent to asshes ī Smythfeld; whose oppinyons, for the heryng of thē shuld be tedious and vnfruttefull I therefore wyll nat wt them blot my booke. In this moneth of Marche also, was ye towne of Pont Melance, on the river of Seyne, deliuered by apoyntmēt vnto Grafton ye Regent of Frauce: of the whiche appoyntement one artycle was yt al horses, abylementes of warre, harneys and other shulde be lefte within the sayd place: and also golde and syluer, and other iewellys there to remayne hooly, and that if any persone were within the holde founde whiche before tyme had been gylty or consentyng to the deth of the Duke of Burgoyn, that he should be delyueryd vnto ye regent and nat to take any benefet or pryualage by that appoyntemēt.

"And this yere the west gate of the cytie called Newgate was newly buyldyd and repayred by the executours of Richarde Whytyngdon late Mayre of London, and thys yere after mydsomer fyl great water or rayne so that for the more party, euery daye atwene the begynnynge of July and ende of September, it rayned lytell or morhe, and yet that notwithstandynge that yere was conuenyent plentye of all grayne, so that whete passyd nat VIII *s.* at London, and malte V *s.*"—*The new Chronicles of England and France*, by Robert Fabyan, (died A.D. 1511).

[6] *Histoire du Mont Saint Michel et le l'ancien diocèse d'Avranches, par M. l'Abbé Desroches. Caen*, 1839.

the month of October, 1423. They drew on with a formidable artillery and an army of fifteen thousand men under the command of Count de Lescale. Their siege works (*bastilles*) surrounded the place on the land side, and they had numerous small vessels of war on the sea side. At the tidings of danger menacing this important point, the valiant soldiers of the counties of Avranches, Vire, Coutances, Valognes and Caen hurried to the defence. Louis d'Estouteville was made Governor. The names of these gallant gentlemen have been preserved to the number of 120, and fill four pages of the good Abbe's narrative: those who belonged to the diocese d'Avranches being honored with especial notice—

> The knights are dead, their swords are rust,
> Their souls are with the saints we trust

and we will not repeat the roll. The first assault of the English preceded by a fierce cannonade was nevertheless a failure; they were beaten off much discouraged, and beheld in superstitious fancy the arm of the Archangel Michael fighting in defence of his servants, the monks. The English commander, Lescale, thought he would try his fortune next in a naval attack, and covered the bay with his shipping. It is related that a hermit of the neighbouring Mont Tombelaine[1] gave him fair warning that as often as the hostile fleet menaced the Mont, so often could he behold the Archangel stirring up storms and tempests to engulf his ships. The English general paid not the slightest attention to these hints; but scarcely had his vessels taken their places round the Mont when a furious tempest scattered them. Next day the shore was strewed with wreck, intermingled with the bodies of those who had perished.

Profiting by the eight days of neap tide, during which the Mont is approachable at all hours,[2] the English recommenced their attack by land. Their batteries were ready by sunrise: two of their pieces were of a prodigious size, and threw stone balls of more than a foot in diameter. The walls of the lower part of the town were shattered, and the English precipitated themselves in assault with a greater resolution than they had ever before shewn since the siege began; but the defence was no less vigorous than the attack. The ladders were capsized, the assailants were pitched into the ditch, they returned to the assault, placed new ladders, and managed to gain the rampart. The carnage was frightful. The defenders, more particularly the Sieur de Cantilly, Thomas de Brayeuse and Guillaume Carbonel fought with desperation. However, they were driven into the castle. Then the monks trembling for their liberty united with their defenders, and took part in the fray. The English seemed to multiply, and the Abbey was on the point of falling into their hands, when the bravest of the knights Jean Guiton, Thomas de la Paluelle, Robert du Homme, Guillaume de Verdun, the Chevalier de Breuilly, forming themselves into a little band broke into the melée, forced themselves through the combatants, broke the English ranks and reached the pennons, which they threw under foot.

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[1] *Tumba Beli*, a twin islet, about two miles distant, on which as on Mont St Michel, were shrines to Baal in the pagan period.

[2] It is not surrounded with water at any time of the day during *les eaux mortes*.

Then, according to the chronicler, did the English give way. In vain did their leader endeavour to hold them together—in vain he set an example of gallantry—he was carried away in the crowd, and the rout became general. The field of battle, with the baggage, the chest, the equipages, the artillery, and the provisions all fell into the hands of the garrison.

Dejected by this reverse the English converted the siege into a blockade, which lasted till the beginning of April, 1424, when the Bretons, led by Guillaume de Montfort, Bishop of St Malo, dispersed or sunk the shipping and threw succour into the Mont. Repulsed by sea and land, the English had lost courage, but they did not cease to watch the fortress and look out for a chance of gaining it by surprise. They maintained troops in the neighbourhood at Genets and at Ardevon, where a fort (*bastille*) had been constructed: they rebuilt others at Servan and at Tanis where the blockade was still maintained, and frequent skirmishes took place between their forces and the garrison.

"En ce temps" says a contemporary historian, quoted by the Abbé, "Ceux de la garrison dudit Mont saillaient souvent et presque tous les jours pour escarmoucher avec les Anglais et y fesait-on de belles armes. Messire Jean de la Haye, baron de Coulonces était lors en un château du bas Maine, nommé Mayenne la Juhais, et allaient souvent de ses gens audit Mont St Michel et pareillement de ceux du Mont à Mayenne; dedit baron sçeut la manière et l'état des Anglais et fit savoir à ceux du mont qu'ils saillissent un certain jour et livrassent grosse ercarmouche au jour de vendredy et qu'il y serait sans faute, et ainsi fut fait; car ledit de Coulonces partit de sa place avant le jour, accompagné de ceux de sa garrison qui chevauchèrent neuf à dix lieues, puis eux et leurs chevaux repurent assez légèrement, et après ils remontèrent à cheval en venant tout droit vers la place des Anglais, et cependant ceux du Mont qui avaient beau espérance que ledit baron viendrait, saillirent pour escarmoucher, et aussi firent les Anglais, et tonjours Français saillaient de leur place et aussi fesaient Anglais de leur part: tellement que de deux à trois cents repoussèrent les Français jusque près du Mont: et lors environ deux heures après midi arrivèrent ledit baron de Coulonces et sa campagnée et se mit entre Ardevon et les Anglais tellement qu'ils eussent pu entrer en leur place pu......qu'ils n'eussent sans passer parmi les Français que avait ledit Coulonces. Finalement ceux du Mont et les autres Français chargèrent à coup sur les dits Anglais, lesquels se défendirent vaillamment: mais ils ne purent résister et furent défaits et y en eut de deux cents à douze vingts de morts et de pris, et entre les autres y fut pris Messire Nicholas Burdet, Anglais: puis ledit baron de Coulonces et sa compagnée s'en retournerent joyeux en sa place de Mayenne la Juhais."

Here then we have a very distinct account of the last disaster of the English. They were taken in rear by the baron of Coulonces, surprised and routed. The time appears to have been not long subsequent to the latter end of April, 1424. They abandoned forthwith their *bastilles* of Ardevon, Servan, and Tanis, and another that they had near the bourg des Pas, and losing all hope of success, they retired leaving a garrison in the neighbouring Mont Tombelaine to annoy that of Mont Saint Michel. The gallant knights, says the Abbé, erected a monument of their victory. "They placed at the entrance gate of the Mount two enormous pieces of ordnance of which they had made themselves masters. They were formed of bars of iron two inches in thickness, bound round by hoops of the same material. The largest is eleven feet long, and eighteen inches in calibre (French measure.) There is still to be seen in this piece one of the stone shot which were thrown by the English. It is about fifteen inches in diameter."[1] Such is the narrative of this eventful siege. Well might the grateful monks three years later emblazon in their abbey church the names and armorial bearings of those who had so stoutly held the

—place
Par laide de Dieu et la grace
et de Monseigneur St Michel
Prince de chevaliers du ciel
Qui a tonjours remede quys
à ceux qui lont ceans requis.

Professor Pole, F.R.S., whose association with the Committee on Iron Defences has naturally led him to take a warm interest in all subjects of artillery, having decided to spend his vacation of 1863 on the coast of Normandy, the writer called his attention to these curious memorials of the age of chivalry, and with characteristic activity he made it a business to visit and examine them. By the obliging assistance of M. Marquet, Director of the prison establishment at the Mont, his researches were completely successful.

The following is an extract from his personal narrative :—

"I passed," says Mr Pole, "Pontorson (the place opposite Mont St Michel) on Tuesday, the 15th September; but as I learned the regulations at the Mont were strict, I thought it best in the first instance to go on to Avranches, to get the necessary authority from the Sous-Préfet to examine the guns. I accordingly went to the sous-prefecture on the 16th, read your letter to the officer there, and he gave me a note of introduction to the 'Directeur de la Maison Centrale de detention' (for you probably know that the ancient church establishment is now a prison),[2] requesting him to give me all necessary facilities.

"Armed with this, I returned to Pontorson, and from there to the Mont. On presenting my note, I found the authority was addressed to the wrong person—there being three authorities on the rock: (1) the director, M. Marquet, a man of consideration; (2) the Maire of the little fishing village, or commune; and (3) the commandant of the fortress: and I was told that the director had no power over the guns, as they belonged to the commune. He however sent a special guide with me to shew me the beautiful chapel and buildings, and when I had seen these I hastened down to begin my work with the guns. I found that your sketch,[3] although something like one of them, was so imperfect that it was desirable for me to

[1] One of these shot has been recently presented to the Museum of Artillery at Woolwich, by M. Marquet.

[2] Since this time the prison has been abolished, and the beautiful buildings put in order for public view.

[3] Copied from the "Recueil des Bouches à feu les plus remarquables."—J. H. L.

take all the dimensions afresh, and I accordingly proceeded to do so. My first difficulty was that the breech end of the north gun was inserted through the wall into a private cellar on the other side; and to get its length and girth I must go there. I found only the wife at home, who said the cellar was filled with things which could not be moved. I tried to persuade her, but she was a regular virago, as immovable as the things in the cellar, so I was obliged to wait till her husband came home, and he agreed to clear the place to a certain extent for one franc compensation. I had also to get stone and rubbish removed from the outside, and so, with some patience, I succeeded in getting views and dimensions of the exterior of the guns.

"The inside, however, (as I have stated in my memorandum), I found stopped up with the granite balls; but as I was very desirous to make my work complete, I enquired for the mayor, to get his permission. I found he was a fisherman, and was out fishing, and would not return till late, so I had to return to Pontorson to sleep, and go back to the Mont the next morning.

"I found the mayor an impracticable individual, who, apparently to shew his little authority, refused to allow me to remove the balls, or touch the guns other than the outside. I told him I had the sub-prefect's permission, but he said the guns were the property of the commune; *he* was the commune; he would not allow it, and there was an end of the matter. The real motive of the refusal however, came out soon; he said the commune wanted to *sell* the guns, and that if I could persuade our government to buy them, we could take them away and measure them at our leisure! I found it hopeless to argue further, so I bid him good morning; and after taking all the further particulars I could, I returned to Avranches, and made my arrangements for proceeding on my journey.

"I thought it proper to write to the director, telling him the result of my application to the mayor, but so little did I think of any result from this letter, that I did not even give him my address at Avranches. Judge therefore of my surprise when, on Sunday evening, a special messenger came to me with a letter, having been sent with it by the director 12 or 13 miles through pouring rain, with orders to find me out without fail and without delay. The letter was so exceedingly courteous and considerate that it is worth while to send you a copy, which I enclose; and it gave me so polite an invitation to return to the Mont, that it would have been ungracious to refuse. I accordingly went back there on Monday morning, and saw the director. I dont know what had passed between him and the Maire, but it was evident the latter was extinguished; for the director had got men and tools ready to draw out the balls, and though during the operation the fisherman passed by, he studiously turned his head away, and I saw him no more.

"We began with the north or smaller gun, but we had great trouble to move the ball, it was so hard caked and rusted in. We commenced about 2 p.m., and by dark we had got it out, and by dint of poking and raking with heavy iron bars, we had also succeeded in somewhat clearing out the barrel and chamber behind. The ball in the biggest gun, however, although we had a separate gang at it all the afternoon, had hitherto refused to stir; and I had proposed to give it up, but the director would not hear of that, and insisted on my dining and sleeping with him, where I was made very welcome.

"Early in the morning the men were at work again; but for a long time the ball was still obstinate, and I was again setting off when I was called back, as it had given way, and in another minute it had rolled out of the mouth, and gave opportunity to clear out the interior and measure it, as I had done the other; and so I obtained, I hope to your satisfaction, all I desired.

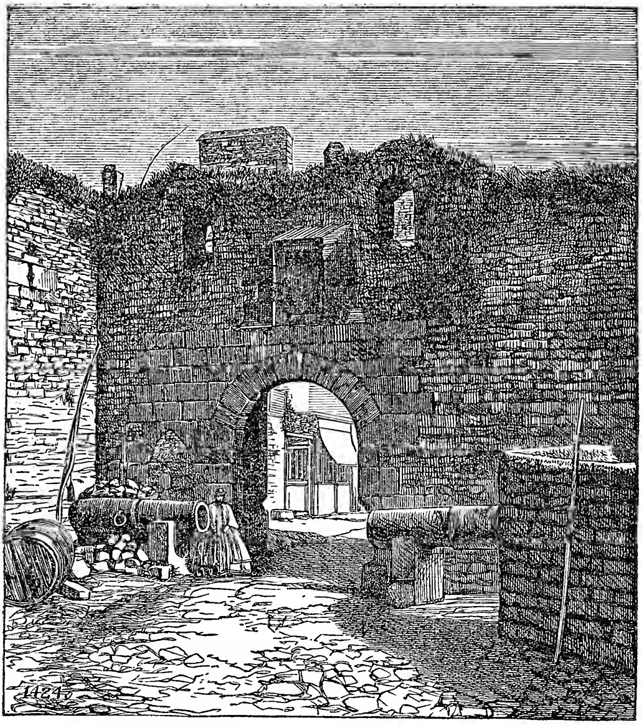
"The operations made quite a sensation. Nobody living had seen what the inside of the guns was like, and all the population of the island (except the prisoners and the mayor) came to see. Then we had to hire a little boy to creep into the guns to clear them, and the people were afraid they would go off and blow him to pieces; and then we had all sorts of tools to make and alter and mend; and then we had to coax a young woman to lend us her dressing glass to reflect light into the barrels; and we had to wheedle our friend of the cellar again to empty a barrel of water which was in the way, and as water is said to be dearer on the island than cider, we had to adjudicate on the compensation to be awarded; and then when the balls rolled out there was such a jubilee of all the little boys, who rolled them on each others toes quite delightful to see; and then all the military people of the garrison came and speculated about the construction and the use of the guns, and quarrelled with each other thereupon in their peculiar way; and everybody seemed to do honour to M. le Directeur, who stood by in the rain, and helped, all the while; and many of the workmen employed were prisoners, who evidently liked the relief; and so altogether we got some amusement out of the business in spite of *M. le Maire.*"

"Yours very faithfully,

"WILLIAM POLE."

"Col. Lefroy, F.R.S.

"&c., &c."



View of the Gateway, from a Photograph, 1863.

Memoranda on the Two large Wrought-iron Guns, left by the English at Mont St Michel, Normandy, in 1424.

"The guns now stand in front of the second gate of the fortress, their general position being shewn above.

"They are in bad condition, being much corroded by oxidation, the rust covering them in large flaky masses. This renders it difficult to obtain very accurate dimensions, or to gather very satisfactory details as to their construction. The particulars given, however, may be relied on, as I took them with all possible care.

"I found that each of the guns had a granite ball in the barrel, some distance down. These balls had been there beyond the memory of 'the oldest inhabitant,' and they had become firmly fixed by rust and dirt. To examine the interior it was necessary to draw these, as well as to clear the barrels of a mass of hard conglomerated rubbish that filled them behind the balls. It was not possible, in the time, to effect this latter operation very perfectly, and therefore the dimensions of the small chamber may be somewhat uncertain. If, however, any important correction is made hereafter, I shall probably be informed of it.

"The two guns are of different sizes; I will call them the large and small gun respectively.

Large Gun.

"The larger gun (Plate, fig. 1) is on the south side of the gate.

"It is 19 inches in calibre, and 12 ft. in total length, of which the chamber composes more than one-fourth.

"The granite balls, of which several lie about, are about 18 in. diameter.

"The general construction is evidently similar to that of the smaller gun, but the bars and hoops are not so distinctly visible. The internal longitudinal bars are about 3 in. wide. The hoops are visible round the back end of the barrel.

"The breech chamber piece consists externally of 10 longitudinal bars, the construction being evidently similar to that of the smaller gun.

"The muzzle of the gun is somewhat ragged, and has no projecting rings like the small gun. Possibly a piece may have been carried away.

"There are no eyes or rings; there is a trace of a projection where one of the eyes may have been, but I find nothing corresponding to it on the opposite side."

Small Gun.

"The smaller gun is on the north or left-hand side of the doorway.

"The dimensions will be seen from the accompanying Plate, fig. 3; it is 15 inches in calibre, and 11 ft. 9 inches in total length.

"The granite ball is rough in shape, about $\frac{3}{4}$ or an inch less in diameter than the calibre.

"The construction of the barrel is quite clearly visible. It is formed of wrought-iron, being in fact a true 'built-up' gun. The inside is made up of longitudinal bars, each about $2\frac{3}{4}$ in. wide by 1 in. thick, and round the outside are seen the lines of hoops, each about $2\frac{3}{4}$ in. wide, placed quite close to each other. It is not possible to discover whether the hooping is single or in several layers.

"The exterior of the breech or powder chamber consists, not of hoops, but of *longitudinal bars*, as shewn in the Plate, their flat surfaces giving to it the section of a polygon. This would seem exceedingly weak, but the longitudinal marks on the exterior are perfectly distinct, and there is not the slightest trace of any hooping. The construction of this chamber and of the breech end of the barrel, are obscure; I examined the parts as carefully as possible, but without gaining anything towards an explanation. The hoops are quite distinct on the commencement of the barrel, as shewn on the Plate, and this made me suspect, before examining the interior, that the breech-piece was solid, and the powder placed in the barrel, like modern guns. But on clearing the inside, the chamber appeared.

"The gun has an eye on each side for a ring; and one of the rings, a split one, is still there, as shewn in the Plate. The other eye is broken, and the ring gone. The eyes appear to have formed one mass with the hoop encircling the gun at that place.

"The powder chamber of this gun appears shallower than that of the larger one; it is however possible that the bottom may have become stopped up with some hard substance."

"The exterior of both guns is very rough and irregular. This is doubtless caused to a great extent by the rust; but I think the surface must originally have been far from smooth and even.

"I cannot find any trace of a vent-hole in either gun.

"I estimate the present weight of the guns as follows:—

"Large gun, about $5\frac{1}{3}$ tons.
"Small ,, ,, $3\frac{1}{4}$,,

"The granite ball for the large gun would probably weigh about 300 lbs.

"The Mont St Michel is about 1 to $1\frac{1}{2}$ mile from the nearest coast, and the intervening sands are overflowed at high water, except at neap tides. The besiegers cannot, I should think, have used the guns on the shore, but, as they succeeded in breaching the walls, they must have either fired them afloat, or mounted them in battery on the sands. Tradition says the latter; and adds that on the repulse of the English, the knights of St Michel took possession of the guns, and hoisted them high up on the rock, where they remained till 1793. In this turbulent year, it is said, the Revolutionists threw them down upon the sands again, and they lay there, washed by the sea, till about 20 or 25 years ago, when they were placed in their present position.

"I have been indebted to M. Marquet, the Director of the 'Maison Centrale' at Mont St Michel, for the facilities given me for the examination of the guns.

"(Signed)

"WILLIAM POLE."

"3, Storey's Gate, Westminster, S.W.,
"3rd October, 1863."

It is needless to say that *M. le Maire* must have been indulging his wit at the expense of the Englishman when he hinted that the guns were to be purchased. If any doubt could exist on this subject, the following letter from M. Marquet, would completely remove it: and it is agreeable to terminate this short notice with a communication which reflects so much credit on the enlightenment and good feeling of that gentleman. The guns will doubtless continue to adorn the gate of the castle, and long tell their tale to the peasants of Brittany and Normandy of the days when St Michel's Mont alone of Norman castles maintained the oriflamme, of the heroic struggles of their ancestors, and of the Anglo-Norman defeat.

Maison Centrale,
du Mont St Michael,
le 20 7^{bre}, 1863.

Monsieur,

Combien je regrette de ne pas avoir été informé des difficultés, je dirai même des obstacles, qui vous ont empêché de remplir la mission dont vous étiez chargé, car j'ai la conviction qu'il m'aurait été possible de les vaincre.

Si cette lettre a le bonheur de vous parvenir avant votre départ, venillez le retarder et revenez au Mont St Michel, je me mets entierement a votre disposition, et crois pouvoir vous assurer que vous pourrez remplir a votre satisfaction l'honorable mission qui vous a été confiée.

Comme vous l'avez bien pensé le maire du Mont St Michel n'avait pas le droit de vous proposer la vente des canons, qui sont une proprieté nationale, et dont la France ne saurait se dessaisir.

Trop heureux de pouvoir être utile à ceux qui se sont donnés la glorieux mission de travailler a la conservation des precieux souvenirs de l'histoire, je vous prie d'agréer l'assurance de ma haute consideration.

(Signed)

Le Directeur du Mont St Michel,
A. MARQUET.

à Professor Pole.

APPENDIX.

THE obscurity of the transaction in which the *Michelettes* were lost and won, induces me to annex extracts from two other writers, kindly furnished to Professor Pole, by M. Marquet. It is to be regretted that we have not yet been able to procure an extract from the contemporary Latin chronicle which is the foundation of all the accounts, and is said to exist still in the public library at Avranches. It might possibly explain the discrepancies of date, which are puzzling. Lehericher makes the siege last with intervals from 1423 to 1427, in which year he places the capture of cannon, and he disconnects this event entirely from the successful surprise of the baron de Coulonces. Girard brings the whole transaction down to the years 1433-4. We have preferred the authority of the Abbé Desroches, supported as it is by the authors of the *Etudes, &c.*, and of the *Recueil.* It is also the date of the *Histoire Pittoresque, &c.*

I. *Extrait from Avranchin Monumental et Historique, par Edouard Lehericher.*

"Cependant les Anglais s'étaient emparés de toute la Normandie, et avaient peu à peu resserré le cercle de leurs troupes autour du Mont St Michel, le seul point de toute la province où flottait encore la bannière de France, et où l'indépendance nationale, etait vaillamment défendue par quelques moines et quelques chevaliers. It fallait que ce Mont, si merveilleux en tout, offrît encore le rare spectacle d'une forteresse qui garde la nationalité, quand tout le pays est conquis, foyer sacré où vit le feu qui remplira un jour les cœurs et les enflammera contre l'étranger. Les moines du Mont, se voyant sans pasteur et leurs gens de guerre sans capitaine s'adréssèrent au Dauphin, qui dirigeait les affaires dans la maladie de son perè. Le prince envoya Jean d'Harcourt, comte d'Aumale, qui fut bien reçu des religieux parce qu'il venait pour les défendre et parce qu'il promit de respecter leurs privilèges.[1] Les Anglais avaient mis garnison sur Tombelaine, et avaient fortifié' ce rocher de hautes et fortes murailles, sans que les soldats du Mont pussent les en empêcher, les trois rivières de la Baie coulant alors entre les deux places. Nonobstant se voiants tousiours avoir du pire, ils redoublèrent leurs troupes[2], et firent le siège du Mont par terre et par mer, le roi insulaire y ayant envoié' un grand nombre de vaisseaux...... du costé de la grève bastirent plusieurs forts et bastions, entre autres une bastille en la rive d'Ardevon et une dans la paroisse d'Espas.[2] C'était en 1423. Le duc de Brétagne, craignant pour

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[1] Il demanda au grand-maître l'artillerie et les munitions nécessaires pour défendre le Mont et faire des courses sur les côtes. En 1423, il lui fut délivié 27 livres de saltpêtre, 60 du soufre, un millier de trait commun, 50 pelotons de fil d'arbalète. M. Desroches.

[2] Dom. Huynes.—*Histoire de la célèbre abbaye du Mont Saint Michel, au péril de la Mer, recueillie des anciens titres et chartres par Jean Huynes qui la composa en* 1638. *M.S.*

lui-même, fit armer secrètement dans le port de St Malo quelques navires par l'evêque et le sire de Beaufort, son amiral. Les Bretons ayants cramponné les vaisseaux et combattants main à main mirent la plus part des Anglais à mort et le reste en déroute, ce que voiants ceux du fort d'Ardevon se sauvèrent à la suite.[1] Le Mont fut ainsi ravitaillé et débloqué pour quelques jours. Mais les Anglais revinrent et se fortifièrent dans leurs bastilles: la guerre devint une guerre d'escarmouches dont les grevès étaient le théâtre. Un intéressant épisode de ce siège fut la défaite des Anglais pris entre les troupes du Mont et celles du baron de Coulonces qui venait de Mayenne.[2] Un autre fut la victoire du comte d'Aumale et de Coulonces sur les Anglais qui faisait une pointe sur l'Anjou.[3] Mais les français furent défaits à Verneuil par le duc de Bedfort, et Jean d'harcourt y resta parmi les morts.

"Son successeur, comme capitaine du Mont, fut Jean, batârd d'Orléans, comte de Mortain, qui, ne pouvant venir lui-même, envoya au Mont Nicholas Saisnel, son lieutenant. Le monastère était dans une telle détresse qu'il lui fallut engager son argenterie à Dinan et à Saint Malo. Cependant les Anglais attaquaient le Mont, si furieusement qu'ils sembloient estre capables de l'ébranler.[1] Le roi nomma en 1425, à la place du batârd d'Orléans, Louis d'Estouteville, illustre chevalier, qui avait sacrifié, pour rester français, la plus grande fortune de la Basse-Normandie.

"Une de ses premières mesures fut d'empêcher les femmes et les enfans de se refugier dans l'abboye pendant les assauts, et de transporter ailleurs les prisonniers de guerre, débarrassant ainsi une place affamée de bouches inutiles. Cependant les Anglais redoublaient d'efforts; la garnison de Tombelaine avait été renforcée, et escarmouchait tous les jours contre les Michelistes. Ceux du Mont, se décidant à hasarder une sortie, furent assez heureux pour écraser les ennemis dans les grèves, peu desquels se guarantirent de la mort ou de la prison, ce qui arriva vers la feste de la Toussaint 1425.[1] Ce succès anima tellement les moines qu'ils engagèrent en Bretagne les croix, mitres, calices, &c. Une partie de l'argent servit à faire fortifier la ville: aux remparts de Rob. Jolivet, on ajouta en cette année des tours entre les autres, des demi-lunes avec parapet et marches-coulis ou massacres; l'on fit aussi la porte de la ville ainsy qu'elle est à présent avec son pont-levis et le logis du dessus, une grande grille ou herse.[1] Les religieux obtinrent du roi, en 1426, de battre monnaie pour l'espace de trois ans.[4]

"L'année suivante, année glorieuse dans les fastes du Mont, la veille de la Saint Aubert, les Anglais vinrent au nombre de plus de vingt mille, sous la conduite de Lord Scale, tous bien armes avec plusieurs machines espouvantables et divers engins de guerre; ayant observé le flux et le reflux de la mer, ils dressèrent une batterie si furieuse contre les murailles qu'ils y firent brèche, mais ils furent reçus si vertement par ceux du Mont, conduits par Louis d'Estouteville, qu'il demeura presque deux mille Anglois de tués dans les murailles et sur les grevès. Le peu qui s'échappa se refugia en leur

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[1] Dom. Huynes.

[2] En Ardevon. Voir G. Gruel.

[3] Quand les batailles du dit comte et dudit La Poule Anglais furent pris comme d'un trait d'arc, les Anglais marchaient fort et piquaient de gros troupeaux.........il y eut grandes vaillances faites, mais les Anglais ne purent soutenir le faix........

[4] Acte de 1426.

bastille d'Ardevon, craignant qu'on allât leur y donner quelque aubade....... Cette victoire peut être comparée à celle de Josué, d'autant qu'il ne s'en trouva aucun du Mont ne de tué ni de blessé, ce qui fut attribuê à la protection de S. Michel et aux mérites de S. Aubert.[5] Il reste encore des trophées de cette victoire; ce sont les deux énormes canons, appelés les Michelettes, qui furent pris sur les Anglais. Cette victoire avait été remportée par Louis d'Estouteville et 119 chevaliers qui s'étaient jetés dans la place, et dont les noms furent inscrits, avec leurs armes, dans le cheur de l'église en cette année 1427.[6] Charles VII. envoya au Mont, Dunois, pour complimenter les héros."

II. *Extrait from Histoire Geologique, Archeologique et Pittoresque du Mont Saint Michel, par Fulgence Girard,* p. 226.

"Le Mont St Michel jouissait depuis quelques années d'une sorte de trève armée, qu'il devait moins à la protection de ses boulevarts qu' à la terreur dont avait frappé l'ennemi le succés de ses armes, lorsqu'un désastre inopiné éclata dans ses remparts, et vint ranimer les espérances des Anglais. Un incendie ayant réduit en cendres presque toute la ville, le lundi de la Quasimodo 1433, l'ennemi pensa pouvoir, à la faveur de cette catastrophe, donner enfin satisfaction à sa vengeance. Sire d'Escalles prépara dès-lors un effort désespéré contre cette place. Une armée de 20,000 combattans se réunit sous ses ordres, et, trainant une artillerie formidable, parut l'année 1434, le 17 Juin, sur les grèves; son arrivée était calculée sur l'epoque mensuelle des basses eaux. Ces épouvantables machines de guerre, dressées en batterie sur les grèves; ouvrirent bientôt contre les remparts un feu terrible: ébranlées par le choc multipliê des boulets de granit vomis par ces pièces énormes, les murailles s'ouvrièrent, croulèrent avec fracas. Encouragé par ce succès, l'ennemi s'elança avec audace à travers ces décombres; les assiégés ne se jetterent pas avec moins de résolution dans la brêche pour en défendre les abords et le passage. Le choc fut terrible. Les chevaliers normands avaient à conserver quinze années de gloire; les barons anglais voulaient effacer vingt défaites par un succès. C'était un jour décisif pour les uns et pour les autres: aussi l'assaut fut il aussi impétueux que la

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5 Dom. Huynes. Voir l'Archéologie.

6 Ces chevaliers avaient avec eux leurs soldats. Le Chiffre 1427 est bien la date de ce grand événement. Nous avons sous les yeux un parchemin du Mont, délivré en 1661, extraict fidellement d'une vieille pancarte conservée dans le Chrésor...... laquelle suitte d'armes fut minse en 1427....... Extrait du chartrier du Mont ou sont les noms des 119 qui le defendirent l'espace de 3 ans et demy contre les Anglais ne leur restant que cette place de toute la Normandie à prendre dont ils furent chassez en 1427. Suis les vers:

Le Champ d'armes icy fut fait.
L'an mil IIII^{cc} vingt et Sept. Voir l'Archéologie.

M. Pireh a constaté, en Angleterre, que ce brillant fait d'armes eut lieu 'on a thursday 1427.' Ils furent dépeincts l'an 1427, dit D. Huynes. On raconte que l'ermite de Tombelaine vint avertir Le Scale que quand des flottes menacaient le Mont, l'Archange soulevait les tempêtes; mais il n'en tint compte. Les annales de l'Abbaye signalent une incendie de la ville en 1433. D. Huynes. D. le Roy. Il y a à la bibliôthèque royale un MSS. de Robert Jolivet. "Iste Chronice (Chron. de St Denis) sunt Rob. abbatis M. S. M. empte per eum an 1438." Le MSS. 6859 est aussi de la bibliothèque du Mont.

défense fut héroïque. Aux pierres et aux flèches, qui se croisèrent d'abord de la grève et des remparts, succédèrent bientôt sur la brêche des armes plus terribles: la hache d'armes, l'épée et la lance entamèrent les boucliers et brisèrent les cuirasses. Une lutte corps à corps jette à ces décombres sa sanglante mêleè. Louis d'Estouteville et de Verdun électrisent leurs compagnons par les prodiges de leur courage; l'exaltation de l'ennemi s'épuise en longs et vains efforts. En vain un de ses capitaines, la visière levée, s'efforce-t-il de pousser à l'assaut des forces nouvelles; égorgés sur les remparts ou renversés sur les masses inférieures, les assailans y jettent un désordre que réparent quelque temps la voix et l'exemple des chefs: l'ennemi perd pied enfin; l'épouvante se met dans ses rangs. Les assiègés le pressent avec plus de fureur; la confusion est â son comble; la terreur se généralise; chacun, jettant ses armes, ne songe plus qu' à fuir.

"Un religieux, témoin de ces exploits, décrit ainsi cet assaut dans un fragment manuscrit rapporté par M. Desroches: 'Quel spectacle! voilà que, sur la brêche, on combat corps à corps. Dieu des armées, défendez vos pauvres serviteurs. Notre gouverneur est entouré d'ennemis; il se dégage et monte sur le troisième bastion; il renverse tout ce qui lui résiste, et arrache les enseignes ennemies. L'épée de Guillaume de Verdun vole en éclats; il s'arme d'une hache et porte des coups terribles. Avec quel courage aussi cet homme, couvert d'armes rouges, fait ranger aux pieds des murailles les troupes anglaises! l'épée haute et le visage découvert, il les anime et les ramène au combat. On précipite sur eux des pierres, des poutres, des rochers. Saint Michel combat pour nous: les ennemis sont repoussés.'

"Quelque étranger que soit ce morceau, par ses expressions, au style de cette époque, comme le texte a pu être traduit ou modifié par l'écrivain auquel nous l'empruntons, nous avons cru pouvoir le rapporter, en couvrant toute fois notre responsabilité par cette remarque.

"Emporté par l'exaltation de la victoire, les Normands fondent sur l'ennemi, le poursuivent à travers ces grèves qu'ils couvrent de carnage, et le rejettent jusque dans ses bastilles. L'artillerie anglaise, pièces énormes formées de lames de fer soudées et unies par des cercles de même métal, fut le monument de ce succés mémorable, qui coûta 2000 soldats à l'armée insulaire.

"Cette attaque fut la dernière enterprise que tenterent les anglais contre le Mont Saint Michel. Découragés par cette défaite, ils se bornèrent à le surveiller par les garnisons de Tombelène et de leurs bastilles."

MONS MEG,

THE ANCIENT BOMBARD, PRESERVED AT EDINBURGH CASTLE.

[Extracted from No. 37 of the Archæological Journal, with the consent of the Council of the Archæological Institute, and with the permission of the author, J. Hewitt, Esq., War Office.]

Cannon, constructed of iron staves bound together with hoops of the same material, were in use for so long a period that it becomes very difficult, in the absence of written testimony or well-authenticated tradition, to assign a date to any particular examples that may have come down to us. Of the great gun of Ghent, which, except in its dimensions, is almost identical with *Mons Meg*,[1] Captain Favé has recorded his belief that it is in all probability the very "bombarde merveilleusement grande" mentioned by Froissard as employed by the citizens of Ghent against their neighbours of Oudenarde.[2] And that cannon of this fashion were still in use in the days of Henry VIII., is a fact familiar to us all from the well-known operations upon the wreck of the *Mary Rose*.[3]

Famous guns, like famous nations, begin their history in the faltering accents of tradition. The early days of Mons Meg are chronicled in a Galloway legend; which, however, had so much weight with Sir Walter Scott that he wrote to Mr Train, a distinguished Scottish antiquary, who had communicated to him the local story with such corroborative facts as he could collect: "You have traced her propinquity so clearly as henceforth to set all conjecture aside."

The legend in question has been preserved in Wilson's "Memorials of Edinburgh in the Olden Time."[4]

"The Earl of Douglas having seized Sir Patrick M'Lellan, Tutor of Bomby, the Sheriff of Galloway and chief of a powerful clan, carried him prisoner to Threave Castle, where he caused him to be hanged on 'The Gallows Knob,' a granite block which still remains, projecting over the main gateway of the Castle. The act of forfeiture, passed by Parliament in 1455, at length furnished an opportunity, under the protection of government, of throwing off that iron yoke of the Douglases under which Galloway had groaned for upwards of eighty years. When James the Second arrived with an army at Carlingwark, to besiege the Castle of Threave, the M'Lellans

[1] A representation of this bombard may be found in the Vade Mecum du Peintre, par Felix De Vigne, Gand, 1844, plate C.

[2] Du reste, il existe encore aujourd'hui à Gand une énorme bombarde qui, selon toute probabilité, est celle dont a parlé Froissard."—*Du feu Grégeois*, &c., p. 174.

[3] Of the wrought-iron bar-and-hoop guns recovered from this vessel, sunk at Spithead in 1545, several very perfect specimens remain. One is preserved in the Museum of the Royal Military Repository at Woolwich; another is in the Tower; and a third is figured and described by Sir Charles Lemon in the Reports of the Royal Institution of Cornwall for 1844. All these retain their wooden carriages, with the blocks by which the chambers were wedged close to the chase.

[4] Vol. I., page 130.

presented him with the piece of ordnance now called 'Mons Meg.' The first discharge of this great gun is said to have consisted of a peck of powder and a granite ball nearly as heavy as a Galloway cow. This ball is believed, in its course through the Castle of Threave, to have carried away the hand of Margaret de Douglas, commonly called the Fair Maid of Galloway, as she sat at table with her lord, and was in the act of raising the wine-cup to her lips. Old people still maintain that the vengeance of God was thereby evidently manifested, in destroying the hand which had been given in wedlock to two brothers, and that even while the lawful spouse of the first was alive. As a recompense for the present of the gun, and for the loyalty of the M'Lellans, the king, before leaving Galloway, raised the town of Kirkcudbright into a Royal Burgh, and granted to *Brawny Kim*, the smith, the lands of *Mollance* in the neighbourhood of Threave Castle. Hence the smith was called Mollance, and his wife's name being Meg, the cannon, in honour of her, received the appellative of 'Mollance Meg.' There is no smithy now at the 'Three Thorns of the Carlingwark;' but a few years ago, when making the great military road to Portpatrick, which passes that way, the workmen had to cut through a deep bed of cinders and ashes, which plainly showed that there had been an extensive forge on that spot at some former period." * * * In addition to this, (adds the correspondent of Sir Walter,) Symson, in his work written nearly a hundred and sixty years ago, says: "The common report also goes in that country, that in the Isle of Threaves, the great iron gun in the Castle of Edinburgh, commonly called *Mount Meg*, was wrought and made."

To the above tradition the sober-minded archæologist will probably object that it is of somewhat too melodramatic a character. "Brawny Kim," and the Tutor of Bomby, King James and the rebel Douglas might have passed; but the shot of retribution,—as heavy as a cow, and impelled by a peck of powder,—passing through the walls of the Castle, straight into the banqueting-room of the Fair Maid of Galloway, dashing the wine-cup from her perjured lips, and carrying off her hand; that very hand which had been given in wedlock to two brothers, and given moreover while the lawful spouse of the first was alive: all this smacks too much of the minnesinger's budget to be readily accepted as true history. The transition too from *Mollance* to *Mons* is sufficiently violent, besides having no voucher in contemporary records. But worse than this is, the Lady of Mollance, Brawny Kim's wife Meg, being called in to stand parcell-godmother to the great gun, when we know that in all the ancient records in which it is mentioned, the name *Meg* never appears: the piece is simply called *Mons*, and the first writer who applies to it the name of Meg is Drummond of Hawthornden.

The first appearance of Mons for which we have a contemporary voucher, is on the expedition of James IV. to besiege Dumbarton, when she was brought forth from Edinburgh Castle and carried to take part in the attack. In the accounts of the Lord High Treasurer of Scotland of that period, under date 10 July, 1489, we have:

"Item, given to the gunners to drink-silver when they cartit Monss, by the king's command, xviij shillings."[1]

In 1497 the great gun was again withdrawn from the Castle of Edinburgh

[1] Tytler's Hist. of Scotland, Vol. III., Note U. Third Edition.

and carried in solemn procession to Holyrood House, from whence she was taken by James IV. to the siege of Norham Castle.

In the Scottish Treasury accounts of this time are many interesting notices of our bombard. She was mounted on a new carriage for the occasion, as appears by the following entries:—

July 24, 1497. "Item, to pynouris to bere ye trees to be Mons new cradill to her at St Leonard's quhare scho lay, iij sh. vi d."

July 28. "Item, for xiij stane of irne to make graith[2] to Monsis new cradill and gavilokkis[3] to gu with her, xxx sh. iiij d."

"Item, to vij wrights for twa dayis and a half ya maid Monsis cradill, xxiij sh. iiij d."

Among other entries of the same period we have:—

"Item, for viij elne of canwas to be Mons claiths to cover her." Another item is for painting the canvas.

"Item, to the Minstralis that playit before Mons doune the gait, xiij sh."[4]

In 1501, 1527, 1532, and 1539 various payments are recorded for the well-keeping of Mons and her carriage. On one occasion she is "ourelaid with reed leid" and her "quheles and extreis creischit[5] with Orknay butter."[6]

In 1558, on the rejoicings consequent on the marriage of Queen Mary with the Dauphin of France, the great gun was again in request; for, on the 3rd of July in that year, we find this payment made by order of the Queen Regent: "To certain pyonaris for thair labouris in the * * * of Mons furth of her lair, to be schote, and for the finding and carrying of hir bullet efter scho was schot, fra Weirdie Mure[7] to the Castell of Edinburgh, x s. viii d."[8]

In 1578, among the "Towellis, Plenissingis,[9] Artaillierie and Munitioun within the Castell of Edinburgh, pertening to our Soverane Lord and hienes derrest Moder," our bombard again appears as "Ane grit peice, of forgit yron, callit Mons."[8]

In 1633, when King Charles I. visited Edinburgh, Mons was found unfit to join in the salute which welcomed His Majesty from the Castle: "Item, to * * * * for rining and wining of the tuich hole of the iron peice that had beene poysoned thir many yeares by gane, iij * * *."[8]

At the surrender of Edinburgh Castle in 1650, Mons appears under a new style and title: "The great Iron Murderer called Muckle Meg;" and in another document she is denominated "the Great Mag."[8]

Sir John Lauder, Bart., of Fountainhall, in his Historical Notices of Scottish Affairs, records that in October, 1680, "the Duke of York having visited the Castle of Edinburgh,—for a testimony of joy, the gun called *Muns Meg* being charged by the advice of ane English Canonier, in the shooting was

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[2] Gear.—*Jamieson.*

[3] Iron crows.—*Ibid.*

[4] Tytler, as above; and Letter of A. Macdonald, Esq., Curator of the Museum of the Society of Antiquarians of Scotland, to the Board of Ordnance, Oct. 1835. See also Sir Walter Scott's "Provincial Antiq. of Scotland," Vol. I., p. 21.

[5] Wheels and axletrees greased.

[6] Macdonald, as above.

[7] Wardie is fully two miles from the castle.—*Wilson* p. 131.

[8] Macdonald.

[9] Furniture.—*Jamieson.*

riven; which some foolishly called a bad omen. The Scots resented it extremely, thinking the Englishman might of malice have done it purposely, they having no cannon in all England so big as she."

In Maitland's History of Edinburgh, published in 1753, we re: "Adjoining to the fourth or innermost gate of the Castle, *on the ground*, lies a huge piece of ordnance denominated *Mount's Meg*." By the phrase, "on the ground," it would appear that Mons was at this time without a carriage.

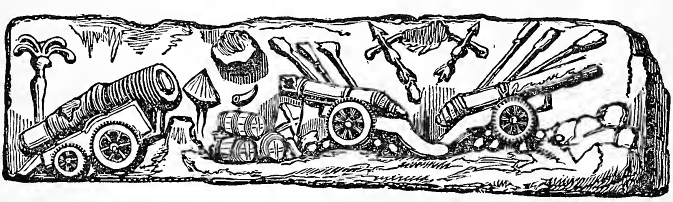
In 1754 our venerable bombard, riven, rusty, and carriageless, was sent to England; but she does not seem to have quitted the land of her glories without a plunge, for in the Tower books of this date we find John Dick applying to the Board of Ordnance for compensation "for injury to his vessel and hawser on shipping the great gun at Leith for conveyance to the Tower."

In 1829, on an application to George the Fourth, in which Sir Walter Scott was prominently active, Mons Meg was restored to Scotland; and in her march from Leith to Edinburgh she was "attended in grand procession, and with a military Guard of Honour, to her ancient quarters in the Castle."[1]

Under date of June, 1835, the Officer commanding Royal Artillery at Leith Fort informs the Board of Ordnance that "the large gun called Mons Meg, placed in the Battery in the Castle of Edinburgh, fell down with a great crash." The Society of Antiquaries of Scotland also report the wreck of "the old wooden carriage, which had crumbled almost to dust," and pray the Board to grant the supply of a new one. In accordance with this wish, a new carriage was constructed at the Royal Carriage Department at Woolwich, and forwarded to Edinburgh in 1836. It is of cast-iron, and still supports the honoured remains of *The Great Murtherer*.

The name of *Mons* borne by this bombard is generally attributed to its having been fabricated at the town of that name in Flanders; and this probability seems to gather strength from the circumstance of the great gun of Ghent resembling it so closely in model and construction. Hall tells us besides how James II. of Scots in 1460 besieged Roxburgh Castle with "his newe Bombarde lately cast in Flaunders, called *the Lion*."

At various periods of her career, the appearance of Mons Meg has been preserved by the arts of portraiture; by the sculptor, the modeller, and the engraver.



An ancient sculptured stone, apparently of the close of the sixteenth century, which once formed part of a gateway in Edinburgh Castle, and is now fixed over the entrance to the Ordnance Office there, exhibits the figure of Mons mounted on one of her old "cradills." In the "Memorials of Edinburgh" is an engraving of this stone, which, by the kindness of the

[1] Macdonald.

author, we are enabled to place before our readers. The appearance of Mons, when forming one of the "Lions" of the Tower, may be seen in the model which is still preserved in the Tower Armories.

The engraving at page 30 is from a drawing also preserved in the Tower, the one furnished by Lieutenant Bingham, R.A.,[2] for the purpose of constructing that new carriage which, we have seen, was supplied in 1836. The Commanding Officer of Royal Artillery, in forwarding this drawing from Scotland, communicates also the traditional account, that "the fracture disclosing the longitudinal bars took place the last time the gun was fired." It is scarcely necessary to say that the bursting of the cannon may be attributed to the increased strength of the powder of the seventeenth century as compared with "a peck" of that of the fifteenth. Of the extraordinary charges used anciently for various kinds of *gonnes*, there is no more curious instance than that cited by Captain Favé (*Du feu Grégeois*, &c., p. 158), from an old treatise of "Canonnerie," of unknown date, printed at Paris in 1561. To charge your "baston de canonnerie:"

"Vous debvez mesurer la longueur du baston par dedans, despuis la bouche d'iceluy jusques au fond, et icelle longueur diviser en cinq parties égales; desquelles l'une sera pour mettre le tampon, et l'autre sera vuide, et les autres dernieres doivent estres chargées de bonne poudre." That is, the charge of "strong powder" is to occupy *three-fifths* of the barrel.

The mode of construction of the Scottish Gun is plainly shown at the point where it has been "riven." Longitudinal strips of iron are ranged like the staves of a cask and welded together; and then a number of rings or hoops, also of wrought iron, are driven tightly over them. The thickness of the bars is 2½ inches; that of the hoops, 3½ inches. There is no core beneath the strips, as in some early bar-and-hoop guns (for instance, Nos. 118 and 119 of the collection at the Royal Military Repository at Woolwich); but the welded staves themselves form the concave cylinder. The magnitude of this engine, the contrivance of its parts, and the nice proportions of its outline, show that it is by no means one of the earliest efforts of the gunsmith's art. Cannon at first were conical in form, a curious example of which will be found in a Sloane manuscript in the British Museum, No. 2433, vol. B, fol. 113; figured by Strutt in his *Dress and Habits*, and by the Emperor of the French in his *Etudes sur l'Artillerie*. When first made cylindrical, the gun would probably be of equal thickness throughout. The next step would be to strengthen the portion near the charge. Further experiences would show that the action of the powder on the various parts of the piece would be best met by a graduated construction; and thus we arrive at the plan of the gun before us; consisting of chamber, first and second reinforce, and chase. To such a model one can scarcely accord a higher antiquity than about the middle of the fifteenth century.

Monstrelet, under the year 1478, has an amusing account of the trial of a "grosse bombarde," carrying a ball of "ccccc livres de fer," made at Tours; which may be consulted by those who find interest in the details of the early days of "Canonnerie."

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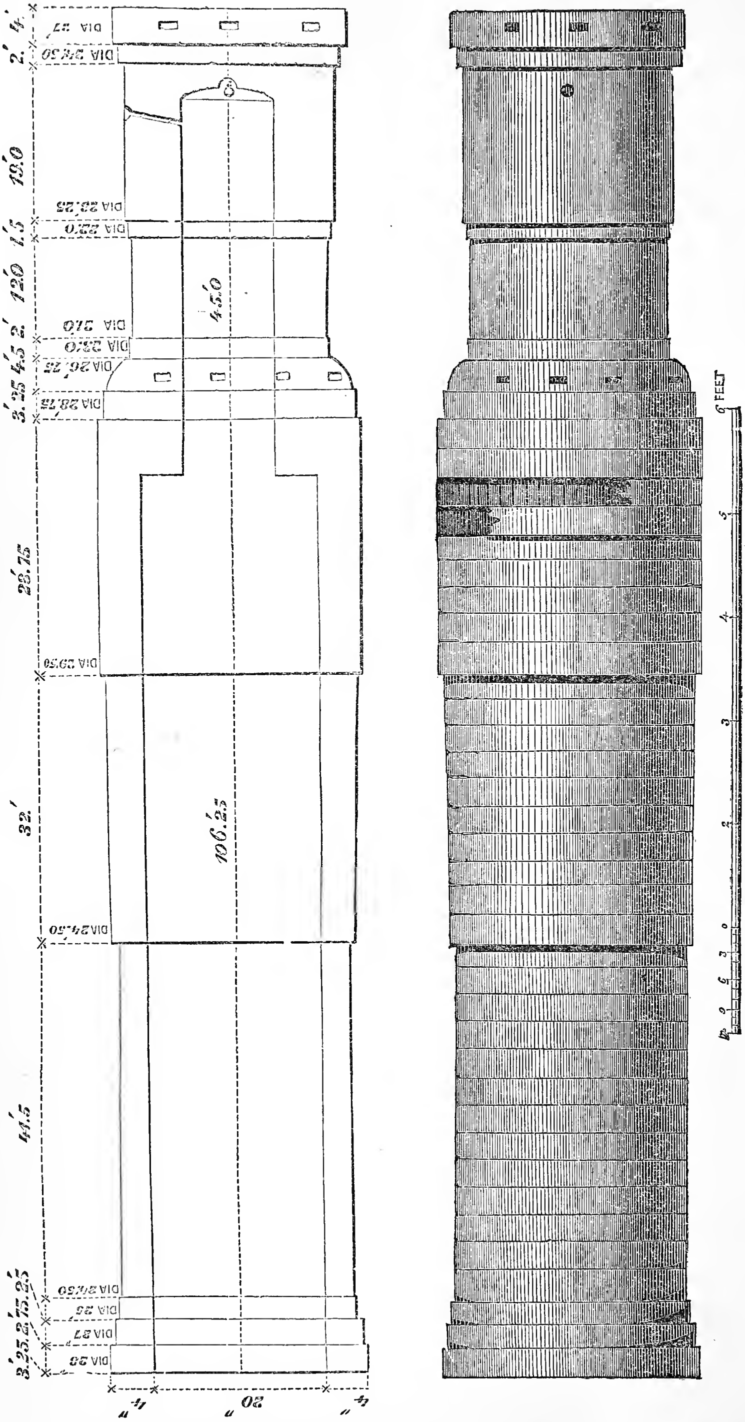
[2] Col. Charles Bingham, R.A., Deputy-Adjutant-General.

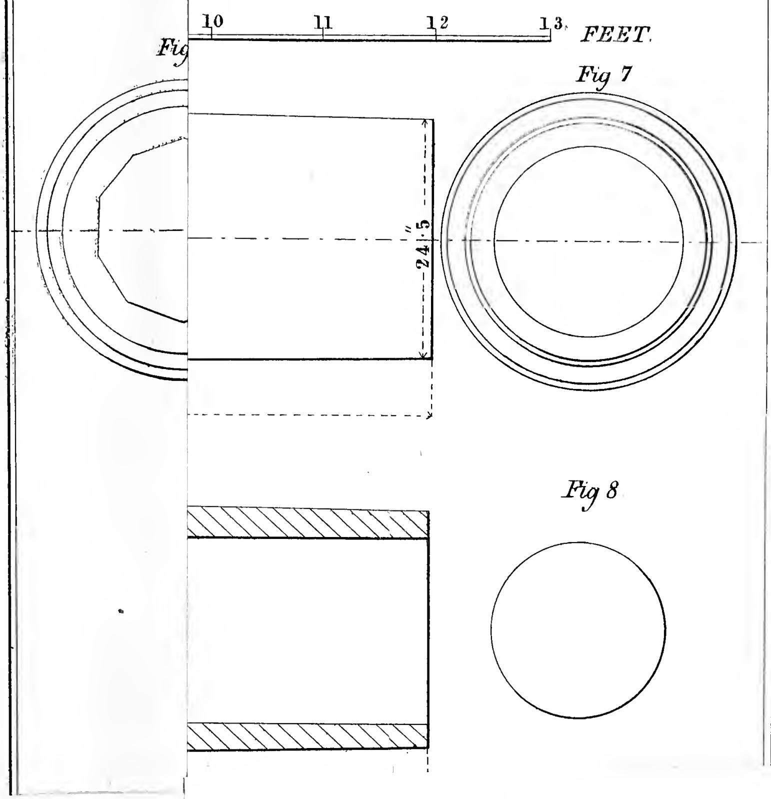
ANCIENT ORDNANCE, PRESERVED AT EDINBURGH CASTLE.



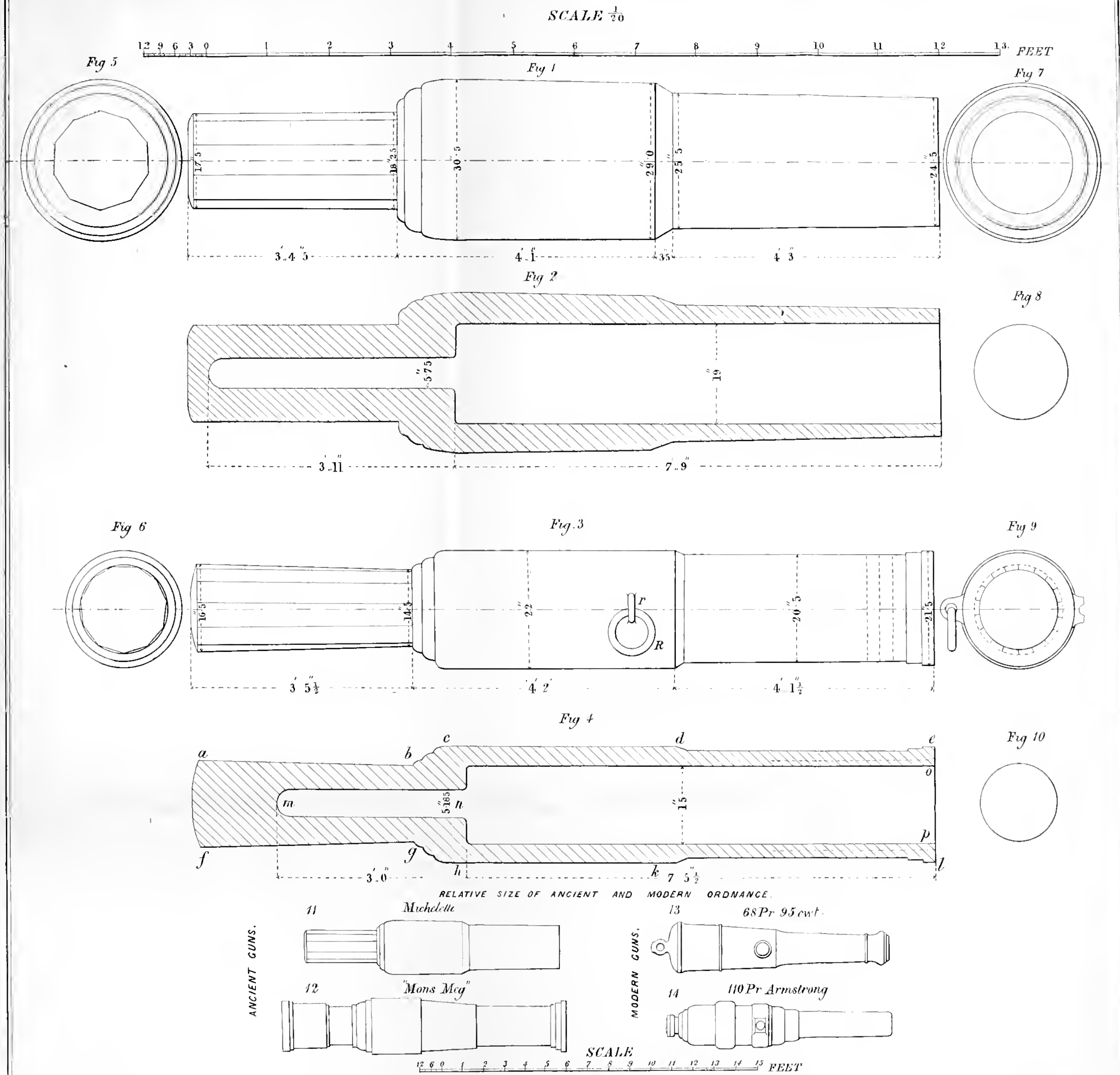
Mons Meg, used at the Siege of Dumbarton, 1489, and at Norham, 1497, in the reign of James IV., King of Scots.

By an error of the engraver, the measurements in this wood-cut, have been shewn as *feet*, where (it is plain) they should be *inches*.—E. J. B.

DRAT ST. MICHEL, MAY 1424.



DRAWINGS OF WROUGHT IRON GUNS LEFT BY THE ENGLISH AT MONT ST. MICHEL, MAY 1424.



Lithographed at the Royal Artillery Institution, Woolwich.

ACCOUNT

OF

AN EXPERIMENT CARRIED ON AT SHOEBURYNESS, 8TH DECEMBER, 1863, BY THE SPECIAL COMMITTEE ON IRON, ON A TARGET (20′ 9″ × 8′ 6″) CONSTRUCTED TO REPRESENT A PORTION OF THE "BELLEROPHON" IRON-CASED FRIGATE.

[FURNISHED BY CAPTAIN E. J. BRUCE, R.A.]

THE part of the ship which was tested by the target is that situated between the main and lower decks, and not in the line of ports, the object being to test the strength of the general side of the ship. Special arrangements will be made to strengthen the side in the vicinity of the ports, which will be few in number, as the "Bellerophon" is to carry a small number of very large guns. These few ports can be strengthened by the introduction of additional iron to an extent which would not be practicable if the number of ports were large.

Each frame of the target is made of an angle-iron $10'' \times 3\frac{1}{2}'' \times \frac{1}{2}''$, and two angle-irons, $3\frac{1}{2}'' \times 3\frac{1}{2}'' \times \frac{5}{8}''$, riveted together; to the double angle-irons of this frame the skin, which is composed of two thicknesses of $\frac{3}{4}''$ plating, making together $1\frac{1}{2}''$, with a layer of painted canvas between, is riveted.

On the outside of the skin plating four horizontal angle-iron stringers are attached, two under the upper armour plate, $9\frac{1}{2}'' \times 3\frac{1}{2}'' \times \frac{1}{2}''$, the broad flange being square to the skin, and not reaching out to the armour by half an inch; the other two are placed behind the lower plate, $10'' \times 3\frac{1}{2}'' \times \frac{1}{2}''$. The breadth of the broader flange being the same as the thickness of the backing, it reaches out to and comes in contact with the armour.

Wood backing, 10″ thick, is worked longitudinally on the skin plating and between the angle-iron stringers, bolted with nut and screw bolts through the skin plating.

The armour consists of two rolled plates, 6″ thick (manufactured at the Millwall Iron Works), weighing upwards of 9 tons each. The upper armour-plate is bolted with bolts $2\frac{1}{2}''$ diameter, and the lower plate with bolts $2\frac{3}{4}''$ diameter. In one half of the target, divided vertically, the armour bolts have elastic washers, and are clenched on single nuts. In the other half the bolts have common washers with double nuts, and the bolts *not* clenched.

In erecting the target, care has been taken to support it behind with beam-ends, &c., so that the actual condition of the proposed ship's side may be approximated to as closely as possible.

All the portions of this target were carefully weighed, and the weight, as reported by the Admiralty overseer, is 389 lbs. per square foot.

The range was 200 yards, and the following shot struck the target:—

From 10·5″ Armstrong rifled gun,—
Spherical cast-iron solid shot, one, weight 150 lbs.
Spherical steel ditto, one, weight 165 lbs.
Cylindrical cast-iron ditto, one, weight 308 lbs.

From 7·1″ Ordnance Select Committee gun,—
Steel shell, one, weight 119 lbs.

From 7·″ Whitworth rifled gun,—
Steel shell, one, weight $149\frac{1}{2}$ lbs.

From $5\frac{1}{2}''$ Whitworth rifled gun,—
Steel shell, one, weight 69 lbs.

From 110-pr. Armstrong breech-loading rifled gun,—
Solid cast-iron shot, four, weight $66\frac{1}{4}$ lbs. each.

From 68-pr. smooth-bore gun,—
Solid cast-iron shot, three, weight $66\frac{1}{2}$ lbs. each.

Number of round.	Photographic No.	Nature of ordnance.	Projectile. Nature.	Projectile. Weight in lbs.	Projectile. Form.	Bursting charge.	Charge in lbs.	Elevation.	Deflection.	Effects. Depth of indent in inches.	Effects. Diameter of indent in inches.	Effects. Ripple round circumference of hole	Effects. Bulge of plate in inches.	Velocity at 510′.	Remarks.
						lbs. oz.		′	′						
1	707	68-pr. s. bore gun.	*	66½	Spherical.	...	16	20	nil.	1·5	9·	...	1·65	1405·0	Struck upper plate 9″ from top, and 9″ to left of No. 6 bolt.
2	708	110-pr Armst. rifled.	†	66·187	Cylindrical.	...	„	15	8 R	1·2	8·	...	1·45	1468·4	Struck upper plate 9″ from top, and 2′ to right of last round. Bolt at 9″ from indent started 0·2″. Washer of armour-plate bolt slightly compressed.
3	709	110-pr	„	66¼	„	...	„	10	8 R	...	...	...	...	...	These guns were fired in salvo. No. 709 struck top of target, 3″ of indent on plate; No. 710 struck upper plate, 1′ 9″ from top and 6′ from right side; Nos. 711, 712 struck close to bolt 14″ from bottom of upper plate, the circumferences of indent touching; head of bolt squeezed up. Plate driven in 0·3″ at bottom in length of 5′ 4″. Elastic washers of three armour-plate bolts slightly compressed.
	710	68-pr.	„	66½	„	...	„	20	nil.	1·75	9·2	...	2·1	...	
	711	110-pr	„	„	„	...	„	10	8 R	1·25	8·2	...	1·45	...	
	712	68-pr.	„	„	„	...	„	20	nil.	1·75	9·3	...	1·85	...	
4	713	110-pr	*	59·937	„	...	„	15	8 R	1·8	8·3	...	1·95	1629·6¶	Struck the lower plate 12″ from top and 9″ from a bolt; one backing bolt at 4′6″ from impact broken.
5	714	5½″ Whitworth gun.	s. s. ‖	69	...	2 6	12	18	nil.	1·3	6·	0·6	1·5	1221·1	Struck the lower plate 8″ from top and 5′ from right side, on a bolt; narrow crack on face of indent; armour-plate bolt driven in ½ an inch; nut on bolt loose; one baulk of timber in backing split through. *The nut was tightened up before next round.*
6	715	7·1″ O.S.C. gun.	„	119	Cylindrical.	2 4	16	18	6 R	1·	8·5 × 8·	...	1·4	1273·3	Struck the lower plate 13″ from bottom and 7″ from a bolt; plate driven back from bolt 0·6″; two backing bolts driven out ¼ inch from skin and their nuts loosened.
7	716	7·″ Whit.	„	149·5	...	5 0‡	23	18	nil.	...	...	...	...	...	Shell burst just in front of gun.
8	717	10·5″ Armstrong gun.	*	150	Spherical. 10·36 diam.	...	35	25	„	...	12·	...	5·2	1567·	Struck the upper plate 6″ from the lower edge on a bolt; plate cracked from bolt-hole to bottom; crack 9″ long on face of indent; crack 10″ long and 1″ wide at 5″ from circumference of indent on right side, also two small cracks from bottom of plate at 5″ and 10″ respectively from left side of circumference; plate driven in 3½″ at lower edge in length of 3′; plate started out 0·3″ at top on left side, and 0·2″ from lower plate. At the back a through armour-plate bolt driven out 2″; the heads of two backing bolts and one rivet broken off; one backing bolt driven out 1¼″; skin bulged slightly over area 1¼′ square.
9	718	„	solid steel shot	165	„ 10·43 diam.	...	„	14	„	§	11·5 × 11 2	...	...	1492·	Struck at the junction of the plates 2′ 3″ to right of last round; shot, a good deal cracked, remained in hole; laminæ of plate separated in two places on edge of hole; part of surface of plate for 1·5″ from edge of circumference of hole scaled off; baulk of timber in backing at bottom of upper plate cracked for 2″ from front. At the back the heads of two through armour-plate bolts broken off; considerable bulge of skin over surface of 3′ square; skin cracked for a length of 8″, width ⅛″; vertical frame-piece and angle-iron cracked through and bent back; one rivet-head off, and one backing-bolt driven out 4 inches.
10	719	„	*	308	Cylindrical.	...	35	20	4 R	1·6	...	...	...	1096·	Struck the upper plate on the third bolt from the right side, lower row; plate driven in 2·1″ at bottom in a length of 5′; a crack 18″ long through a bolt-hole at 2′ from impact, and passing through indent made by No. 711 shot; plate started 0·4″ from the backing on the right side for a length of 2′ at top. At the back one through armour-plate bolt driven out 2″; the heads of four rivets and one backing bolt broken off; vertical frame-piece cracked through, and bent out slightly; beam-knee cracked; skin slightly bulged.
11	720	7″ Whitworth rifled gun.	s. s. ‖	149·5	„	5 8‡	27	18	nil.	§	9·× 8·5	1·5 **	...	1283·4	Struck lower plate; head of shell remained in hole; depth to nearest point of shell 9½ inches. At the back the skin bulged at junction of skin plates, bottom plate 2″, upper plate 1″; rib bulged out 2″ at 2′ from ground; two deck-knees separated from angle-iron 0·3″; one armour plate bolt and three backing-bolts broken; burst in backing.

* Solid cast-iron shot. † Solid cast-iron shot, hollow-headed. ‡ In flannel bag. ‖ Steel shell, no fuze.
§ Through plate. ¶ At 120′. ** 1·5 at top, 0·5 at bottom.

DESPATCH

BY

LIEUTENANT A. F. PICARD, "C" BATTERY, 4TH BRIGADE, R.A., RELATIVE TO AN ENGAGEMENT WITH THE MAORIS, AT RANGARIRI, NEW ZEALAND, ON THE 20TH NOVEMBER, 1863. FORWARDED BY MAJOR H. STROVER, ROYAL ARTILLERY.

[Communicated by the Deputy Adjutant.-General, Royal Artillery.]

QUEEN'S REDOUBT,
NEW ZEALAND,
2nd December, 1863.

SIR,

I have the honor to forward the enclosed Report of the engagement with the Maoris, at Rangariri, New Zealand, on the 20th Nov.; also a plan of the native defences at that position, which I have received from Lieut. A. F. Pickard, "C" Battery, 4th Brigade, Royal Artillery.

I have the honor to be,
Sir,
Your most obedient servant,
H. STROVER,
Capt. R.A. and Brevet-Major.

The Deputy-Adjutant-General,
Royal Artillery.

HEAD QUARTERS, CAMP RANGARIRI,
NEW ZEALAND,
23rd November, 1863.

SIR,

I have the honor to inform you that on the 20th Nov., a detachment of "C" Field Battery, 4th Brigade, Royal Artillery, with two 12-pr. Armstrong guns, and strength as per margin, left Mere-mere Camp, under Captain H. Mercer, Royal Artillery, at 7.30 a.m., according to orders. As it was most important to take as little transport and as few bullocks as possible, no ammunition wagons accompanied the guns, but twenty-four extra rounds for each gun, with cartridges and fuzes, were carried in boxes on the footboards. Each limber also carried eight scaling ladders, placed in such a manner as to counterbalance the extra weight of the footboard boxes on the necks of the bullocks.

1 Captain.
1 Lieutenant.
1 Asst.-Surgeon.
1 Staff Serjeant.
3 Serjeants.
1 Serjeant Artificer.
1 Rank and file artificer.
1 Trumpeter.
43 Gunners.

At about 3 p.m. we arrived in front of the native stronghold of Rangariri, and at once opened fire from a distance of about 600 yards. The position consisted of very strong earthworks, arranged in such a manner that an effectual flanking fire from our guns was impossible.

The Waikato river washed the left flank, and the Waikare lake the right flank of their position. About half-way between these two waters is a rising ground sloping both ways towards the waters.

On the highest point was a kind of small redoubt, and the slopes leading to the water, on either side of this, were lined with rifle-pits, having a parapet behind them running throughout the whole length of the position.

The bursting charges in the 12-pr. Armstrong shell not being sufficiently large to effect a breach by bursting the shells in the parapet, we only fired occasional shells, with time fuzes, to burst short and high, so that the segments and pieces might search the different pits and entrenchments.

The practice was most accurate. When the assault was ordered the rapidity of fire was considerably increased, thus keeping down the fire of the enemy, until the storming party had approached so close to the works that further firing from guns would have been dangerous.

We therefore stopped firing, except at some canoes, in which some of the natives were already trying to escape by the Waikare lake. The storming party succeeded in turning the left flank of the native position, but the Maories successfully resisted every attempt to drive them out of their entrenchments on their right.

At about 5.30 p.m., Captain Mercer received orders to bring thirty men of the detachment under his command (who had been previously armed with revolvers), to storm the pits in which the Maories were still resisting.

We accordingly followed in the track of the storming party, and, coming in rear of the native position, endeavoured, but without effect, to force our way into the pits over the parapet, or to find an entrance to the pits broad enough to admit a storming party.

I regret to state that about this time Captain Mercer was dangerously wounded while at the head of his men. Bombardier Martin, and Gunners Keoan and Culverwell were close behind Captain Mercer, and were shot at the same time from a narrow and partially concealed entrance to the ditch. Gunner Quinn and I, were the only two of the storming party who passed this entrance safely. The place we got to, and where Captain Mercer lay, was fortunately sheltered from the Maories fire, but was crowded to excess by dead, wounded, and living officers and men, of different regiments, who had previously attempted to storm the position.

Assistant-Surgeon Temple, Royal Artillery, seeing Captain Mercer and several other men severely wounded, and without surgical assistance, gallantly ran across the entrance, above mentioned, and rendered every assistance in his power. It being absolutely necessary that this entrance should be filled to allow of the wounded being removed before dark, I left the men to guard the entrance from being rushed by the natives, and having acquainted the General with our situation, returned with a party of sappers, under Captain Brooke, Royal Engineers, to fill up the entrance. This, which was a work of great difficulty, was finished about 10 p.m., when Captain Mercer, and the other wounded officers and men, were removed. Some common shells were thrown by hand amongst the Maories in the ditches and entrenchments by Serjeant M'Kay, and Gunner Francis Green, Royal Artillery, which, by setting fire to their huts, and bursting among them, had the effect of considerably checking the enemy's fire.

During the night a practicable breach was made by the Royal Engineers in the principal part of the entrenchment, but at daylight the natives hoisted a flag of truce, and surrendered unconditionally.

Serjeant-Major Hamilton was wounded in two places whilst we were on the parapet firing amongst the Maories. The native who shot him was killed by Serjeant Hayes, Royal Artillery. Gunner James Bold was wounded while assisting Dr Temple to remove the wounded to the rear.

Gunners Tyler, Halder, and Morrison were of the greatest assistance in filling up the entrance, carrying water, stretchers, &c.

I enclose a list of casualties, and ammunition expended, and will send a plan of the position as soon as possible.

I have the honour to be,
Sir,
Your most obedient servant,

ARTHUR F. PICKARD,
Lieut. 4th Brigade, R.A.

The Officer Commanding
Royal Artillery,
New Zealand.

Description of the Maori position at Rangariri, to accompany the Plan.

The main feature of this line of works is a parapet, varying in height from 10 to 16 ft. from the bottom of the ditch, and in breadth from 4 to 9 ft. at the top.

In front of this parapet, which runs from the Waikare lake on the right, to the Waikato river on the left of the position, is a line of rifle-pits arranged in such a manner as to avoid damage from enfilade fire, and occupying the same relative position to the parapet as the ditch does in ordinary fieldworks.

At about the centre of the line of parapet, and flanking it, was a sort of small redoubt, in which were native huts, loopholed. There were also small parapets and traverses inside, from behind which a large number of men could bring a heavy fire to bear on any party attempting to force a passage by the entrance shown from the rear.

It will be seen from most of the sections through the works, that the pits were in many places arranged in terraces, so that there was often a double line of fire, and sometimes a triple line of fire on the principal lines of approach. The Maories were for the most part armed with double-barreled fowling-pieces, which, being often double-shotted, are a most effectual weapon at short distances.

The parapets were built with layers of fern, similarly to those generally built by the Royal Engineers in this country; with no berm, and in some places revetted with sods, where a sandy soil predominated.

The first storming party got over the parapet near where the line *GH* cuts the left flank of the position, and the Armstrong guns then stopped firing at the works.

Having driven the natives out of the ditch, and from the inner line of defence, crossed by the sectional cutting line *AB*, the flying Maories were pursued in two directions.

First towards the rear, where they took to the swamp and canoes, and many lost their lives while trying to get across the lake, both from the rifles of the infantry, and from the shells from the Armstrong guns.

The other direction taken by the Maories in their retreat was into the small earthwork before mentioned, in the centre of the line of parapets. The entrance to this was partially concealed and very narrow. Several ineffectual attempts were made to follow them into their entrenchment, and the loss of life was here very great.

Meanwhile a party of infantry had got in the ditch at *V*, and ran along it until they arrived at a sort of low traverse at the point *W*, which blocked up the ditch, so as to allow only one man to pass at a time, and who would be exposed to the line of fire from the traversed pits on the right. Several casualties occurred here in attempts to force a passage.

Captain Mercer's storming party endeavoured to force an entrance over the parapet at *Z*, and afterwards to find another entrance towards the entrenchment crossed by the line *EF*.

It was crossing the partially concealed entrance at *V* that Captain Mercer and nearly all the leading files of the storming party were killed or wounded.

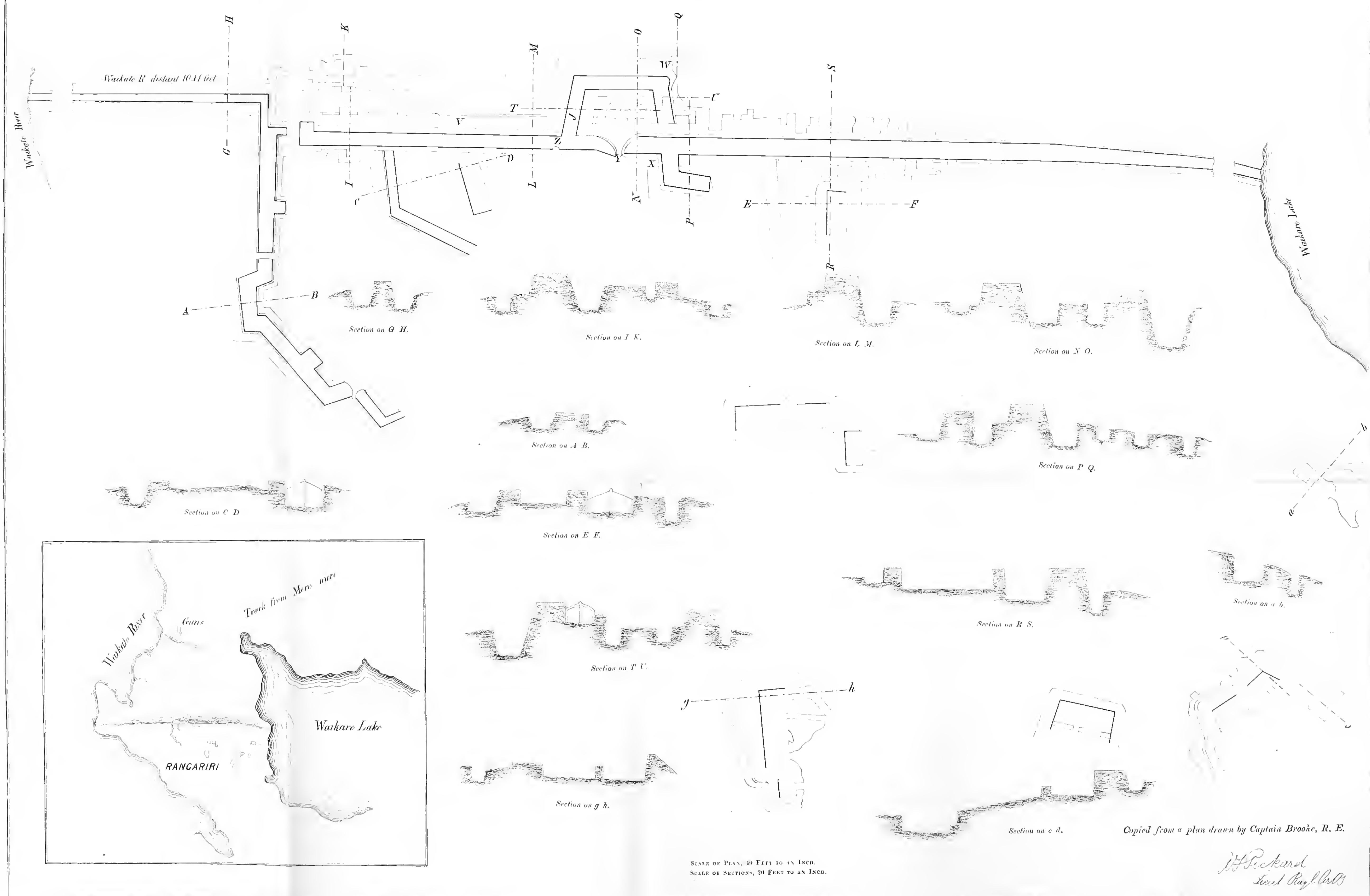
The Navy afterwards tried an attack from the front of the position, but were repulsed. Some common shells, thrown by hand from the rear, set fire to the native huts soon after dark, and the engineers made a breach during the night at the point *J*, but the surrender of the Maories on the following morning put an end to the contest.

It was evident, from the unfinished state of the different parts of the position, that the Maories did not expect an attack so soon.

A. F. PICKARD, Lieut. R.A.

MAORI STRONGHOLD AT RANGARIRI,

Taken by the Troops under Lieut. General Cameron, C.B on the 20th.—21st. November, 1863.



Copied from a plan drawn by Captain Brooke, R. E.

Scale of Plan, 40 Feet to an Inch.
Scale of Sections, 20 Feet to an Inch.

W. H. Pickard
Lieut. Roy. l Art. y

Lithographed at the Royal Artillery Institution

RECENT GUNNERY EXPERIMENTS UPON IRON ARMOUR.

BY CAPTAIN INGLIS, R.E.

[Extracted, with the consent of the Editor, from Vol. XII. of R.E. Corps Papers; and with the permission of the Author].

In last year's volume of these Papers,* when treating the subject of the application of iron to defensive works, I gave a brief account of most of the experiments which had been made, up to June, 1862, upon iron armour.

I propose now to give an outline of the principal experiments made since that time, with a few remarks upon their results.

Minotaur Target. July 7, 1862.

This experiment was made at Shoeburyness to test the merits of the construction adopted in the "Minotaur," and her class of iron clad steam frigates.

In these ships the armour is 5½ in. thick, instead of 4½ in. as in the "Warrior," but the thickness of the teak backing is reduced from 18 in. to 9 in.—9 in. of teak being very nearly equivalent in weight to 1 in. of wrought-iron. The skin and ribs are the same as in the "Warrior."

The target now used was therefore constructed on these principles, and presented a front of three armour plates: one made by Messrs Brown, of Sheffield, measured 12 ft. 6 in. by 3 ft. 4 in.; another, made at the Thames Iron Works, measured 9 ft. by 3 ft. 7 in.; and the third, made by Messrs Beale, measured the same as the first named.

Each plate was secured by three rows of bolts, the upper and lower rows being 1¾ in. diameter, and the middle row 1½ in. diameter; all but a few of the bolts round the port passed through the teak and skin.

The proportion of bolt to surface of the ship's side was as one bolt to about 3½ ft. superficial; and the aggregate sectional area of bolt to a given area of surface was rather greater than in the "Warrior."

There were junction pieces, 1¼ in. thick, at the back of all the joints of the plates.

The guns used against this target were the 12 ton Armstrong muzzle-loading gun, throwing spherical 150 lb. cast-iron and 162 lb. wrought-iron shot, with 50 lb. charges of powder, the former having an initial velocity of 1750 ft., and the latter of about 1700 ft. per second; and a service 68-pr. throwing 67 lb. cast and 71 lb. wrought-iron shot with 16 lbs. of powder—the cast shot having an initial velocity of 1580 ft., the wrought-iron about 1530 ft. per second; all at 200 yds. range.

The first 150 lb. cast shot struck the Thames Iron Company's plate and made a hole about a foot square through the armour and bedded itself deep

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* Vide R.E. Corps Papers, Vol. XI. p. 184.

in the teak. The plate was buckled considerably, several bolts were started, two ribs cracked, and the skin much bulged in: four bolts were broken and a number of rivets.

The second 150 lb. cast shot struck the Sheffield plate, made a hole 13 in. by 12 inches in the armour, and sent pieces of armour plate, shot, and teak, through a large irregular hole in the skin: the armour plate was buckled, three bolts broken, and other damage done.

The third 150 lb. cast shot struck Messrs Beale's plate and did similar injury, making a hole through everything; the diameter of the hole in the armour being about 13 in., and in the skin about 1 ft. 4 in. by 2 ft. 6 in.

The 162 lb. wrought-iron shot stuck in the Thames Company's plate, buckling it and shaking the whole target very much indeed; two ribs were broken and the backing of the target very much displaced and injured. At this round the 12 ton gun burst, the breech being blown out some 30 yds. to the rear, and, but for this, no doubt, the target would have suffered even more severely.

The 71 lb. wrought-iron shot made an indent about ½ in. deep, but neither it nor the 68 lb. cast-iron shot did much other damage: about 750 lbs. weight of shot struck this target.

From this experiment it has been learnt that the powers of resistance of the "Minotaur" are very inferior to those of the "Warrior."

Armour plates protected by a facing of wood and iron. July 31, 1862.

This experiment was made with 68 lb. solid service shot, and 110 lb. Armstrong live shell with a bursting charge of 8½ lbs. of powder, at 200 yds. The facing consisted of an inch plate with a backing of 12 in. of oak. The indentation on the armour made by the solid shot was about one-third of what it would have been without the protection of the facing, but the effect of the live shell in blowing away the facing was so destructive as to render this construction worse than useless, unless considerably modified.

About this time some experiments were made to test the value of compressed millboard as a backing to armour plates in comparison with teak, and the result went to show that, weight for weight, the millboard offers a greater resistance to penetration than teak.

Compressed millboard weighs.........	54 lbs. per cubic foot
Teak	46 lbs. to 50 lbs. ,,

After this, some compound targets, consisting of iron, cork, and india-rubber, and iron, wood, and layers of wire, were tested in comparison with solid wrought-iron plates of equal weight per foot superficial, and failed in establishing any superiority in their resisting powers.

It must be admitted that these experiments were on a very small scale, but the results were too marked to admit of any doubt as to the result in trials on a larger scale.

Horsfall 13-in. gun versus *"Warrior."* Sept. 16 and 25, 1862.

The target used for this experiment was of the "Warrior" construction (10 ft. by 12 ft.) and consisted of three plates, made at the Parkhead forge, all 4½ in. thick, and varying from 12 ft. by 3 ft. to 12 ft. by 3 ft. 4 in.

As compared with the plates used in the original "Warrior" target, their quality was very inferior indeed.

The weight of gun was 24 tons, 3 qrs., 2 lbs.; diameter of bore, 13·014 in.; diameter of shot, 12·8 in.

It was first fired at 200 yds. range, with a solid cast-iron shot weighing 279 lbs., and a charge of powder of 74·40 lbs., which gave an initial velocity of 1630 ft., reduced at 40 yds. to about 1610 ft. per second.

This shot completely pierced the target through and through, making an irregular hole in the armour about 2 ft. square, and cracking but not buckling it: about 3 square feet of the skin were driven in, two ribs were completely smashed, and another one injured, a number of bolts were broken and started, and a quantity of fragments of shot and splinters were sent to the rear.

The effect of this shot was so complete as to render any further experiment at 200 yds. quite unnecessary.

The gun was therefore moved to a range of 800 yds., and a solid shot of annealed cast-iron weighing 285 lbs. was fired at the same target, with the same charge as before, giving a terminal velocity of 1300 ft.

The firing at this range was by no means accurate, so that out of four shot fired on the second day only one gave a result worth recording, and even that grazed 17 yds. short. It however did not lose by this any appreciable velocity or direction, and struck the target in the junction of two plates, breaking a large hole about 2 ft. square through the armour and burying itself in the timber backing. By this blow two ribs were broken through, and the skin considerably bulged, several bolts were broken and rivets driven out.

To show the inferior quality of the iron in these armour plates, a service cast-iron 68-pr. shot was fired at it, and it had the effect of making an indent of upwards of 4 in. deep, with a number of cracks in and around it. The indent made by a similar shot on the original "Warrior" target was little more than 2 in. deep.

The lesson learned then from these experiments seems to be this:—That, at 200 yds. the real "Warrior" ship would be completely pierced by the Horsfall shot; but that at 800 yds., although inflicting very severe injuries upon her, the skin would not be penetrated by an individual shot.

It may be worth noting that previous to these trials some serious looking flaws existed in the bore of this gun, but they underwent little or no apparent change during the five rounds fired from it.

Penetration of Whitworth projectiles. Sept. 16 and 25, 1862.

These interesting trials were made with a 12-pr. breech-loader, $9\frac{3}{4}$ cwt.; a 70-pr. muzzle-loader, 76 cwt. 2 qrs. 14 lbs.; and a 120-pr. muzzle-loader, 148 cwt. 3 qrs., all Whitworth guns.

The 12-pr. was fired at 200 yds. with a solid, homogeneous metal, cylindrical, flat-ended shot, weighing 12 lbs. 1 oz., and with a charge of 1 lb. 14 oz. of powder (giving an initial velocity of about 1360 ft.), against a $2\frac{1}{2}$ in. plate without backing, through which it made a clean hole and fell 20 yds. to the rear.

This gun was next fired at the same range, with a shell of homogeneous metal weighing 12 lbs. 2½ oz., with a charge of 1 lb. 14 oz., and a bursting charge of 6 oz., but no fuze, against a 2-in. plate, with a backing of 12 in. of timber; it passed through both plate and backing and buried itself in the earth beyond; there was however no appearance of the shell having burst in passing through the plate.

It may be well here to explain, that the explosion of these shells without fuzes was supposed by Mr Whitworth to be due to the heat generated in the metal of the projectile on impact, he having specially constructed them with that view, and having also provided an arrangement of flannels covering the bursting charges by which he could govern the time of explosion; but whether the heat was thus generated, or whether it was due to the violent friction of the particles of powder among themselves or against other substances, or the sudden loss of velocity in the projectile, appears a fair matter of doubt. Be this as it may, he certainly obtained some very satisfactory, and, at that time, unprecedented results.

The next gun fired was the 70-pr., with a charge of 12 lbs. of powder, at 200 yards, and with a shell formed of similar material to the others, weighing 69 lbs., having a bursting charge of 2 lbs. 6 oz., but without a fuze. The initial velocity of this shell was 1275 ft., and the loss of velocity in 40 yards, about 10 ft. per second.

The target used on this occasion was made in the form of a box, with the object of putting to the test Mr Whitworth's boast, that he could drive a shell through the side of an armour clad ship and make it burst between decks. The front of the box was made of 4-in. armour on a 9-in. backing of timber; the back of the box was of 2-in. armour plate on 4-in. of wood, and its sides were of 4-in. timber, the cubical contents of the box being about 35 ft.

The shell fired on this occasion, with an initial velocity of 1275 ft., passed completely through the 4-in armour plate and its oak backing, and exploded on the rear side of the box, the plate of which was indented 2½ in., bursting the box and blowing all six sides outwards.

The great success of this and the 12-pr. shell must of course be mainly attributed to the superior quality of metal in the shell, which admitted of its passing through so great a thickness of iron unbroken; previous experience having presented no instance of a shell passing through even 1 in. of iron without breaking up, and 2 in. of iron having hitherto broken even solid shot of steel.

Soon after this Mr Whitworth followed up these experiments on a larger and more important scale by practice with the 120-pr., at 600 yards, against the new "Warrior" target.

In this trial a solid homogeneous metal shot, weighing 129 lbs., was fired with a 23 lb. charge of powder, giving a striking velocity of about 1280 ft., and punched a clean hole through the 4½-in. armour, lodging itself in the timber backing against the skin, which was a good deal injured; a rib previously cracked by the Horsefall gun was now completely broken in two, and some bolts gave way.

A shell of homogeneous metal, weighing 127 lbs., with a bursting charge of 3 lbs. 8 oz., and without a fuze, was next fired at the same range with a charge of 25 lbs. of powder, giving a terminal velocity of about 1263 ft.

This shell went completely through every thing, much to the astonishment of every one present. It apparently penetrated the armour without breaking up, and burst when in the act of passing through the timber backing, most likely when approaching the skin, as the diameter of the hole in the skin was not more than 13 in., and the injury to the skin was confined to this hole. Portions of the shell and the piece of armour punched out by it were picked up at the back of the target; the timber backing was of course very much shattered, and one rib broken.

Looking at the completeness of the penetration in this instance it may be fairly inferred that this shell would have gone clean through this target at any range up to as much as 1000 yards; but it does not follow, nor do subsequent experiments prove, that it would have done the same to a target composed of armour equal in quality to that upon the real "Warrior" ship.

Whitworth Projectiles. 13th and 14th Nov. 1862.

These experiments were made in continuation of those last recorded, and with the same guns, under the following circumstances:—

A box target, presenting a front measuring 12 ft. by 9 ft. 6 in., and having an interior cubical space of 435 ft., was constructed for the purpose.

The front was a target composed of three armour plates on backing, skin, and ribs exactly representing the backing, skin, and ribs of the "Warrior." The upper plate was 4½ in., and was one of those which had been used on the original "Warrior" target; therefore this portion corresponded in every respect with a ship of that class. The two lower plates were 5 in. thick, taken from the Samuda target, and therefore represented a ship's side stronger and heavier than that of the "Warrior" by the difference between ½ in. of iron and ½ in. of teak, or about 18 lbs. per foot superficial.

The box was placed in front of the old Committee target, which therefore formed its back, while the two sides, the roof, and floor, were composed of 12-in. timbers, strongly bolted and secured.

The principal object of the trial was to mark the effect of the Whitworth homogeneous metal shells constructed so as to be capable of holding larger bursting charges than those used in September, and also to correct any false impressions caused by the very inferior quality of iron in the "Warrior" target used on those occasions.

Two flat-headed shells of homogeneous metal, weighing 151 lbs. each, with a bursting charge of 5 lbs., without fuzes, fired at a range of 800 yards, with a charge of 27 lbs. of powder, giving a velocity at 780 yards of 1175 ft., penetrated into the box; the one having punched a hole through the 4½-in. plate, the other through the 5-in. plate. In each case they made a hole of 10 in. diameter in the skin, carrying some splinters and fragments into what may be called the between decks. In the first instance the shell burst, evidently when passing through the timber backing, or rather too soon. In the second, it exploded rather later and did somewhat more execution; but the effect, in both cases, resembled that of a solid shot penetrating the target more than that of a live shell.

A hollow cast-iron flat-headed shot, weighing 130 lbs., next struck one of the 5-in. plates, at a velocity of 1200 ft., and made an indent of 2·3 in., breaking one rib and injuring some bolts and rivets. The shot of course broke up, and showed the great superiority over ordinary cast-iron of the metal used for projectiles by Mr Whitworth.

A flat-headed shell of homogeneous metal, weighing 130 lbs., with a bursting charge of 9 lbs. 8 oz., was also fired from the same gun, and struck a 5-in. plate, at a velocity of 1240 ft. It punched a hole through the armour, and burst in breaking through the skin, in which it made a large irregular hole, carrying on some splinters and fragments of plate, skin, rivets, bolt heads, &c.

A solid 130-lb. shot of the same metal and form from this gun, at a velocity of about 1200 ft., struck a 5-in. plate and went clean through the target, carrying a quantity of fragments into the box.

The range at which the above were fired was 800 yards.

The 70-pr. gun was next fired at the same target at 600 yards. A shell of homogeneous metal, weighing 81 lbs., fired with a charge of 13 lbs., and having a bursting charge of 3 lbs. 12 oz., struck a $4\frac{1}{2}$-in. plate at a velocity of 1100 ft., and penetrated it, afterwards bursting in the teak backing which it injured very much. The skin was not penetrated.

Another shell of the same kind burst immediately on striking a 5-in plate, in which it punched a hole $4\frac{1}{3}$ in. deep, but had no effect on the inside of the target.

Another shell, weighing $72\frac{1}{2}$ lbs., with a bursting charge of 2 lbs. 10 oz., penetrated a $4\frac{1}{2}$-in. armour plate, and burst in the wood backing, but did no damage to the skin; and a blind shell, weighing 70 lbs., striking with a velocity of 1140 ft., broke to pieces on a 5-in. plate, after making an indent of $1\frac{1}{2}$ in.

All these projectiles were of homogeneous metal and flat-headed.

The general result of these experiments may be summed up in a few words. Mr Whitworth has, by the use of a superior metal, produced shells which will penetrate, without breaking up, as much as 5 inches of armour and burst afterwards; but with ships of the "Warrior" class, these shells would have no great effect in board, as, although the skin is broken through by the explosion of the shells, in no case have they been made to pass through the skin before explosion.

Whitworth Projectiles at Sloping Plates. Nov. 1862.

In this trial some cylindrical flat-headed 12-pr. shot, and blind shell of homogeneous metal and of common cast-iron, were fired at a range of 200 yards at $2\frac{1}{2}$-in. plates, sloping back at an angle of 45°, the charge used being $1\frac{3}{4}$ lbs.

It is almost needless to say that the cast-iron shot broke up and only made a slight indent.

The homogeneous metal shell and shot completely penetrated the plates and were almost uninjured themselves.

It is interesting to notice here that the fragments of the cast-iron shot, when picked up afterwards, were too hot to be handled, while the homogeneous metal projectiles were quite cool.

Effect of shot varying in weight and velocity, but with equal vis viva.

The object of this experiment was to ascertain the difference of effect between cast-iron shot from 68-prs. and 110-prs., striking iron plates at such velocities as would make Wv^2 equal in each case.

For this purpose the following were used:—

The 68-pr. threw a 66-lb. shot, with a charge of 16 lbs. of powder, at a velocity, at 200 yards, of 1367 ft.

The 110-pr. threw a shot of 110½ lbs., with a charge of 11½ lbs., at a velocity of 1056 ft., and the same gun threw a shot of 200 lbs., with a charge of 11 lbs., at a velocity of 786 ft.

The plates fired at were 3-in., 3½-in., 4½-in., and 5½-in.

It was difficult to mark the general result of this experiment, but the deepest indent was decidedly made by the 68-pr., and the least indent by the 200-lb. shot; all the shot of course broke up, and, but for the difference of work thus consumed, there is little room to doubt that the total effect produced upon the plates would have been equal for all three shot, local and clearly marked with the lighter shot and higher velocity, more general and less defined with the other shot, but, as is stated above, the result was somewhat obscure.

Armstrong shot of various weights against iron plates. Nov. 14, 1862.

The 110-pr. Armstrong gun was made to fire on this occasion lighter shot than its proper projectiles at higher velocities, and, of course, with increased charges of powder. The range was 200 yards, and the plates were 4½ in. and 5 in. thick.

The comparison made was between the service 68-pr., throwing spherical cast-iron shot at a velocity of 1367 ft., and an Armstrong 110-pr. throwing cylindrical cast-iron shot varying from 60 lbs. to 68 lbs., at velocities ranging between 1580 and 1475 ft.

The result of this was that the indent made by the 68-pr. service gun was 2 in. deep, and that by the Armstrong gun from 2½ to 3 in. deep, and the damage altogether appeared to be in the same proportion, which corresponds pretty nearly with the relative values of Wv^2 in the different shot.

Whitworth and Armstrong 12 *lb. steel shot.* Nov. 1862.

This comparative trial was made with 12-pr. breech-loading rifle guns, against a target covered with 4½-in. armour, at 100 yards. The shot were of steel, charge of powder, 2 lbs. One of the Armstrong round-headed shot made an indent rather more than 2 in. deep, and a flat-headed one made an indent of 1 in.; the former was slightly broken, the latter only set up.

The Whitworth made an indent of 1·4 in. and broke up.

Projectiles of various forms and qualities of metal. Dec. 1862.

At this time several cast-steel shot, and shot made of other patented materials, were tried, with a view to determine the best form and material for projectiles intended to penetrate iron plates.

Some were tried with flat ends, some with flat ends in steps, some with conical ends, and others slightly concave in front.

On the whole the conical end answered best, and the steel manufactured by Messrs Makin, of the Attercliffe Works, Sheffield, gave highly satisfactory results.

Armour plates suddenly cooled. Dec. 1862.

This experiment was made to set at rest a question which had been much disputed, and upon which there had been some contradictory results in former trials. The plates used were $4\frac{1}{2}$-in., made by Messrs Beale, of Rotherham, and had been rapidly cooled down from a high temperature by sudden immersion in cold water; they were tried by 68-prs. and 110-prs., in comparison with plates manufactured by the same firm in the ordinary manner.

The indents made on the cooled plate were about twice as deep as those on the ordinary plate, and altogether no advantage seemed to be gained by the cooling process.

Second casemate shield of my own construction. Dec. 29, 1862.

In the Paper in Vol. XI., before referred to,* a short account is given of the trial of the first shield proposed by myself, and the Committee on Iron having formed a favourable opinion of the results then gained, recommended further trial of the principle.

Accordingly, a new shield was made of which the following is a description:—

It measured 11 ft. in length, by 8 ft. 2 in. in height, and contained an embrasure 3 ft. 6 in. high and 2 ft. 4 in. wide.

It was composed of vertical face planks of hammered iron of various sections, namely, 23 in. by 8 in., 23 in. by 7 in., $19\frac{1}{4}$ in. by 8 in., $19\frac{1}{4}$ in. by 7 in., and $19\frac{1}{4}$ in. by 6 in.; these were backed by horizontal planks of rolled iron 14 in. by 5 in., and secured by 3-in. screw bolts and rivets to a framework in the rear. This framework consisted of four vertical pieces 14 in. by 4 in., and two horizontal pieces 14 in. by 5 in., and the whole was supported at either end by a boiler plate diagonal strut having a base of 3 ft., and made up of a web of 1-in. plate, and angle iron stiffening pieces 8 in. by 5 in. by 1 in., and 5 in. by 5 in. by 1 in.

These struts were secured to sill pieces 14 in. by 4 in., running front and rear, and these again secured to a cross beam 18 ft. long, 11 in. wide, and 3 in. deep, placed 6 ft. in rear of the shield.

This beam was heavily weighted, and secured at each end in a mass of masonry in precisely the same manner as it would be in the real piers of a fort, and formed the sole means of holding the shield in its place.

One half of the target was made to represent half of a shield 12 ft. wide, and the other half, one 10 ft. wide.

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* Vide p. 37.

At the end, representing the 10-ft. shield, the strut, being brought nearer to the embrasure than the other one, was splayed outwards at an angle of 15° from the perpendicular, as this would be necessary in actual practice to admit of the gun being traversed through an arc of 70°. The other strut stood perpendicular to the shield.

Between the surfaces of the front and rear planks, sheet lead, weighing 6 lbs. per foot superficial, was introduced to check vibration in the mass; and under the nuts of the screw bolts elastic washers of various descriptions were used. Some of these washers were of the nature of buffers, composed of 3 in. of india-rubber inside a strong wrought-iron cylinder; others were of coils of wire-rope similarly confined; and in other cases several lead washers, and washers of iron and brass were used.

The shield was made by the Millwall Iron Company.

For this experimental work it was of course out of the question to go to the expense of providing rolls for producing all the various sections of planks used in it, and therefore hammered iron had to be adopted for the face planks, yet the shield is designed with the special view of using rolled iron throughout in actual practice; and as upon this depends very much the expense of the structure, it is important that it should be mentioned here.

The following guns were used on the first day's trial:—

One 120-pr. Whitworth rifled gun.
One 110-pr. Armstrong „ „
One 68-pr. Service smooth-bore gun.

Range 200 yards.

Twelve shot from these guns struck the shield fair, namely:—

From the 120-pr. { One round-ended cast-iron shot, 119·5 lbs.
One flat-ended homogeneous metal shot, 130 lbs.

From the 110-pr. { Three cast-iron solid shot, 110 lbs. each.
Two „ „ 68 lbs. „

From the 68-pr.—Five cast-iron solid shot, 67 lbs. each.

In all, 1050 lbs. weight of shot struck the shield on this first day's trial.

The effects produced were highly satisfactory.

The indents made by the 68 lb. and 110 lb. solid shot from the 68-pr. smooth-bore and Armstrong guns varied from 1·15 in. to 1·6 in.; those made by the 68 lb. shot from the 110-pr. were 2·3 in. and 2 in. respectively; and the indents of the Whitworth shot were 1·8 inch in the case of the cast-iron, and 2 inch in the case of the homogeneous metal, which latter shot broke up.

With the exception of one small crack in a 7 in. plank, where a shot had struck near its edge, the shield was really none the worse for the day's firing.

The lead between the planks was squeezed out a good deal under some of the blows, some of the lead washers were flattened, and other minor effects were visible, but nothing to render the shield at all unserviceable.

Such being the case, it was determined to reserve it for the Armstrong 300 lb. rifle projectiles, and a batch of other monster guns soon expected to be ready.

Further trial of my second casemate shield. March 3, 1863.

The guns placed in position at 200 yds. in front of this shield for its further trial, consisted of four of the most formidable pieces of ordnance ever before brought together in a battery.

They were as follows:—

One 300-pr. Armstrong muzzle-loading 10 grooved shunt gun, weighing $11\frac{3}{4}$ tons, calibre, 10·48 in.

One 7-in. 130-pr. Whitworth rifled gun, weighing $7\frac{1}{2}$ tons.

One 7-in. Lynall Thomas rifled gun, weighing $7\frac{1}{2}$ tons.

One 9-in. Armstrong muzzle-loading smooth-bore gun, weighing 6 tons.

The first shot fired was from the Whitworth rifled gun. It was of Frith's steel, solid of course and flat-headed, weighing 148 lbs., length of shot, 17·3 in.; charge of powder, 25 lbs.; velocity, at 12 yds. short of the shield, 1240 ft. per second.

The accumulated work in this shot on striking or $\frac{W_v^2}{2g}$ was 35,557 lbs., or, in other words, sufficient to raise about 1587 tons 1 ft. high.

It struck on the joint of an 8-in. and 7-in. plank, and stuck there; two very small cracks appeared in the planks, and at the back of the shield a very slight bulge of less than $\frac{1}{2}$-in. might be detected, a little of the sheet lead was also squeezed out, but no injury of any consequence appeared.

The shot which thus adhered to the face of the shield was subsequently got out by means of heavy sledges, and the indent made was found to be only from $2\frac{1}{4}$-in. to $3\frac{3}{4}$-in. deep; the impression made is a very remarkable one, and testifies to the superiority of the metal of the shield and the wonderful hardness as well as tenacity of the metal of the shot. The effects of this blow, and of a subsequent one soon to be described, are interesting, as they exhibit with an unusual distinctness the work done by the shot during its action upon the shield, and no doubt a very large part of the work accumulated in the shot on impact could be accounted for in the effects produced upon the shield.

After this, the 9-in. smooth-bore Armstrong gun was fired. The shot was of wrought-iron, spherical, weighing 102 lbs., charge of powder 25 lbs., velocity, at 12 yds. short of the shield, 1461 ft. per second.

The accumulated work on striking or $\frac{W_v^2}{2g} = 1537$ tons raised 1 ft. high.

It struck close to the edge of a 6-in. plank, and a bolt, with lead and iron washers, distant about 3 ft. from the point of impact, was broken; also one of the horizontal backing pieces was cracked through in a vertical direction, and one of the vertical frame pieces slightly curved.

The indent made by this shot was 2·4 in. deep, and in diameter from 10·4 to 11·3 in.

The next shot was from the 300-pr. shunt gun; it was of cast-iron, cylindrical, with a hollow hemispherical head, and weighed 230 lbs.; length of projectile, 19 in.; charge of powder, 45 lbs.; velocity, at 12 yds. short of the shield, 1400 ft. per second.

Accumulated work on striking or $\frac{Wv^2}{2g}$ = 3145 tons raised 1 ft. high.

This shot struck on an 8-in. plank, and made an indent of 1·45 in. deep, and 9·5 to 10 inch in diameter. The plank was cracked through the indent, and at another place distant from the point of impact, two bolts were broken and two or three others more or less injured. Some other minor injuries were inflicted but nothing of a serious character.

The Lynall Thomas gun was next fired; the projectile was of wrought-iron, cylindrical, with a round head, weighing 151 lbs. Its length was 16½ in. The charge of powder was 25 lbs., and the velocity at 12 yds. in front of the shield was 1215 ft. per second.

The accumulated work on striking or $\frac{Wv^2}{2g}$ = 1547 tons raised 1 ft. high.

It struck a 7-in. plank within 5 in. of its edge, making an indent 1·8 in. deep, and 7½ in. to 8 inches in diameter; the plank was cracked through a bolt hole rather more than a foot from the point of impact, and at another bolt hole about 18 in. below the point of impact.

The shield seemed to be generally shaken, though not materially so, and little or no further injury appeared at the back.

The next round was from the 7-in. Whitworth, with the same shot and charge as the first round.

This shot struck an 8-in. plank, and broke up, but a large portion of it remained imbedded in the face of the plank. When subsequently removed, this indent was found to be from 2½ to 3 in. deep, or rather less than on the other occasion before described; two bolts were broken, and some minor injuries received elsewhere, but nothing worth speaking of.

After this the 300-pr. shunt gun was again fired, the shot this time weighing 307 lbs.: it was of cast-iron, cylindrical, with a round end, 18½ in. long. It was fired with a charge of 45 lbs. of powder, and at 12 yds. in front of the shield had a velocity of 1225 ft. per second.

The accumulated work on striking or $\frac{Wv^2}{2g}$ = 3186 tons raised 1 ft. high.

This shot struck at the joint of an 8-in. and 7-in. plank, and of course broke up. It made an indent varying from 1·3 in. to 2 inches in depth, broke a bolt, and enlarged some cracks previously made. The shield showed general symptoms of having been shaken by this terrific blow, but on the whole bore it remarkably well.

The Lynall Thomas gun was next fired with a solid steel shot weighing 138 lbs., and a charge of 27½ lbs. of powder, but the gun burst, and the shot did not hit the shield.

After the success of this day it was deemed proper to reserve the shield for further experiments proposed in connection with a masonry casemate about to be erected at Shoeburyness, by which arrangement the Armstrong 600-pr. lately mounted there, will probably be brought against it.

The chief lesson to be learnt from this experiment is that,—given a big gun, a shield of wrought-iron can be made that shall resist it, and that being decided, the problem narrows itself into a simple enquiry as to how the necessary resistance can be obtained at the least cost.

It would be too much of course to say that the principle here tried fulfils these conditions better than any other that can be invented, but that it fulfils them better than any other that has yet been tried, all that witnessed the experiment admitted beyond question.

Numerous modifications and alterations to meet the various conditions of strength and resistance necessary in different works have been drawn up since this experiment took place, but it seems hardly desirable or possible to describe them now.

It is enough to say that the very simplicity of the principle makes it easy to adapt it to almost all circumstances, whether it be for the purpose of filling the front of a casemate, or for a small embrasure only, or for constructing a work of iron altogether, or for covering a masonry wall.

To all of them the principle is applicable, and it only requires to be treated with a little practical skill in its development.

Trial of thick Armour. March 17, 1863.

This experiment was made to test the resistance offered by some rolled armour plates, $5\frac{1}{2}$ in., $6\frac{1}{2}$ in., and $7\frac{1}{2}$ in. thick, manufactured by Messrs John Brown and Co., of Sheffield.

The plates were of the following dimensions:—

One 13 ft. $4\frac{1}{2}$ in., by 3 ft. 7 in., and $5\frac{1}{2}$ in. thick.
One 12 ft. $2\frac{3}{4}$ in., by 3 ft. $7\frac{1}{2}$ in., and $6\frac{1}{2}$ in. „
One 11 ft. 9 in., by 3 ft. $8\frac{1}{2}$ in., and $7\frac{1}{2}$ in. „

They were secured by $2\frac{1}{2}$-in. screw bolts, to the skin and frame of Mr Samuda's old target; one half of each plate had a backing of from 7 to 9 in. of teak, and at the back of the other half, it was left hollow for an equal interval between the plates and the skin. India-rubber washers were used under the nuts.

The guns in position for this trial were—

One 300-pr. Armstrong muzzle-loading shunt gun.
One 9-in. Lynall Thomas gun.
One 7-in. Whitworth rifle gun.
One 110-pr. Armstrong breech-loader.
One 68-pr. service 95-cwt. gun.

All were fired at a range of 200 yds.

The first three shots (all cast-iron) were fired from the 68-pr., one shot struck each plate and made indents $1\frac{1}{2}$ in. deep in the $6\frac{1}{2}$-in. and $7\frac{1}{2}$-in. plates, and 2 in. deep in the $5\frac{1}{2}$-in. plate.

These were followed by three shots from the 110-pr., also of cast-iron; the indent upon the $5\frac{1}{2}$-in. plate was 1·9 in. deep, that upon the $6\frac{1}{2}$ was 2·05 in. deep, that upon the $7\frac{1}{2}$ was 1·65 in. deep. There was scarcely any other effect visible.

The next shot was from the Armstrong 300-pr., with a cylindrical steel shot weighing 301 lbs., and fired with a 45 lb. charge of powder. This shot had a velocity of 1295 ft. per second at 30 yards in front of the target, and struck the $7\frac{1}{2}$-in. plate, where it had the teak backing. The indent made was 6·2 in. deep, and its diameter about 12 in., or rather a circular piece of this diameter was driven in to a depth of 6·2 in., and nearly, if not quite, separated from the plate, which was of very good quality. There is therefore here a well defined measure of the full force of this shot. Besides this local effect, the target had evidently received a serious shake: one rib was cracked through and bent out, a number of small rivets were broken; the plate struck was buckled about $1\frac{1}{2}$ in. and slightly cracked. The shot which rebounded from the target was set up about $2\frac{1}{2}$ in., and was of excellent material.

A cylindrical steel shell, with a cast-iron head, made on a principle designed by Sir William Armstrong, for the purpose of penetrating iron plates by directing the force of the explosion of the bursting charge *forward*, was next fired from the same gun. It weighed 288 lbs., had a bursting charge of 11 lbs., and was fired with a charge of 45 lbs. of powder, which gave, at 25 yards in front of the target, a velocity of 1320 ft. per second. It struck the $5\frac{1}{2}$ in. plate on a part supported by the teak backing. It completely penetrated the armour plate, leaving a hole about 14 inches in diameter, burst in the teak backing, tearing away the inner skin and breaking a rib, and carried a shower of fragments and splinters in board. The teak was set on fire by the explosion but easily extinguished, one bolt was broken, and other injuries done.

Altogether, for completeness of penetration and for the destructive effects which would have been produced both upon the ship and crew, this experiment carries with it great significance.

After this, a cylindrical flat-headed homogeneous metal shell, weighing 148 lbs., with a bursting charge of 5 lbs. 12 oz., was fired from the Whitworth 7-in. gun, with a charge of 25 lbs. of powder, which gave a velocity, at 30 yards in front of the target, of 1265 ft. per second. This shell struck the $5\frac{1}{2}$-in. plate near the hole made by the last Armstrong shell, punched out a clean cut hole about 9 inches in diameter, and burst in the teak backing; beyond blowing out some of the timber, it added very little indeed to the injury done by the Armstrong shell.

Lynall Thomas' 9-in. gun next missed the target with a round-headed solid steel shot, weighing 327 lbs., fired with a charge of 50 lbs. of powder, which, at 546 ft. from the gun, gave a velocity of 1220 ft. per second.

The same gun next fired a wrought-iron solid flat-headed shot, weighing 302 lbs., with a charge of 50 lbs. of powder; the velocity of this shot was not obtained with certainty, it struck partly on the $6\frac{1}{2}$-in. and partly on the $7\frac{1}{2}$-in. armour; the greatest depth of impression on the latter plate was 6 in., and on the former 4 in. The $7\frac{1}{2}$-in. plate was cracked through a bolt hole and round the indent, as was also the $6\frac{1}{2}$-in. plate; but, altogether, the injury done was less than had been expected.

A hardened steel shot was next fired from the same gun; it weighed 330 lbs., was round-headed, was fired with a charge of 50 lbs. of powder, which gave a velocity of 1220 ft. per second at 25 yds. in front of the target. It struck close to the lower edge of the $7\frac{1}{2}$-in. plate, and made an irregular indentation measuring about 1 ft. by 1 ft. 8 in., and 7 in. deep; two bolts were broken, one rib broken through, two others much bent, and the skin bulged in. The shot itself broke in half lengthways.

After this the 300-pr. Armstrong shunt gun fired a spherical wrought-iron solid shot, weighing 163 lbs., with a charge of 45 lbs., which, at 30 yards in front of the target, gave a velocity of 1630 ft. per second. It struck the $7\frac{1}{2}$-in. plate where it had no teak backing, and made an indent $3\frac{3}{4}$ in. deep, and 13 inches in diameter, with a crack on the face of the indent; the plate was considerably bulged in, and at the back it showed a large starred crack. The shot was flattened out to a diameter of 13 in.

The material of which these armour plates was made proved itself to be of uniform and excellent quality.

The practical lessons to be learnt from this day's experiments seem to be these:—

1st. That guns are already in existence which can completely penetrate with shot the best $7\frac{1}{2}$-in. armour that can be made, and which can, with shell, pierce the sides of a ship built, as to frame, much more strongly than our best ship, and protected with our best $5\frac{1}{2}$-in. armour.

2nd. That iron plates can now, with the improved manufacture of the country and the energy brought out by the occasion, be made of dimensions hitherto quite unattainable, and yet without losing anything in quality.

Chalmers' target. April 27, 1863.

The next experiment of any importance was made at Shoeburyness to test the merits of a principle of construction proposed by Mr Chalmers for iron-clad ships of war.

The chief features of the system advocated by this gentleman (and with such confidence that he made the target to test its value at his own expense, a thing not thought of in recent times by any other inventor), may be thus described:—

The ribs and skin constituting the frame of the ship are very similar to those of the "Warrior," and the difference consequently lies in the external protection; this, instead of being obtained by armour in one thickness with a simple backing of teak, as in all the ships yet building or afloat, is composed as follows: first, he presents to the shot an armour plate $3\frac{3}{4}$ in. thick, of hammered iron, which is backed by a compound mass of iron and teak 10 in. thick; this backing is made up of alternate timbers 10 in. by 5 in., and wrought-iron ribs 10 in. by $\frac{7}{16}$ in., laid horizontally, and bolted together at frequent intervals by vertical screw bolts of 1 in. diameter. This compound backing is supported in rear by, and attached to, a plate $1\frac{1}{4}$ inch in thickness, this being called an intermediate or second armour plate; and the intermediate armour is again backed by a thickness of 5 in. of teak to form a cushion, behind which come the skin and ribs before described as being similar to the "Warrior's." The armour is held on by $2\frac{1}{4}$-in. screw bolts formed with a peculiarly shaped stepped head, instead of the usual conical form, and nutted at the back of the skin.

Thus the side consists, exclusive of skin and ribs, of 5 in. of armour and 15 in. of backing (10 in. of which is a compound of iron and teak), against

$4\frac{1}{2}$ in. of armour and 18 in. of teak in the "Warrior," and this difference accounts as nearly as possible for this structure weighing about 20 lbs. per foot superficial heavier than the "Warrior."

The object aimed at by the inventor was to give a better support to the outside armour than is afforded by timber only, and at the same time to avoid rigidity of structure which he considers so destructive to both armour plates and fastenings.

The target for this experiment presented a front measuring 13 ft. 4 in. by 10 ft. high; and to give it support equivalent to what it would receive from adjacent parts, if forming part of a large structure, it was surrounded on all sides by a casing of boiler plate, which, if included in the weight of the target, would add about 48 lbs. per foot superficial to the weight already given.

It is not necessary here to describe minutely the practice at this target. It will be sufficient to say that it was carried on by 68-pr. service guns and 110-pr. Armstrongs, at 200 yards, firing first with shells filled with sand, then with live shells, then with solid cast-iron shot, then with 200-lb. bolts from 110-prs., first singly and afterwards in a salvo of three, in one instance a salvo of five guns being fired against it; the object of the experiment being to give this target a battering as nearly as possible equal to that received by the original "Warrior" on its first trial.

After this the Armstrong 12-ton gun fired two spherical cast-iron shot and one cylindrical steel shot; but this last shot bore no part in the comparison with the "Warrior," as that target was never struck by a *steel* 300-lb. shot.

The shells filled with sand did of course little or no damage beyond the usual marks on the armour: in the case of the 110-pr. about $\frac{1}{2}$-in. deep, and of the 68-pr. about $1\frac{1}{4}$-in. deep.

The live shells did much the same.

The 68-pr. cast-iron shot indented the armour about one-third more than the "Warrior," the depth of the impression itself being about $2\frac{1}{2}$ in., and of the more extended bulge about 1 in. more.

The 110-pr. cast-iron shot also indented altogether from $2\frac{1}{2}$ to $3\frac{1}{2}$ in., including some local bulging, the depth of the impressions themselves being from $1\frac{1}{4}$ in. to $1\frac{3}{4}$ in. deep, or about twice as much as in the "Warrior."

A few rivet heads were broken off by these shot and the plates were cracked slightly, especially the lower one, which was of inferior manufacture, but no bolt was broken, and the plates were only slightly displaced.

The salvo from the three 110-prs., throwing 200-lb. cast-iron shot, did little damage.

That from the two 68-prs. and three 110-prs. did somewhat more injury, but still the target stood remarkably well; the first through-bolt broken occurred in this salvo. At the rear some of the ribs were slightly buckled and slight curvatures appeared, but nothing whatever of any consequence.

After this the 300-lb. steel, cylindrical, round-headed Armstrong shot, fired with 45 lbs. of powder, struck at the junction of two plates, and completely penetrated the target, making a hole in the armour of about 1 ft. 2 in. by 1 ft. 1 in. The hole in the skin measured about 2 ft. by 1 ft. 6 in.; one rib was smashed and a quantity of fragments were carried through to the rear.

One 150-lb. cast-iron spherical shot from the Armstrong 12-ton ($10\frac{1}{2}$-in.) gun, fired with a 50-lb. charge, struck on the junction of two plates, just as a similar shot fired with a 40-lb. charge did on the "Warrior:" it made a hole in the armour of about 1 ft. 2 in. by 11 in., and buried itself about 1 ft. deep in the backing, bulging the skin considerably and slightly opening it in one place; two through-bolts were broken and other minor injuries done.

Altogether it may be said that about the same injury was done to this target by the 300-lb. shot as was done to the "Warrior" by the same shot.

Another 300-lb. shot did much the same damage.

The result of this experiment appears to be—that Mr Chalmers' compound backing is superior, as a support, to the simple backing of timber, and although his $3\frac{3}{4}$-in. armour plates were more injured than those of the "Warrior," yet, on the whole, his target resisted better than that target.

Whether or not the advantage was in a greater degree than is due to the excess of weight over the "Warrior," or whether it is at all due to the peculiar distribution of the armour in two thicknesses, are fair subjects for question. To decide these there should now be made a target, similar in every respect to the original "Warrior," only instead of the simple teak backing 18 in. thick, the $4\frac{1}{2}$-in. armour should have a compound backing about 10-in. thick, with an elastic cushion for the compound backing to bear upon.

Clark's target. July 7, 1863.

This target was constructed to test a system of naval armour, with compound dovetail fastenings and iron cellular backing, advocated by Mr George Clark.

The object this gentleman had in view was to gain greater solidity and strength of structure by means of a rigid backing, and so to give his armour plates greater power of resistance; while, at the same time, he hoped to get an increase of holding power, without weakening his armour, by means of dovetail bars let into the back of his plates, and forming as it were continuous heads to sets of 3 or 4 bolts.

The target was a somewhat complicated one, several different principles having been introduced in it. It presented a front measuring 13 ft. 6 in. by 10 ft. in height, and was covered with seven armour plates, which, with their backings and fastenings, may be described as follows:—

No. 1 Plate measured 6 ft. by 3 ft., and was $4\frac{1}{2}$ in. thick. It was held on by three dovetail bars let in flush into the back of the armour, each bar forming the head to three bolts, in one case, $2\frac{1}{2}$ in. diameter, in the other two, 3 inch in diameter. This armour plate had a cellular backing formed by angle irons $7\frac{1}{2}$ in. by 5 in. by 1 in., laid horizontally, one side of the angle being attached to the skin of the target, the other projecting to the front, and thus forming cells $6\frac{1}{2}$ in. deep by 5 in. wide. The cells were divided transversely into lengths of about 2 ft., and were filled with compressed millboard.

No. 2 Plate measured 7 ft. 6 in. by 3 ft. by $4\frac{1}{2}$ in., and was held on by 10 through-bolts instead of the dovetail fastenings; six of the bolts were 3-in., and four 2½-in. The cellular backing was the same as in No. 1 plate, but the cells were filled with teak instead of millboard.

No. 3 PLATE measured 7 ft. 6 in. by 2 ft., and was 4 in. thick; but on its back were formed three vertical projecting ribs 2½-in. deep and about 9 in. wide, in which ribs vertical dovetail slots were cut to receive the dovetail bars, which were very similar to those in No. 1 plate; these dovetail bars had six 2½-in. bolts attached to them.

The cellular backing was similar to that in the two former cases, only that the angle irons were made of ¾-in. iron instead of inch, and the filling was of millboard.

No. 4 PLATE was the same as No. 3, only that the filling in the cells was of teak instead of millboard.

No. 5 PLATE measured 6 ft. by 4 ft., and was 4 in. thick, with ribs at the back, and slots as in Nos. 3 and 4 plates. It was held on by twelve 2½-in. bolts, attached to three continuous heads. The cellular backing was the same as that of Nos. 3 and 4 plates, and the filling of teak.

No. 6 PLATE measured 6 ft. by 3 ft., and was 3 in. thick, and had at the back 4 horizontal ribs, across which, in a vertical direction, were cut three slots to receive three continuous heads as before, to each of which were attached three holding-on bolts; six of these nine bolts were 3 inches in diameter, and three were 2½ in. The cellular backing was formed of vertical angle irons 6½ in. by 3½ in. by ½ in., and thus the cells ran vertically and were 6½ in. deep and 4⅓ in. wide; the filling was of millboard. The structure, in this case, received additional support through some stiffening pieces or double knees attached to the ribs of the ship and abutting against the back of the skin.

No. 7 PLATE measured 7 ft. 6 in. by 3 ft., and was 3 in. thick, with three vertical projecting ribs at the back, very similar to those on plates 3, 4, and 6. There were three continuous heads running vertically in the three ribs, and to each head were attached two 2½-in. and one 3-in. bolt.

The cellular backing was composed of double angle irons 9 in. by 2½ in. by ½ in., forming horizontal cells 8½ in. deep and 4 in. wide, filled with teak. Teak was also filled in at the back of the skin between the ribs, and the ribs were likewise stiffened in a similar manner to those in No. 6.

The iron representing the skin of the ship was ½ in. thick, and the ribs 10 in. deep, and 15 in. apart.

The weight, per foot superficial, varied in the different plates: that of No. 6 was the greatest, and No. 5 the least.

The average of the whole was about 375 lbs. per foot superficial, of which about 25 lbs. were due to extra support given at the sides, top, and bottom of the target.

The guns used in the experiment were the 68-pr. service, the 110-pr. Armstrong, the smooth-bore muzzle-loading Armstrong 9-in. (6 ton) gun, and the 10½-in. Armstrong (12 ton) gun—all at 200 yds.

The firing commenced with two live shells from the 68-pr., and one from the 110-pr., which made the usual indent, broke 16 rivets at the back, injured one rib, and made a slight bulge in the rear.

These were followed by six solid cast-iron shot from the 68-pr., which made indents varying from 1·5 in. to 2·3 inches in depth (or a mean of 1·84 in.), breaking 5 bolts, one only of which was a through-bolt; the plates were more or less bulged and cracked, and some rivets at the back broken, but nothing very serious.

After this, two 68-lb. shot struck plates Nos. 6 and 7 in their weak parts, that is to say, where the armour was only 3 in. thick; they broke through the armour, doing some injury to the skin and fastenings in rear, especially to the stiffening pieces or double knees, three of which were broken.

The next four shots were fired in a salvo from one 68-pr. and three 110-prs.; they all struck about the centre of the target, and principally on No. 5 plate. They made indents from ·9 in. to 2 inches in depth, cracked the armour a good deal, and displaced the plates and buckled them an inch or two; at the rear, the skin was found to be cracked, one rib broken, and two others injured, and one bolt attached to the dovetail bar driven in $\frac{3}{4}$ in.

A steel jacketed cylindrical shot, flat-ended, weighing 109 lbs., from the 110-pr. gun, with a charge of 16 lbs., struck No. 5 plate, but did little mischief beyond making an indent 1·2 in. deep.

A spherical steel shot, weighing 156 lbs., fired from the 12 ton gun, with a charge of 50 lbs. of powder, went clean through everything, and out to sea, with considerable force left in it. The damage done was very serious indeed, and of such a nature, both as to rupture in the skin and general smashing of ribs and supports, as to make it fatal to a ship at sea. The injury done by the fragments and splinters on board the ship would also have been terrific. One bolt close to the spot struck was driven through.

A 300-lb. steel shell was then fired from the same gun, with a charge of 35 lbs. of powder, and a bursting charge of $12\frac{3}{4}$ lbs. This shell went as completely through everything as the spherical shot did, and the general damage done was not less serious.

Lastly, a 100-lb. cast-iron shot was fired with 25-lbs. of powder, from Armstrong's 9-in. smooth-bore muzzle-loading gun (6 tons), at the same range. It struck No. 5 plate, and made a hole through it measuring $9\frac{1}{2}$-in. by 10-in., with some cracks round the hole. It did not pass completely through the target, but it broke open the skin and left some timber protruding; the shot itself, broken up, remaining in the hole. One rib, injured before, was broken in two, and one bolt (not a through-bolt) broken; several rivets also were broken. Had this shot been of superior metal—that is of homogeneous metal or steel—it would undoubtedly have passed easily through the target.

The results of this day's firing are somewhat perplexing.

It is easy to see some defects in the target, such as that of a single armour plate having different thicknesses in its different parts, and that of the reduced size of the plates, together with some unnecessary complications of design; but it is not easy to account for the structure being so much inferior to Chalmers', and even to the original "Warrior" target.

The "Warrior" presents an extreme of elasticity in its backing to the armour. Chalmers did not depart entirely from this principle, for he provided a cushion of timber, 5 in. thick, behind his inner or intermepiate armour. Clark gave up elasticity altogether, and aimed at rigidity. Samuda and Scott Russell did the same, and the Iron Committee in their target also had no elastic substance.

In this no doubt lies one cause of failure in Clark's, as in the other three last named.

Next, the interval between the armour and the skin of the ship in the "Warrior" is 18 inches, in Chalmers' 16 inches, in Clark's only 7 inches; this may have a good deal to do with the inferiority of the latter, inasmuch as the greater thickness of backing, of whatever material it may be composed, must have more or less the effect of distributing the force of a blow, delivered upon the armour, over a large surface of the inner structure—and it must be observed that the examples of Scott Russell's, Samuda's, and the Committee's target, all point to a similar conclusion.

In addition to other objections to any of the principles advocated by Mr Clark, there is that great one of extreme complication of design and consequent costliness; the latter consideration might give way to the promise of increased strength, but nothing can compensate for the former. To re-model the ships of the British fleet on Mr Clark's principle would occupy the greater part of the remainder of this century.

This being the last experiment which can be recorded in this paper, it may be interesting to repeat a few of the most notable results obtained in the year.

First then.—The side of the "Minotaur" has been completely pierced by the Armstrong $10\frac{1}{2}$-in. gun (12 tons), throwing a spherical cast-iron shot at 200 yds. range, while similar shot had failed to penetrate the inner skin of the "Warrior."

Secondly.—The Horsfall 13-in. gun ($24\frac{1}{2}$ tons) completely penetrated the side of the "Warrior," at 200 yds., with a cast-iron shot; but at 800 yds., it pierced the armour only of the same ship and buried itself in the timber backing.

Thirdly.—Mr Whitworth's 70-pr., at 200 yds., has succeeded in passing a shell of homogeneous metal through 4 in. of armour and 9 in. of timber previous to bursting; also his 120-pr., at the same range, has passed a shell of the same metal through the side of the "Warrior," bursting in its passage; and the same gun, at 800 yds., has completely pierced, with both shot and shell of the same metal, a ship's side, constructed as to frame of equal strength with the "Warrior," but covered with 5-in. of armour.

Fourthly.—The Armstrong 12-ton gun has just penetrated $7\frac{1}{2}$-in. armour with a steel shot at 200 yds., and it has completely pierced a ship's side, consisting of $5\frac{1}{2}$-in. armour, 9 in. of teak, and strong inner skin and frame, with a steel shell.

Fifthly.—A shield for land defences has been produced that is equal to resist a battering from guns up to 12 tons in weight, at a distance of 200 yards.

In this state the question of guns against iron armour must be allowed to stand for the present, but it is one which cannot stand still long; already we have a 600-pr. mounted at Shoeburyness and ready for trial, and there are manufacturers who are anxious to begin upon still larger guns.

Immense activity is being displayed in all our great foundries—an armour plate, 12 in. thick, 19 ft. long, and 3 ft. 9 in. wide, weighing 15 tons, has been rolled at Sheffield with almost as much ease as one of less than one-third its size could be produced, only as it were a few months since; so much science and skill is brought to bear upon the manufacture of improved wrought-iron and steel, as well as in converting cast-iron, by a direct and easy process, into a metal possessing all the good qualities of soft steel and tough wrought-iron, that it may be confidently assumed that we have neither yet seen the full resistance to be got out of a given thickness of armour, nor can we yet see the limit to our power of piercing it; one thing only stands out clear in the uncertainty of the future, and that is, that land defences will ever be superior to attack by sea. Ships of form and power, that we little dream of now, may carry armaments heavier than our most enthusiastic inventors yet dare to suggest; but forts, if made of the proper material, and of form and capacity adequate to the reception of the largest growth of gun, must ever be able to crush anything afloat.

Whatever advance science may make in gunnery, or mechanical skill in the production of monster guns and the means of working them, every step must tell in favour of forts to a greater extent than of ships; so that whatever else may undergo change in this age of monster guns and iron armour, our coast defences must maintain their importance, indeed they must become more important than ever.

ACCOUNT

OF

EXPERIMENT CARRIED ON AT SHOEBURYNESS, ON 12TH AND 13TH NOVEMBER, 1863.

[CONTRIBUTED BY CAPTAIN E. J. BRUCE, R.A.]

THE following Experiment was carried on to test steel, wrought-iron, and cast-iron projectiles. The 12-pr. solid shot were fired at $2\frac{1}{2}$-inch unbacked plates, and the shell at 2-in. plates backed by 12 in. of wood. Each plate measured 6′ × 3′. The 40-pr. shot were fired at a "Warrior" target (No. 14).

Range, 200 yds.

The plates were manufactured by Messrs John Brown and Co., of Sheffield, and proved to be of uniformly good quality; they were secured at their sides to a wooden frame by means of railway bars, which were bolted to the frame.

The guns used in the experiment were—

One Armstrong breech-loading 40-pr., weight, 35 cwt. 1 qr. 24 lbs.; diameter of bore, 4·75″; length, $10\frac{1}{12}$′; rifling, one turn in 37 calibres.
One Armstrong breech-loading 12-pr., weight, 8 cwt. 2 qrs. 23 lbs.; diameter of bore, 3″; length, 7′; rifling, one turn in 38 calibres.
One Whitworth breech-loading 12-pr., weight, 9 cwt. 3 qrs.; diameter of bore, major-axis, 3″, minor-axis, 2·75″; length, $8\frac{8}{12}$′; rifling, one turn in 55″.

The projectiles were of the following description :—

(1) Homogeneous metal, Mr Whitworth. (H .M.)
(2) Steel, Sir W. Armstrong.
(3) Bessimer's metal, Messrs John Brown and Co., Sheffield.
(4) Steel (unforged castings), Mr Attwood, Tow Law Iron Works.
(5) Homogeneous metal and case-hardened wrought-iron, Messrs Shortridge and Howell, Sheffield. (H. M. and W. I.)
(6) Chilled cast-iron,* Captain Palliser.
(7) Steel .... } Manufactured in the Royal Laboratory, Woolwich.
(8) Cast-iron remelted, }

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* Six shot and three shells were cast from the following mixture :—Langloan No. 1, 10 cwt.; Calder No. 4, 2 cwt.; old shot, 10 cwt.; foundry scrap, 10 cwt. Three shells were cast from a mixture of half hot-blast, or Calder No. 4, and half cold-blast, or Pontypool.

12th November.

Number of round.	Photographic No.	Nature of ordnance.	Projectile. Nature.	Projectile. Weight in lbs.	Projectile. Form.	Projectile. Length in inches.	Charge in lbs.	Elevation.	Deflection.	Effects. Depth of indent in inches.	Effects. Diameter of indent in inches.	Effects. Ripple round circumference of hole.	Effects. Bulge of plate in inches.	Penetration into earth bank, 2 yards in rear of plates.	Velocity. At 120′.	Velocity. At 530′.	Projectile after firing. Length.	Projectile after firing. Diameter at head.
								′	′			in.		ft. in.				in.
1	629	W* 12-pr.	Solid H. M. shot.	12·062	‡FE	7·17	1·75	10	Nil	T§	4· × 3·5	0·6	...	2 6	1383	1291	broken	...
2	630	„	„	„	„	„	„	„	„	„	3·5 × 3·3	0·4	...	2 0	1387	1283	„	...
3	631	„	„	„	„	„	„	„	„	„	3·2 × 3·	0·2	...	3 0	1378	1278	„	...
4	632	„	„	„	„	„	„	8	„	„	3·5	0·3	...	Nil	1334	1237	6·57	3·415
5	633	A† 12-pr.	Solid steel shot.	11·937	„	5·92	„	9	8	„	3·1	Nil	...	Uncertain	1201	1104	5·285	3·259
6	634	„	„	„	„	„	„	6	10	„	3·3	0·2	...	2 6	1247	1144	5·509	3·319
7	635	„	„	„	„	„	„	„	12	„	3·8 × 3·2	0·4	...	2 6	1215	1117	5·618	3·301
8	636	„	„	„	„	„	„	„	14	...	3·5 × 3·4	0·3	...	Uncertain	1209	1105	5·673	3·346
9	637	W 12-pr.	Solid H. M. shot.	12·062	„	7·17	„	9	Nil	...	...	...	...	Nil	1363	1277	...	...
10	638	„	„	„	„	„	„	10	„	T	3·5 × 3·3	0·4	...	...	1350	1277	...	...
11	639	A 12-pr.	Solid steel shot.	11·937	„	5·92	„	6	14	„	3·2	none	...	3 0	1215	1110	5·583	3·289
12	640	„	„	„	„	„	„	„	„	„	3·2 × 3·1	0·1	...	2 6	1222	1119	5·624	3·273
13	641	„	„	11·875	‖RE	6·48	„	„	10	„	3·1	0·3	...	Uncertain	1199	1150	6·281	3·008
14	642	„	„	„	„	„	„	„	9	„	3·1 × 3·	0·4	...	4 2	1185	1137	6·34	3·001
15	643	„	„	„	„	„	„	„	„	...	...	...	...	Nil	1215	1156	6·448	2·983
16	644	„	„	„	„	„	„	„	„	T	3·1 × 3·	0·4	...	3 9	1214	1158	6·31	3·005
17	645	„	Bessimer's metal.	12·687	„	7·04	„	„	„	1·35	3·5 × 3·3	none	...	Nil	1202	1147	5·569	3·473
18	646	„	„	„	„	„	„	„	„	...	...	...	...	Nil	1244	1185	...	...
19	647	„	Case-hardened W. I.	13·687	FE	6·82	„	8	14	1·2	4· × 3·8	...	...	...	1149	}	5·7	3·59
20	648	„	„	„	„	„	„	„	„	0·8¶	...	...	...	...	1163	} not taken	5·662	4·129
21	649	„	„	13·812	RE	7·02	„	„	10	...	...	...	...	...	1196	}	6·156	3·06
22	650	„	H. M.	„	„	,	„	6	„	1·4	...	0·7	2·5	...	not	taken	...	...
23	651	„	W. I.	„	„	„	„	„	„	1·3	3·5 × 3·3	...	...	...	1241	1169	5·795	3·878
24	652	„	Cast steel.	12·5	„	7·05	„	„	10L	...	...	...	...	...	1214	1169	6·58	2·85
25	653	„	„	„	„	„	„	„	„	T	3·1	0·3	...	2 0	1193	1157	6·10	3·153
26	654	„	„	„	„	„	„	„	„	„	3·4 × 3·2	0·3	...	2 6	1231	1183	5·92	3·245
27	655	„	Chilled cast-iron.	11·937	„	7·48	„	„	„	1·4	3· ×	...	...	...	1228	1189	broken	...
28	656	„	„	„	„	„	„	„	„	hole	3·4 × 3·3	...	...	...	1226	...	„	...
29	657	„	„		„	„	„	„	„	1·6	3·4 × 3·2	...	...	...	1228	1189	„	...

* Whitworth. † Armstrong. ‡ Flat ended.
‖ Round ended. § Through. ¶ At greatest depth.

REMARKS.

Struck the plate 2′ from top, and 16″ from right side. At back, round crystalline fracture; outer circle of fracture, 7″; a rim of metal, for half the circumference, thrust out half an inch beyond flat surface of plate.
Struck the plate 15″ below last round, and 22″ from right side. At back, similar hole and dimensions to last round, only an inner rim or flange thrust out about 1″ for half the circumference.
Struck the plate 3″ above and $2\frac{1}{2}$″ to the right of last round; circumference of holes touching. At back, fracture breaking into No. 630; similar hole to the first two.
Struck the plate 12″ from bottom, and 9″ from right side. At back, dimensions and shape of hole as before, only inner flange driven out all round circumference about half an inch.
Fresh Plate.—Struck 1′ 8·5″ from top, and 1′ 11″ from right side. At back, outer diameter of fracture, 7″; very clean inner hole.
Struck 1′ below last round, and 0·2″ to left. At back, hole a little irregular in form; 7″ × 7·5″, exterior diameter.
Struck 2·5″ above, and 7·5″ to the right of last round. At back, exterior diameter, 8″ × 6·5″.
Struck at 6″ from bottom, and 5·5″ from left of plate; ripple only extended round half circumference. At back, exterior diameter, 8″ × 7″.
At Armstrong Plate.—Struck lower edge, only half circumference on plate. No use for comparison.

Struck the plate 1′ 1·5″ from top, and 1′ 5″ from right side. At back, outer diameter, 7″.
At Whitworth Plate.—Struck 1′ 3″ from top, and 18″ irom right side. At back, outer diameter of fracture 7″.
Struck 4′ from top and 1′ from right side. Outer diameter of fracture, 6·5″.
Fresh Plate.—Struck 2′ 6″ from top, and 1′ 2·5″ from right side. At back, outer diameter, 6·5″; more ragged hole; projecting layers or flanges protruding 1′.
Struck the plate 1′ 2·5″ above, and 3″ to right of last round. At the back, exterior diameter of fracture, 7·3″ × 6·4″; rim of metal forced out for 1″ beyond the plate.
Struck railway iron and made a hole 3″ in diameter and 3″ deep, and shot fell back in front of plate. Damage at rear could not be ascertained owing to baulk of timber; bolt head at 5′ from impact broken off.
Struck 11″ below No. 641. At back, exterior diameter of fracture, 6·6″ × 6″; rim of metal projecting three-quarters of an inch.
Fresh Plate.—Struck at 2′ 2″ from top, at 1′ 1″ from right side; small crack on face of indent. At back, bulge projecting 1″, with two vertical cracks 0-3″ wide.
Struck 1′ 11″ from bottom, and 1′ 3″ from right side; shot remained in plate, projecting 3·4″. At the back, the plate was broken through, interior diameter 3″ × 2·5″, exterior diameter of fracture, 7″ × 6″; piece of plate, measuring 6″ × 3″, forced back but not detached.
Fresh Plate.—Struck 2′ 3″ from top, and 1′ 3″ from right side. At back, bulge projecting 1·″, with vertical crack 6″ long across it, and two horizontal cracks, one 3·″ long and 0·5″ wide, at middle, the other a narrow one at top.
*Struck at 4·5″ from top, and 6″ from right side of plate. This shot struck a little sideways. At back, only slight bulge with vertical crack 6″ long.
Struck 10″ from top, and 1′ 8″ from right side: shot remained in plate, projecting 4·5″. At the back five radiating cracks, 1·2″ wide, extending over 6″ × 5″.
Missed the plate, and struck Captain Inglis' shield on No. 1 plank.
Struck 11″ from top, and 7″ from right side of plate. At back, plate opened 0·8″ × 0·5″, with four radiating cracks. Plate where struck partly supported by timber.
Fresh Plate.—Struck railway bar, and broke two bolts. Shot broke in half longitudinally.
Struck 2′ 7″ from top, and 6″ from left side; ripple only extended round portion of circumference. At back, outer diameter, 8″ × 6·5″. Thrust out inner flanges 1·5″.
Struck 1′ 4″ from top, and 6″ from right side. At back, outer diameter 7·5″ × 7″.
Fresh Plate.—Struck 2′ 7″ from top, and 1′ 3″ from right side. At back, slight bulge, hardly perceptible; two slight vertical cracks, 1·5″ and 1″ long, $\frac{1}{8}$″ wide.
Struck 7″ above last round. At back, exterior fracture 8″ × 7″; half the thickness of the plate driven off, for this surface (8″ × 7″); a hole through the entire thickness, 2·5″ × 1″.
Struck 1′ from bottom, and 1′ 3″ from left side. At back, slight bulge, a three-starred small crack, each crack about 2·5″ long.

* This shot had been leaded at the wrong end, and the front part was therefore not case-heardened.

13TH NOVEMBER.

Number of round.	Photographic No.	Nature of ordnance.	Projectile. Nature.	Projectile. Weight in lbs.	Projectile. Form.	Projectile. Length in inches.	Charge in lbs.	Burster.	Elevation.	Deflection.	Effects. Depth of indent in inches.	Effects. Diameter of indent in inches.	Effects. Ripple round circumference of hole	Effects. Bulge of plate in inches.	Velocity. At 120′.	Velocity. At 530′.	Projectile after firing. Length.	Projectile after firing. Diameter.
									′	′								
1	658	A 40-pr.	Steel solid shot.	44·5	RE.	10·26	5	...	16	nil	2·5	5·4 × 5·	0·4	2·7 in length of 2′	...	...	7·207	6·2
2	659	”	Cast-iron service shot.	41·125	”	”	”	...	”	”	2·	4·2 × 4·	...	2·3 in 2′	...	...	broken up	...
3	660	”	Cast-iron,[1]	41·5	”	”	”	...	”	2	1·	4·4 × 4·3	...	...	...	...	”	...
4	661	”	Cast-iron,[2]	41·875	”	”	”	...	”	”	1·15	4·7 × 4·5	...	...	...	...	”	...
5	662	”	Cast-iron,[3]	44·0	”	”	”	...	...	...	...	...	...	...	...	...	”	...
6	663	”	Steel, solid shot.	48·5	”	”	”	...	16	”	2·7	5·5 × 5·	0·3	...	...	..	9·134	6·15
7	664	”	Service shot.	41·125	”	”	”	...	”	”	...	...	...	...	...	...	broken	...
8	665	”	”	”	”	”	”	...	”	”	0·7	4·1 × 3·8	...	...	...	...	up	...
9	666	”	Cast-iron,[1]	41·5	”	”	”	...	”	”	0·9	4·4 × 4·2	...	...	...	...	”	...
10	667	”	Cast-iron,[2]	41·875	”	”	”	...	”	”	1·1	4·7 × 4·5	...	...	...	...	”	...
11	668	”	Cast-iron,[3]	44·0	”	”	”	oz. dr.	”	”	...	...	...	...	...	...	”	...
1	669	A 12-pr.	Armstrong steel shell.	11·625	FE.	7·03	1·75	5 2	6	14	...	3·4 × 3·2	Very slight	...	1222	1127	broken in two	...
2	670	”	”	”	”	”	”	”	”	”	...	3·3 × 3·2	...	...	1210	1119	6·645	3·329
3	671	”	”	”	”	”	”	”	”	”	...	3·1	...	...	1210	not taken	...	...
4	672	”	”	”	RE.	8·15	”	”	8	10	...	3· × 2·9	...	...	1211	1151	...	...
5	673	”	”	”	”	”	”	”	6	”	...	2·95	Slight	...	1233	1161	6·958	3·000
6	674	”	Case-harden. W. I. shell.	12·437	FE.	7·01	”	2 9	”	14	2·5	3·9 × 3·7	...	...	1219	1119	6·015	3·88
7	675	”	”	”	”	”	”	”	”	”	1·9	3·7 × 3·5	...	...	1177	1062	5·697	3·42
8	676	”	”	11·875	RE.	6·73	”	”	”	10	1·3	3·8 × 3·5	...	...	1257	1196	...	...
9	677	”	Chilled cast-iron shell.	11·312	”	7·37	”	12 6	”	”	...	...	...	...	1275	1201	...	...
10	678	”	”	”	”	”	”	”	”	”	2·65	3·5 × 3·4	...	...	1261	1202	...	...
11	679	”	”	”	”	”	”	”	”	”	2·4	3·6 × 3·2	...	...	1270	1210	...	...
12	680	W 12-pr.	Hom. metal shell.	12·062	FE.	9·52	”	6 1½	10	nil	...	...	Slight	...	1336	not taken	8·719	3·197 at centre of shell
13	681	A 12-pr.	Steel solid shot.	11·937	RE.	7·03	”	...	6	10	...	...	...	...	not	taken	...	
14	682	”	”	”	”	”	”	...	”	”	1·75	3·7 × 3·4	1·	...			6·17	3·08
15	683	W 12-pr.	H. M. shell.	12·062	FE.	9·52	”	...	10	nil	...	3·	...	...	1346	1250	...	...
16	684	A 12-pr.	Cast-iron service shot.	11·625	RE.	7·0	”	...	6	10	1·2	4·3 × 4·	...	1·45	1246	1187	...	...
17	685	”	”	”	”	”	”	...	”	”	1·2	3·7	...	1·5	1252	1189	...	...
18	686	”	”	”	”	”	”	...	”	”	0·7	3· × 2·9	...	0·9	not	taken	...	...
19	687	”	”	”	”	”	”	...	”	”	0·75	3 × 2·9	...	...	not taken		...	...
20	688 *	”	Chilled cast-iron shell.	11·312	”	7·37	”	...	”	”	2·1	3·5 × 3·3	...	2·25			...	...
21	689 *	”	”	”	”	”	”	...	”	”	1·0	3·3 × 3·	...	1·5			...	...
22	690	”	Chilled cast-iron shot.	11·937	”	7·48	”	...	”	”	...	3·6	...	...			...	...
23	691 *	”	Chilled cast-iron shell.	11·312	”	7·37	”	...	”	”	...	3·5	...	...			...	...

NOTE.—The whole of the shells used in the above practice were plugged, and had bursting powder in them, wi the exception of those marked *

[1] Four times melted. [2] Eight times do. Twelve times do.

REMARKS.

Struck the upper plate 12″ from bottom, and 2′ 6″ from right side; radiating cracks on bulge at back. The armour plate, where struck, was not supported by any backing.

Struck upper plate 8″ from bottom on a bolt; crack on indent from bolt-hole; bolt started 1″.

Struck upper plate 6·5″ from bottom, and 7·5″ to right of last round.
Struck upper plate 12″ above last round.
Struck 12″ from bottom of upper plate; cone stuck as a splash.
Struck upper plate 6″ from top, and 4′ 6″ from left side; indent very much cracked; plate cracked through its thickness at top, and opened in the weld for a length of 1′ at 2″ from front of plate.
Struck on old indent. No use for comparison.
Struck 7″ from bottom, and 10″ from left side of plate.
Struck 6″ from bottom, and 12″ to right of last round; edge of indent on bolt-hole.
Struck 1′ 7″ from bottom, and 7·5″ from left side; bolt, at 12″ from point of impact, started 1″; plate cracked through for 3″ from rear side.
Cone remained in plate; effect precisely similar to No. 5 round.
At 2″ Plate backed by 12″ of Wood.—Struck the plate 2′ 8″ from top, and 1′ from right side, penetrated the plate, made a clean hole, and burst in the wood, all the shell in the hole; blew out part of the timber for a length of 2′, and a width of 6″.
Struck the plate 8″ above, and 3″ to right of last round; penetrated plate and backing, and burst in earth bank in rear.
Struck plate 1′ 3″ from top, and 1′ 4″ from right side; penetrated plate and burst in backing; piece of plate punched out and picked up at rear; bolts holding railway bar both broken; and plate driven forward 9″ from backing.
Struck the plate 2′ 4″ from top, and 1′ from right; penetrated plate and burst in wood backing; nearly all the shell, which broke into about six pieces, found in rear.
Struck the plate 6″ from top, and 1′ from right side; penetrated; powder blew in backing; shell found sticking in earth bank.
Struck plate (Armstrong R.E.) 11″ below No. 4 round, and 1′ from right side; shell stuck in plate and was broken in half longitudinally. No explosion in wood backing.
Struck 2′ from bottom, and 4″ from left side of plate; head of shell remained in plate, remainder rebounded 54 yards; powder exploded.
Struck 1′ from top, and 5″ from left of plate; shell could not be found.

Struck the plate 12″ from top, and 9″ from left side; shell broke up; head remained in hole.

Fresh Plate.—Penetrated 2·65″ to nearest part of shell; most of the shell, including interior chill, found in front.
Struck 13″ from top, and 14″ from left side; cone remained in plate.
Fresh Plate.—Struck 18″ from top, and 16″ from left side; penetrated through plate and backing, and into earth bank about 5′. Shell did not burst; bursting powder in bag.
Nos. 681 and 682 were fired at an unbacked $3\frac{3}{4}$-inch Plate.—Struck top edge of plate, and glanced over.
Struck 1′ from top of plate; crack on face of indent, and horizontal crack, 3·5″ long, on back of plate; shot rebounded 17 yards; a few small longitudinal cracks at front of shot.
Struck the plate 2′ 2″ from top, and 13″ from right side; penetrated plate and backing, glanced upwards, touched top of earth bank, and passed over it into the sea; bursting doubtful.
Palliser's 2″ backed Plate.—Struck at 3′ 4″ from top, and 1′ 3″ from left side.

Struck 6″ below, and 6″ to right of last round; slight crack on face of indent.
Palliser's $2\frac{1}{2}$″ unbacked Plate.—Struck at 19″ from bottom, and 16″ from right side of plate; bulge in rear 0·5″, with slight vertical cracks.
Struck 15″ from top, and 14″ from right side; bulge in rear, with cracks similar to last round.
Struck $2\frac{1}{2}$″ plate 2′ from top, and 14″ from left; crack on face of indent. At back, bulge 1·″, with vertical crack 5″ long and 0·5″ wide, and a horizontal crack, 3·″ long, from centre of vertical one.
Struck plate where backed by wood support; damage in rear could not be seen.
Cone remained in plate; plate cracked in rear.

Cone of shell in plate projecting in rear 1·5″.

Comparative trial of 68-pr. cast-iron shot made of scrap and cast-iron, and 68-pr. shot made of Dr Price's refined iron, both manufactured in the Royal Laboratory, Woolwich.

17TH NOVEMBER.

Number of round.	Photographic No.	Nature of ordnance.	Projectile. Nature.	Projectile. Weight in lbs.	Projectile. Form.	Charge in lbs.	Elevation.	Effects. Depth of indent in inches.	Effects. Diameter of indent in inches.	Remarks.
1	692	68-pr. smooth-bore gun.	Solid shot, R. L.	67·250	Spherical, 7·88″ diameter.	16	′ 20	2·2	8·9	A vertical crack 15″ long; backing cracked 7″ horizontally, and bulged back 4·5″
2	693	,,	,,	66·625	7·90″ diameter.	,,	,,	2·5	8·8 × 8·2	A few slight cracks on plate; half of shot struck on T iron.
3	694	,,	Dr Price's	66·0	7·87″ diameter.	,,	,,	2·2	8·9 × 8·3	A vertical crack 19·5″ long; backing split, and bulged 6″.
4	695	,,	,,	66·625	,,	,,	,,	,,	8·9	A vertical crack 6″ long; backing spilt and bulged.

NOTE.—These shot were fired at Scott Russell's target, at 200 yards range.

ACCOUNT

OF AN

EXPERIMENT CARRIED ON AT SHOEBURYNESS, 11TH DECEMBER, 1863, TO TEST THE PENETRATING POWER OF STEEL PROJECTILES FIRED FROM A 600-pr. AND A 300-pr. ARMSTRONG RIFLED GUN AT A FLOATING TARGET OF THE "WARRIOR" CONSTRUCTION, AT 970 YARDS RANGE.

[FURNISHED BY CAPTAIN E. J. BRUCE, R.A.]

The plates of the target were hammered and manufactured at the Thames Iron Works.

600-pr.,—Weight, 22 tons, 18 cwt. Length, $14\frac{5}{12}$ ft. Rifling, 1 turn in 65 cal. Diameter, 13·3 in.	Carriage, Garrison, sliding on casemate platform; slope, $3\frac{1}{2}$°.
300-pr.,—Weight, 11 tons, 14 cwt. 3 qrs. Length, $12\frac{7}{12}$ ft. Diameter, 10·39 in.	Carriage, Garrison, sliding on an experimental slide; slope, $10\frac{1}{2}$°.

Number of round.	Photographic No.	Nature of ordnance.	Projectile.			Bursting charge.	Charge in lbs.	Length of charge.	Elevation.	Recoil; platform dry.*	Deflection.	Effects.		Velocity.	Remarks.
			Nature.	Weight in lbs.	Form.							Depth of indent in inches.	Area of indent in inches.		
						lbs.		in	° ′	Quadrant ft. in.					
1	...	600-pr muzzle loading shunt gun.	Cast-iron shell	612	Cylindrical.	...	70	25	2 5	9 0	nil.	...	...	...	Fired for range at a wooden target moored at 1000 yds. and a little clear of the iron one. Struck the target and broke into three pieces.
2	721	„	Steel shell with cast-iron head	„	„	†24	„	...	2 10	10 9	...	...	...	...	Fired at "Warrior" target. To the right, and over. A large piece (apparently the head) struck the water about 150 yds. from the gun.
3	722	„	„	„	„	„	„	...	2 3	10 6	...	...	...	...	Struck top of wood and iron rib, and burst into four pieces.

* Inside compressors used with both guns.

† The "stemming" of the shells took half an hour to perform.

Number of round.	Photographic No.	Nature of ordnance.	Projectile. Nature.	Projectile. Weight in lbs.	Projectile. Form.	Bursting charge.	Charge in lbs.	Length of charge.	Elevation.	Recoil; platform dry.	Deflection.	Effects. Depth of indent in inches.	Effects. Area of indent in inches.	Velocity.	Remarks.
						lbs.		in	Tangent. ° ′	ft. in.					
4	723	600-pr muzzle loading shunt gun.	Steel shell with cast-iron head.	612	Cylindrical.	24	70	25	2 0	10 0	...	...	...	...	Struck the target 11″ below edge of centre plate, 2′ to the left of bull's eye; hole in armour plate 24″ × 21″, hole at back 30″ × 24″; six bolts in centre plate broken, nine in upper, and one in lower plate; upper plate buckled forward 12″ at left end, and lower plate 2″; back of target shattered over an area of about 4 square feet; daylight through target; skin 2′ square completely doubled back; two vertical frame-pieces broken and bent back; two wood struts partially detached from target, and one split across; large piece of armour plate (142 lbs. weight) at foot of target in front. The shell burst into 12 pieces, and had apparently exploded whilst passing through wood backing.
1	...	300-pr ditto	Solid cast-iron shot	306	Cylindrical.	...	40	16	1 55	7 6	6	...	...	...	Fired for range.
2	724	,,	Steel shell	302	,,	15	,,	15	1 57	7 9	8	...	...	...	Fired at "Warrior" target. Missed.
3	725	,,	,,	301	,,	,,	,,	...	1 52	8 6	nil.	...	...	...	Do. do.
4	726	,,	,,	,,	,,	...	,,	22	1 55	7 3	,,	...	...	...	Ditto. Struck target after graze and broke into nine pieces. The target was at an angle of about 30° to 35° to the line of fire; the shell struck the upper plate of target; after graze, cracked the right hand corner of the plate, and started the wood backing at the side.

GUN COTTON:

AN INTRODUCTION TO THE PROPERTIES AND HISTORY OF THE SUBSTANCE.

In nova fert animus mutatas dicere formas
Corpora. OVID.

BY MAJOR F. MILLER, V.C., R.A.

Introductory Remarks.

A Committee has lately been appointed by the Secretary of State for War to examine into the applicability of gun-cotton to military purposes and to mining or other engineering operations. It is composed partly of scientific men, fellows of the Royal Society, and partly of naval and military officers selected from various branches of the service. The President combines the experience of a military profession with the acquirements of a long course of distinguished scientific researches, and the entire committee may fairly be said to have every qualification for the proper treatment of the subject.

Whatever the result of this examination may be, the course of the inquiry cannot fail to possess a high degree of interest. The phenomena presented by the combustion of gun-cotton under various conditions would attract the attention of the curious for their own sake, but the object of instituting the inquiry gives a practical importance to the subject. The point to be determined is whether gunpowder, the curse of the devil, as it was called by writers of old, the "villainous saltpetre," to use Shakespeare's words, "which many a good tall fellow hath destroyed so cowardly" shall be supplanted by a new agent with more secret and more formidable powers of destruction. It is a question of relinquishing a substance which has been growing in importance during five hundred years, and of which the consumption has become enormous throughout the world; whilst the proposed substitute has been as yet so little used that up to a few months ago the manufactory established by the Austrian government was the only one in existence.

Published accounts of the qualities of gun-cotton and of the experiments made upon them are almost as scarce as the material itself. Scattered notices are to be found in various works, and a few reports may be met with, but they are neither complete nor easy of reference. One article has already appeared in these pages,* but it was confined to special points and

* Vol. III. p. 367.

was of too isolated a character to contain in itself all the information likely to be required. The present paper is also brief and incomplete, but it takes a wider scope and may serve as an introduction to the subject in general. The portion relating to the properties of gun-cotton is mainly derived from the report presented to the British Association at the meeting of 1863 by the Committee to whom the subject had been referred for consideration at the meeting of 1862. This report is not yet published, but will be purchasable in the course of the present year; it is founded partly on experiments made by Mr Abel, F.R.S., Chemist to the War Department, partly on information given by Baron von Lenk, a Major-General in the Austrian artillery (to whom are due the improvements which have made gun-cotton practically useful), and partly on the labours of its own members. The historical notes on the career of gun-cotton in Austria which are inserted here, are condensed from an article which appeared about September, last year, in a military periodical entitled "Archiv für die Offiziere der Kœniglich Preussischen Artillerie und Ingenieur Corps." I have tried to make the historical part more complete by the help of other Foreign and English periodicals, but there is so little reference to gun-cotton in the indexes which I have examined that they contributed but little to the present remarks. The description of the mode of manufacture is taken from an account contributed by Mr Abel to the Report of the British Association already mentioned.

Composition and Properties of Gun-cotton.

The substance called gun-cotton is prepared by impregnating ordinary cotton with a mixture of sulphuric and nitric acids. The method pursued in preparing it systematically will be further described at a later part of this article, for the present it will be sufficient to state that the proper quantity of sulphuric acid is about three times that of the nitric acid, and that when the saturated cotton has been thoroughly washed and completely dried its conversion into gun-cotton is complete.

The cotton thus treated is transformed into an explosive substance, but has undergone so little change in its appearance that the difference would not be remarked. The process has added about 80 per cent. to its weight, and has made it harsher to the touch, but has not given it any colour, smell, or taste, as an indication of the new properties it has acquired. To all appearance it is still fit for weaving into calico or for applying to any domestic purpose, but it possesses a power which fits it for new employments. It is capable of being substituted for gunpowder, it is made for that sole purpose, and it bears accordingly in all countries a name expressive of that application.*

Whether the material is qualified in all respects to be substituted for gunpowder is at present a moot point. The gun-cotton made seventeen

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* In German it is Schiesswoll, 'shooting cotton;' abbreviated from Schiessbaumwoll the name at first used. In French it is now called 'poudre-coton' or 'coton-poudre,' but in 1847 it was described under the name of 'coton-détonnant' and 'fulmi-coton.'

years ago, when the process had been but lately discovered, was certainly unfit for adoption, but since that time experience has taught precautions which must be observed in the process of manufacturing it and improvements which can be introduced in the mode of using it. There are grounds for supposing that the original objections are removed, and that the great advantages which gun-cotton has always possessed over gunpowder in some points are no longer neutralized by still greater drawbacks in others. But at the same time there are many reasons against our relying on the statements made to that effect without testing their trustworthiness by independent investigations. Even if all the points claimed in its favour are proved it will probably require some time to establish a general conviction of their truth. Only a few years have passed since the subject was generally discussed and the material generally condemned, and the recollection of its previous history will be apt to prevent its receiving fair consideration in the present stage of its development. Whether, however, gun-cotton is yet perfect or not, there is no doubt about its being so much improved as to have new claims upon our attention. And, even if the present inquiry should show that it is still unfit to supersede powder, the investigation might be the means of leading to such further improvements as would remove the existing defects. It will at any rate lead to a more thorough acquaintance with the compound, and the time has come when a new propelling substance is positively required, for the use of gunpowder entails many difficulties in the construction and management of large rifled guns, and thus impedes the further development of artillery fire.

Qualifications of Gun-cotton for Military and Engineering Purposes.

The object of manufacturing gun-cotton being to provide a substitute for gunpowder, the first questions that present themselves will naturally relate to the comparative powers of the two materials, and the points of resemblance or difference between the results of using them.

Some of these results are so obvious and so different that they attract immediate attention, others require careful observation and scientific deduction, though the dissimilarity may be comparatively as great and the consequences equally important.

To exemplify the former we will suppose a charge of gun-cotton (properly made up) and a charge of gunpowder to be fired out of any two similar pieces of ordnance. The first things that will be noticed will be that the gun-cotton produces only the most trifling amount of smoke, and leaves no appreciable residue, or "fouling" matter, in the bore. If the discharges are repeated a great many times it will also be noticed that the piece becomes less heated by firing cotton than by firing powder, so that three great advantages have already presented themselves.

If we proceed next to observe the power of the cotton in throwing any kind of projectile we shall find that in order to throw the shot as far with the cotton as with the powder we need only use about 1 lb. of the former to 3 lbs. of the latter; and when the ranges of the two shots are the same the recoil of the gun loaded with cotton is much less than that of the gun loaded with powder.

We may then try what explosive power the cotton has when it is substituted for powder as the bursting charge of a shell. For this purpose the cotton must be made up in a form rather different from that in which it was applied as a firing charge, but if rightly prepared, and duly apportioned to the capacity of the shell, it will produce about twice as many fragments as would be obtained from a corresponding shell burst by a charge of powder. We may test the same kind of power in other ways less connected with the artillery service, such as blasting rocks or removing any kind of obstacle, and the observations will corroborate the first result in showing that gun-cotton can exert a greater explosive power than gunpowder.

So far the comparison is easily made, and the results are self-evident, but a more difficult inquiry remains. It is important, in order to become thoroughly acquainted with gun-cotton, to determine the rate of its explosion, the temperature generated at the moment of explosion, and the compounds produced by the explosion. It is also desirable to measure the dynamic force exerted by charges of gun-cotton under various conditions, and information on these points can only be gained by delicate observations and experiments conducted with great care. None of them have yet been sufficiently determined. It has indeed been learned that the rate of explosion depends very much on the amount of space which the cotton occupies, and that the rate may be varied from one foot per second up to one thousand feet in the same unit of time,* but the means of regulating it by previous calculation, so as to give the required result in every case, are not yet established.

It is on this power of regulating the rate of explosion that the practical value of gun-cotton for artillery purposes mainly depends, and its too rapid explosion in the early trials was enough to justify its rejection at that time. The difference between an instantaneous and a progressive ignition of the charge is all-important. The former has such an immediate effect on the surrounding material that the breech of a weak piece would be blown out before the movement of the shot could give the gases a free exit at the muzzle; it is, in consequence, far more dangerous to the gun, and even if the construction is strong enough to bear the strain there is less velocity communicated to the shot.

But if the rate of explosion can indeed be regulated under all circumstances with such exact nicety as to combine the maximum of effect on the range and velocity of the shot with the minimum of strain upon the gun, the superiority of gun-cotton over gunpowder for the charges of fire-arms will be quite indisputable. With gun-cotton charges the absence of fouling would enable the windage to be reduced, or in other words allow of a better fit between the shot and the bore, in muzzle-loading pieces, and the accuracy of the firing could not fail to be increased thereby. The velocity and range, if not improved, would remain at least equal to what are at present obtained. Firing might be carried on in closed batteries at a continuous rate which is now unattainable because of the heating of the guns and the volumes of smoke. The service of the guns would be facilitated in all cases by the saving of labour which results from the smallness of recoil, the absence of

* Mr Abel has lately shown some experiments, in his lectures on gun-cotton, in which he controlled the ignition of gun-cotton thread to an extent far beyond what is here mentioned.

fouling, and the diminished weight of the charge; the last being indeed of no importance with light pieces, but of sensible effect with very heavy artillery. Lastly, the shells would have a greater destructive power, on account of the increased violence of their bursting charge and the increased number of splinters produced.

In small arms the advantages arising from the absence of fouling will be equally great, the accuracy of the aim being at present more impeded by that fault of the powder than by any defect in the barrel or the bullet. The loading will become easier, the piece will not be injured by any neglect in cleaning it, which is so liable to happen when a soldier is tired by a long day's skirmishing and marching, and any difference in weight of the gun or ammunition, or in simplicity of parts, will be on the favourable side.

There remains one important feature of gun-cotton which has not yet been noticed. It has been hitherto spoken of as an explosive compound, and explosive it is, but when it is not subject to any pressure the explosion is harmless.

If an ounce of loose gun-cotton be ignited in a common pair of scales the scale in which it rests will not be disturbed; whereas, with gunpowder the scale would be depressed. Similarly, a bag of gun-cotton will have no effect against a door or gate, although a bag of gunpowder will blow it open. If, however, the gun-cotton be put into a box, whose sides offer some resistance to the gases, it will do more harm than the gunpowder. The reason of this is that the force exerted depends on the quickness and completeness of the ignition. When the gases produced at the point of ignition are at all confined they rapidly penetrate the rest of the cotton, but when they have a free escape the ignition is communicated by degrees, and little or no force is exerted.

The practical use of this gradual ignition is that gun-cotton may be used instead of quick match or trains of powder to carry fire to mines or other exploding charges. Loose gun-cotton laid as a train burns about 1 ft. per second; gun-cotton woven into a hollow line and coated with india rubber burns about 30 ft. per second, because there is some pressure on the gases. The flame does not however have much destructive effect, for a line of this sort may be folded crossways without interrupting the regular progress of the flame from one end to the other. It does not leap from one point to another where the folds touch. If the gun-cotton is made into the form of a close twisted rope it explodes with some violence.

The more perfectly the gases are kept inclosed, without means of escape or expansion, until the whole mass of cotton is ignited, the more powerful is the explosive effect. At the same time some little free space must be left for them as a channel of passage from the point of starting to every other part. If their passage is stopped and the penetration prevented the ignition is incomplete. For instance, if a piece of gun-cotton be held tightly between the fingers and one end of it be lighted the ignition will not extend to the part where the pressure keeps the cotton close. It goes out on reaching the fingers, and there is so little heat or force that the fingers are not hurt. Large charges of gun-cotton require more management in this respect than similar quantities of gunpowder. The perfect ignition can however be easily ensured by making up the cotton in the form of a hollow twisted rope, however close the chamber where it is exploded may be.

Results obtained from various Experiments.

It cannot be denied that any material with the preceding qualifications would be an improvement on gunpowder if it possessed the important ones in a high degree, and if there were a sufficient uniformity of strength between all the samples that were made by the same treatment. Neither can it be reasonably doubted that gun-cotton, when in good order, has many of the advantages claimed for it. To what extent it possesses them is another question; the statements which have been made about the improved material rest principally on the authority of its acknowledged supporters, and have not yet been put to any independent tests. In the country where the subject has received most attention gun-cotton has bitter opponents as well as earnest advocates, and we know that the former have so far prevailed on more than one occasion that the inquiry has been dropped, and the orders for introducing it have been withdrawn. The following statistical notes must not therefore be taken as established facts, applicable to all cases, but as the results of such experiments as the advocates of gun-cotton bring forward in support of their opinions. Most of them are extracted from the Report of the British Association, to whom they were communicated by Baron von Lenk, and it will be interesting to observe how far they are corroborated by trials in this country.

General rate of firing.—100 rounds can be fired with cotton to every 30 rounds with powder.

Heating effect on the gun.—100 rounds were fired by the Austrian Commissioners from a 6-pr. with cotton, in 34 minutes, and the temperature of the gun was raised only to 122°*: 80 rounds more were fired without any danger being apprehended. With powder, 100 rounds could not be fired in less than 100 minutes, yet the gun became so much heated that water, when dropped upon it, immediately evaporated with noise, and it was not thought safe to continue the firing.

Recoil.—In the trials made by the Austrian Commissioners in 1860, the recoil of the gun with cotton was found to be only two-thirds of the recoil with gunpowder.

Fouling.—The deposit from gun-cotton is so slight that the barrel requires no cleaning. In gunpowder the waste, or useless portion of every charge amounts to no less than 68 per cent., most of which is thrown out at the muzzle, the rest being deposited on the sides of the bore.

Smoke.—An experiment to ascertain the advantage which might result from the absence of smoke was made in 1852 by a committee of which General von Hauslab was President. The trial took place in some casemates at the fortress of Comorn, the ventilation of which was purposely stopped. After twelve or fifteen rounds with powder any aiming became impossible; after 30 rounds some of the men fainted, and when brought into the open air, they required the administration of active remedies by the surgeons in attendance before they recovered. After 50 rounds the smoke was so thick

* The temperatures are given in degrees of Fahrenheit throughout this article.

that breathing became almost impossible, and the doctors in attendance declared that to remain there any longer would be attended with the highest danger to the gun detachment. The fifty rounds lasted eighty minutes.

After a much greater number of rounds had been fired with gun-cotton there was only a thin light cloud which did not impede the aiming of the piece or the breathing of the men in the slightest degree. No one complained of any uncomfortable sensation, and the medical men were of opinion that the firing might have been continued much longer without any harm arising. Gun-cotton was likewise fired from the lower decks of men-of-war with similar results.

Effects on the sides of embrasures.—It is well known that the firing of a gun with a large charge of powder through an embrasure causes such a concussion that the embrasure becomes, in the course of time, considerably damaged, and the fact is of sufficient importance to render desirable that the comparative effect of gun-cotton should not be overlooked. A trial was accordingly made by the Austrian committee (in 1853) in which gun-cotton was put under a disadvantage, by being fired from shorter guns and through embrasures with narrower openings. The embrasures for the powder guns were of a bad construction, in order that the damage might soon be apparent, but they were of the ordinary width. After no very great number of rounds (nicht übergrossen zahl) these embrasures became positively unserviceable, the sides, soles, and tops being all in such a state that the firing could not have been continued without rebuilding them. With the gun-cotton, notwithstanding that the guns were shorter and the openings narrower, an equal number of rounds were fired without causing more than a very slight injury (nur die mindeste Beschädigung) and the firing might have been continued much longer without rendering necessary any repairs to the embrasures.

Effect on the materials of the gun.—This depends very much on the manner in which the cartridge is made up, the strain upon the gun being enormously increased if the rate of explosion is not adapted to the resistance which the shot offers. Previous to the discovery that the rate of explosion might be regulated by the mechanical arrangement of the cartridge the bores of the guns were very much injured, and this was one of the great objections to the use of gun-cotton. What practical importance it may still have can only be determined by experiment, but it appears that gun-cotton may be used without leaving any trace of its action. Baron von Lenk states that about one thousand 12-pr. shots were fired with a charge of 17 oz. of cotton from a bronze gun, without affecting the bore in the slightest degree. In this case the cartridges were hollow; in other instances solid cartridges, slightly compressed, were used, and a considerable enlargement of the bore was caused, although the actual quantity of cotton was less. With a harder metal than bronze the gun-cotton has less effect on the bore, and it may be employed in a manner which will produce a more energetic force.

Effect on the range and velocity of the shot.—It has been already mentioned that 1 lb. of gun-cotton produces about the same range as 3 lbs. of gunpowder, and the resultant initial velocity is about equal, but the reports on these points do not give that precise information on various details, without which the statements are only liable to be misunderstood. Experiments on dynamic force and initial velocity will be made by the present Committee; in the meantime the following may be taken as illustrations of the comparative results that have been obtained:—

In 1846, with a 68 lbs. shot and an 8-in. mortar, ½ oz. of gun-cotton gave a range of 255 ft.; whilst 2 oz. of gunpowder gave a range of 152 ft. A rifle, with the ordinary powder charge (60 grains) carried the bullet through three 1 in. elm boards, the same rifle with half the weight of gun-cotton (30 grs.) drove the bullet through six similar boards.

In 1862 Mr Abel made frequent trials at Waltham Abbey with the usual proof mortar and small charges. The range obtained with gun-cotton was never less than that obtained with three times the weight of ordinary cannon powder, but the cotton was wound round a wooden plug, and the range was found to vary according to the strain to which the cotton was subjected when it was being wound. For instance, when the strain was one pound the range was as above mentioned, but when the strain was only two ounces the range was longer, and equal to what was afforded by Enfield rifle instead of cannon powder.

Explosive effect in shells.—The first observable effect of substituting gun-cotton for gunpowder as the bursting charge of a shell is that the splinters produced at the explosion are doubled in number, but an experiment to test more closely the comparative powers of destruction possessed by such shells was tried at Comorn in 1853, and gave a very striking result in their favour. Shells filled with cotton and powder respectively were buried in the earth over bombproof casemates at the depth to which they might be expected to pierce if they had been fired from mortars in the course of a siege. They were then ignited. The powder shells did no harm to the masonry arches beneath them, they only threw out one crater and did not disturb a covering of common fascines which rested upon the masonry. The cotton shells caused a much larger crater, and loosened the surrounding earth in a much greater degree; they threw the fascines out of position and broke through the arch below. Consequently the construction which made the casemates safe against a bombardment with powder shells would have failed in its purpose if bursting charges of cotton had been used.

Explosive effect in mines.—The superior explosive powers of gun-cotton for damaging palisades or other military obstacles, for sinking ships, for mining bridges, for blasting hard rocks, or for destroying large masses of masonry, seem to be more generally admitted than its applicability as a charge for artillery and small arms. The force exerted on everything in the near neighbourhood of the charge is undoubtedly greater than with powder, and the difficult problem of adapting the rate of explosion, to meet the exact circumstances of the case, may generally be overlooked. In artillery practice the safety of the gun has to be studied as well as the movement of the shot; in mines a general destruction is desired, and the full power of the gas is applied to its utmost instead of being controlled; consequently the comparative effect is doubled: 1 lb. of gun-cotton, as used in blasting rocks is equivalent to 6¼ lbs. of gunpowder, instead of 3 lbs. as in artillery cartridges.

If the use of the full blasting power has to be made subordinate to other considerations the equivalent proportion is somewhat reduced.

Under water its powers are developed to their full extent, and promise to make it a tremendous agent for the destruction of ships, or for the operations by which harbour entrances and important channels may be defended and attacked. The examples cited on this point are, first, that two tiers of piles 10 in. thick, with stones between them, were swept away by the explosion of a barrel with 100 lbs. of gun-cotton. The water was 13 ft. deep; the barrel was 8 ft. below the surface, and 3 ft. from the face of the piles. The discharge made a clean sweep through a radius of 15 ft., and raised the water 200 ft. Secondly, a barrel containing 400 lbs. was exploded in 10 ft. of water, at 18 ft. distance from a sloop. The sloop was shattered to pieces, and its fragments were thrown to a height of 400 ft.

As an instance of the comparative effect against woodwork, such as would be constructed by military engineers, it is stated that a box containing 25 lbs. of gun-cotton cut a clean opening, 9 ft. wide, through a double row of strong palisades. The palisades in the front row were 12 inches in diameter, 8 ft. high, and driven 3 ft. into the ground; the back row were 8 inches in diameter. Three times the same quantity of gunpowder had no effect whatever except that the piles were blackened by the explosion. A similar box, laid on the centre of a strong oak bridge, 24 ft. span, and made of 12 in. scantling, shattered the timber to atoms.

Keeping qualities of Gun-cotton.

Supposing, however, that all difficulties in controlling the rate of explosion and ensuring uniformity of strength were overcome, that the results were equal to the best anticipations, and that gun-cotton was admitted to be an improvement on gunpowder as a means of throwing projectiles or creating explosions, it would be necessary to become assured that these qualities were permanent under proper care; and it would have to be shown that neither heat nor damp induced any great loss of strength or any dangerous tendencies. This inquiry is especially necessary and important because the gun-cotton made at the time of its first invention was undoubtedly subject to such chemical changes as tended to produce entire decomposition and threatened to cause spontaneous explosion. It is manifest that any danger of this kind, if not entirely removed, would be fatal to the introduction of the material into the service.

With regard to spontaneous ignition the supporters of gun-cotton maintain that no chance of such a catastrophe exists now that the present mode of manufacture is adopted. They attribute the dangerous properties of the early gun-cotton to its not being washed enough to purify it thoroughly from all superfluous or "free" acid; and they cite the opinion given, after careful investigation, by a Committee of Chemical Professors in Austria, that "experimental proofs demonstrate that Lenk's gun-cotton is not spontaneously combustible." On the other hand indications have been noticed, both abroad and in this country, that some acid re-action or some chemical change does take place, especially when the gun-cotton is exposed to sunlight, and these indications cause some suspicion that the permanence is not to be fully relied on. Close attention will be directed to these points; it may be found that the re-action has no practical importance, or, if it has, that means may be devised to guard against its occurrence. It is certain that many specimens of gun-cotton which were made some years ago have been proved and analyzed without any trace of alteration being discovered.

The effects of heat and damp are the next to be considered. In the action of heat gun-cotton certainly lies under a disadvantage as compared with gunpowder, for it will explode at a temperature of 277°, whereas gunpowder does not explode until the temperature has reached 600°. The fact is however said to be unimportant, because, practically, the temperature would never be so high as 277° unless it were raised by means which would make the gunpowder equally liable to explode. This plea seems satisfactory, provided only that high degrees of heat, such as may often be experienced in hot climates, do not have any injurious effect.

Gun-cotton can be exploded by percussion if it is placed between iron and iron, but only that part which is actually struck takes fire, the rest remains unignited. If the cotton is placed on a soft metal, such as copper, or on a stone, and is then struck with a hammer, no detonation takes place.

The facts in connexion with damp are curious. In the first place gun-cotton, after being thoroughly dried, will absorb and hold twice as much moisture as gunpowder does under ordinary circumstances; the usual proportion being 2 per cent. in the former and only 1 per cent. in the latter. But having absorbed this quantity (which is immaterial) gun-cotton has no tendency to absorb more; it can only be forced to hold as much as 6 or 8 per cent. of moisture by being exposed in the very dampest situations, and it has so little power of retaining this additional quantity that it quickly returns to its normal condition when it is put in a drier place. It may even be buried in the earth or soaked in water without receiving permanent hurt, and requires nothing more than exposure to the open air to restore its original condition.

This property not only affords the means of guarding against explosions without hurting the material, but gives great advantages in storage conveyance and practical application. To gunpowder damp is ruinous. If packed in barrels, and exposed to damp, the portion near the outside forms into a cake which gives protection to the rest, but otherwise it will absorb moisture until it is actually dissolved, and if once wetted it can only be restored to serviceable order by submitting it to nearly the whole process of its original manufacture.

Baron von Lenk states that some gun-cotton, exposed in a room completely saturated with moisture, contained only 8 per cent. after remaining there thirty-three days: gunpowder under the same conditions absorbed 79·9 per cent. in the same time, and was converted in the course of a few weeks into a concentrated solution of saltpetre; the gun-cotton remained during the latter part of the time in the same state of saturation as it was at the end of the first period. The best proof however of its freedom from damage by damp alone is that some specimens of a lot of gun-cotton which had been buried in the ground in 1847 were dug up in 1863, and showed on careful examination no evidence of having undergone the least change.

On the minor considerations attending the use of Gun-cotton.

I have now touched upon all the most important points relating to the application of gun-cotton to military purposes. The minor points, such as the manner in which it is prepared for the construction of cartridges, the bursting charges of shells, or the destruction of obstacles, present no difficulty because the cotton is made up into such forms as are best suited to each kind of work. On the whole it appears that gun-cotton is more manageable and more convenient to handle than gunpowder; it is certainly lighter, when estimated by the quantity to produce corresponding effects, and it occupies less bulk in packing, unless, when formed into artillery cartridges, it is arranged so as to occupy an exact amount of space.

Lastly, there remains the important point of expense; a question which need not be discussed here, but would have to be considered if the adoption of gun-cotton were seriously contemplated. The permanent loss or gain would mainly depend on the comparative cost of the substances used for gun-cotton and gunpowder, and of the machinery or labour employed in compounding the separate ingredients; but any such change in the ammunition would entail more or less alterations in the rest of the matériel and require a further outlay on that account. Baron von Lenk states that with raw cotton at its present high price it costs rather more to produce a pound of gun-cotton than a pound of gunpowder, but as one pound of gun-cotton is equal in effect to three pounds of gunpowder when used with fire-arms, and to six pounds in mining operations, the balance is considerably in its favour. There does not appear to be any additional expense attendant on the application of gun-cotton, and there might, on the whole, be some little saving, for the freedom from fouling and from injury by damp tend to diminish the number of side-arms and stores, and to simplify the arrangements for conveyance and storage.

History of the Invention and its Development.

The foregoing remarks have, I hope, described the properties of gun-cotton sufficiently well for any one to understand the advantages to be expected from its use, and to perceive the defects which may prevent its adoption. I now propose to give a slight sketch of its history, in order to fill up the interval between its first introduction to public notice and the appointment of the present Committee of inquiry.

The invention of gun-cotton dates from 1846, and is generally attributed to Professor Schönbein of Basle, though the name of Professor Böttcher is often associated with his. These two brought it into notice in Germany during that year, and the former exhibited specimens of it in the autumn to the British Association when they assembled at Southampton for their Annual Meeting. It was the first explosive compound of the kind, but an inflammable compound partaking of the same nature had been discovered by Braconnet in 1833, and an application of this discovery to military purposes had been suggested by M. Pelouze in 1838.

The compound produced by Braconnet was called xyloidine; and consisted of wood shavings, sawdust, starch, or some linen fabric, treated with highly concentrated nitric acid. The resultant substance was gelatinous and highly inflammable. M. Pelouze proposed to utilize the invention by preparing the substance in a form which would serve for artillery cartridges. He considered that if the cartridge were thus made it would be entirely consumed at the discharge of the piece, and there would no longer be any danger from burning fragments being left in the bore and causing premature ignition when a new cartridge is inserted.

M. Pelouze does not appear to have carried out this application, or to have prosecuted his researches to any important result; but his remarks attracted attention among chemists, and when Schönbein announced that he was in possession of a secret method of making an explosive cotton, there appeared other claimants to the honour of the discovery and to the possession of the secret. Amongst the rest was M. Otto, Professor of Chemistry at a college in Brunswick; and a gun-cotton of his manufacture proved to be very similar to Schönbein's. The acid he at first used for making it was produced by the distillation of ten parts of dry saltpetre and six parts of sulphuric acid, but afterwards at the suggestion of other chemists he used a mixture of nitric and sulphuric acids with much better results. He made public all that he knew, and his cotton was fired for experiment from light pieces of artillery.*

It is not surprising that more than one person should have succeeded in making an explosive substance of this nature, when we consider that the ingredients are susceptible of some variation; the use of cotton is not indispensable; flax, straw, rags, sawdust, or any other form of the substance called lignine† may be substituted for it, and cotton is only selected for secondary reasons, such as the greater convenience for preparing and applying the finished material. It has already been mentioned that Braconnet employed woodshavings and linen fabrics in conjunction with nitric acid to make xyloidine in 1833, and it only required the addition of sulphuric acid in proper proportion to make a near approach to gun-cotton.

The year 1846 may however clearly be taken as the starting point for any historical essay on gun-cotton itself. In most of the countries of Europe official enquiries were instituted to determine whether it might not immediately be used for artillery or small-arms. In England there was not (so far as I am aware) any official inquiry, but there was no want of interest in the discovery. In January 1847, a few months after Schönbein had exhibited it to the British Association, Professor Brande gave a lecture upon it at the Royal Institution, a patent was taken out shortly afterwards to protect the invention, and Messrs Hall, owners of the large powder mills at Faversham, made arrangements for manufacturing gun-cotton on a large scale.

An abstract of Professor Brande's lecture is given in the Annual Register for 1847. He traced the invention back to Braconnet's discovery, gave some illustrations of the great power possessed by the new substance, and compared the advantages and disadvantages attendant upon its use; among

* Journal des Armes Spéciales; 3e série: tome 1er. (1847).

† Lignine is the encrusting matter which is deposited in layers on the cellular membrane of plants.—Encyclopædia Britannica, 1854, Vol. V. p. 72.

the former he mentioned its extreme cleanliness, owing to the absence of residue; the freedom from thick smoke or bad smell, and the safety and ease with which it could be made. Among the disadvantages he stated that the effects were less regular; that it burnt but slowly in cartridges; that it did not burn at all when compressed in tubes; and that the barrel was moistened by water produced during the combustion. He also pointed out the danger arising from the low temperature at which it would take fire.

At the delivery of this lecture the ingredients which Schönbein used were not known, because the patent had not been published, but the cotton wool was supposed to be treated with a mixture of two parts sulphuric to one of nitric acid. At so early a stage it was premature to form a decisive opinion on the prospects of gun-cotton; Professor Brande pronounced that it would no doubt be used extensively for mining purposes, and for several military engineering operations; but was doubtful whether it could be adapted for the use of large or small guns.

Among the purposes to which gun-cotton was applied at this early period of its existence was the manufacture of rockets. What sort of flight was obtained with the rockets so made I have not found mentioned, but the idea of this application being successful is at present rejected by the best authorities. They consider it the purpose for which, of all others, gun-cotton is the least suited. The only fact I have met with is that the process of making the rockets killed three men. The accident occurred in Mr Wade's manufactory at West Ham. The method of making them was to insert successive layers of cotton and to ram down each layer separately by hoisting up a block of wood with a rope and letting it fall into the rocket case. The foreman of the works had so little fear of danger that he frequently (as he stated at the inquest) held the cases between his knees whilst he rammed down the cotton, but the workmen had orders to retire behind screens, put up for their safety, whenever the block or "monkey" was going to fall. Whether these men had neglected the precaution is not stated, but an explosion happened; two of them were killed at once, and the third died of his injuries.*

The date of this unfortunate occurrence was the 24th June; on the 14th July there happened a more serious accident at the new factory established by Messrs Hall, the patentees in England of Schönbein's invention. The explosion caused far more injury to life and property, and as the immediate cause could not be clearly determined, it led to the manufacture being condemned as too dangerous to be kept up. There were four buildings in the factory, out of which two were in use; each was forty feet square and had walls eighteen feet thick; between every two there was an earthen mound forty feet high, and it was hoped that if an explosion happened in one it would do no harm to another. The precautions failed. The ruins of the building where the explosion occurred broke through the roof of the other and set fire to its contents. Buildings, trees, and corn for a wide circle around the spot were more or less damaged. Twenty-one persons were killed and sixteen were seriously hurt; some died of their injuries; one man lost his life from the fumes of nitric acid gas among the ruins in which he was helping to extricate the victims of the explosion.†

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* Annual Register; 1847, p. 74. † Ibid. p. 87.

A practical chemist who superintended the works was amongst the killed. The verdict of the coroner's jury was that "no evidence appeared how the explosion arose," and that no blame was to be attributed to any of the managers. The proper temperatures for the workshops were 120° for one and 110° for the other, and the man in charge of the fires which warmed them deposed that they were as near that as possible on the morning of the explosion, which took place at 11 a.m.

All further manufacture was given up, and all the cotton that had been converted into gun-cotton was buried in the ground as the safest means of getting rid of so uncertain and dangerous a stock. Sixteen years afterwards some of it was dug up for its qualities to be tested. Throughout this period, from the interment to the disinterment, gun-cotton may be considered to have been in a dormant state, so far as this country was concerned, and any attempts to introduce it were suspended. Professors of Chemistry noticed it in their lectures, and praised its powers but condemned it as unpractical. Amateurs of Chemistry made it for their amusement, and generally found cause to avoid it for their safety. It was considered as little likely to become a safe and useful servant as an Ethiopian to change his skin, or a leopard his spots.

Such reports as came from France and Germany, where the inquiry was more systematically conducted, served to corroborate the opinion formed in England. Sooner or later it came to be condemned in all countries, and in all but one it was given up; in Austria alone, men of rank and influence clung to the idea; they were able to get a hearing for it, and they persevered in it, until, after being more than once adopted and rejected, gun-cotton is acknowledged and used by the artillery and engineers. It is therefore in Austria that we shall find the links which connect its fall in 1847 with its rise in 1863, and learn the incidents which accompanied its progress, or had any influence on its career. There happened to appear lately, in a German Military Periodical, an article which relates these details, and as I have reason to believe it may be depended upon as a guide, I have made the following epitome of it, adhering as far as possible, where the statements are of importance, to the exact words used by the writer.

History of Gun-cotton in Austria.

The attention of the Diet (Bundesversammlung) being called to gun-cotton in 1846, by Professors Schönbein and Böttcher the two inventors, they appointed a committee, composed of officers from different German armies to report upon it. This committee pronounced it altogether inapplicable to military purposes; and experiments made about the same time at Vienna and other places led to equally unfavourable opinions being formed.

But one of the members of the committee above-mentioned, Baron von Lenk, a captain in the Austrian artillery, continued his investigations after the committee was dissolved, and his efforts were so far successful that he produced a material whose *possible* applicability to military purposes could not be denied. His experiments were conducted in the first two years (1847 and 1848) almost exclusively at Mayence; afterwards, in 1850 and 1851 they were made also at Vienna, and he received the support of Feldzeugmeister Count Degenfeld, the present Minister of War.

By their joint efforts, backed by the representations of the "General Director of Artillery," Ritter von Hauslab, the government was first induced to extend the experiments, and next to purchase the invention for the sum of 16,000 gulden (about £1350). A gun-cotton committee was appointed, of which von Hauslab was named President, with instructions to make searching inquiry into the material as improved by Baron von Lenk, and adapt it if possible to the use of the service.

It was in 1852 that the committee was appointed; early in 1853 their experiments began. The first conclusion drawn from their trials was that gun-cotton is better suited to artillery than to small arms, and that the first object of their endeavours should be to perfect it for the use of ordnance. In order to produce the cotton on a larger scale the Chateau of Hirtenberg, not far from Wiener-Neustadt, was purchased and turned into a manufactory; and soon afterwards the construction of a 12-pr. gun-cotton battery was determined upon.

The battery consisted of 6 guns and 2 howitzers, constructed almost exclusively from the designs of Baron von Lenk, who was named shortly afterwards Director of the gun-cotton matériel. The pieces were shorter than usual in the bore, but had a greater strength of metal at the base ring; they had short conical shaped chambers, and the charges were of compressed cotton.

This battery was certainly superior in many points to those of the established system. The pieces admitted of easier and quicker loading, the carriages were lighter, and there was increased accommodation for ammunition, but these were held to be as much due to other improvements as to any advantages necessarily resulting from the use of cotton. The superiority in range, accuracy and percussive force of the shot was disputed; in the execution of field manœuvres the battery was excellent, but it had so active a commander and such able officers that it would undoubtedly have been a model battery under any circumstances.

Its performances gave sufficient confidence for four more batteries to be ordered, and they were to be attached to the army of observation which was then (1855) in Gallicia. They were never brought into use. The war with Russia ended, the army was reduced, and a close examination of the state of the gun-cotton pieces showed that besides other objections, which had been already noticed, the effect of gun-cotton was ruinous to the bore. It had been observed that the cotton was of very irregular strength,—that part of the charge was sometimes thrown out unignited,—that the range of the shot was sometimes far too short, and that the percussive force was very variable. Sometimes blue flames were visible in the bore for some seconds after the discharge, and more than once it happened that the charge took fire before the loading was completed. The examination of the bore showed that the inside was much deteriorated, and that in the vicinity of the vent, especially, it was burnt and enlarged in an incredible degree.*

In short the cotton had proved to be more destructive to the piece than

* Most of these results were probably due to the cartridges being made of *compressed* cotton, as stated in a preceding paragraph. In making up cartridges on the present plan compression is carefully avoided.

the strongest kind of powder would have been, whilst it only exerted a projectile force equivalent to powder of a very ordinary quality.

These results were decisive as to the immediate adoption of gun-cotton for the artillery service, and the question of its possible adoption fell, for a long time, into abeyance. The original battery was kept up a little longer for experimental purposes, but was then reduced. The matériel of all the batteries was diverted to other purposes. The "gun-cotton direction" remained in operation, but Ritter von Hauslab shortly resigned his post as President, and then the conduction of experiments and investigations fell into the hands of the Artillery Committee.

Artillery officers were generally averse to the introduction of gun-cotton, and the Artillery Committee was engaged in the production of a, so-called, "Project-material" as an equivalent substitute, so that it would now have come to a standstill, had not the exertions of Baron von Lenk obtained for it a better reception by the Engineer Committee, and thus opened a new field for its utility. In their hands it was applied to mining and submarine explosions, in the most various cases and under the most various circumstances, with a general result far superior to that of gunpowder.

During this time attempts were being made at the Hirtenberg manufactory to derive improved results for artillery practice by altering the form and composition of the cartridges. They put the cotton loose into the bag and pressed it. They pressed it in layers, and built up a cartridge therewith. They spun and twisted it; they wound it in wisps, and wove it like the wick of an argand lamp. They wound gun-cotton twist round pasteboard cylinders. They gave to cartridges of the same cotton, and containing the same quantity, different proportions of length and thickness. Much experience and useful knowledge was thus gained as to the mechanical part of the operation, but the chemical part was comparatively neglected. The mixture of the ingredients, and the process of converting common cotton into gun-cotton were assumed to be perfect, and left untouched, whilst the most elaborate modifications were made in the final stages of its preparation for use.

Thus matters stood in 1859, when the Italian war broke out. Either from want of artillery ready for the field, or (as is more likely) with the view of having some novelty in the way of artillery to oppose to the French rifled pieces, three gun-cotton batteries were ordered to be equipped. The order was given before the battle of Magenta (4th June) but they had not had time to join the army when the peace of Villafranca was arranged (11th July). It does not appear that any gun-cotton was employed in blowing up bridges; if it had been used, says the writer of the article, some of those operations would probably have been more successful.*

As soon as hostilities had ceased in Italy attention was turned to the production of a rifled artillery; the subject had been begun before the war; it was interrupted by the campaign, but was now actively resumed in order that some system might be ready for application however soon the war might again break out. Lahitte's plan of rifling was adopted so far that no small number of the existing 6-pr. guns were converted into rifled pieces; this

* I have learned elsewhere that a supply was sent into Italy and would have been used in the defence of the fortresses if they had been attacked.

conversion of smooth-bores into rifles being one of the advantages which recommended the system to notice. The choice of this calibre was not a judicious one, as the guns were much heavier than the French 4-pr., whilst in power they scarcely excelled it; at the same time they were nearly equal in weight to the French 8-pr. which was a far more effective piece. But by the time this fact had become evident the Lahitte system was disapproved on other grounds, and it was not applied to any other calibres. A new system, peculiar to the Austrian service, was to be devised instead.

About this time Count Degenfeld became Minister for War, and with his appointment the subject of gun-cotton (to which he had previously given a a practical support) was re-opened. The old drawbacks were not forgotten, but the labours of Baron von Lenk, now arrived at the rank of Maj.-General, had been unceasing, and had brought the substance to an apparently sufficient degree of perfection. The direction which the present inquiry took was to determine how the guns could be best constructed: a year and a half passed away in experiments, and at the end of it the plan proposed by General von Lenk was adopted for rifled field and mountain artillery.

The system included guns of three calibres—3-prs. for mountain service, 4-prs. for general field service, and 8-prs. for guns of position and reserve.* The first batteries that were equipped left scarcely anything to be desired in facility of manœuvring, in the effect of the shells, and in the range which the projectiles attained. The manufacture was continued: thirty batteries were expected to be ready in the course of the following year, and in two or three years more the substitution of cotton guns for powder guns would be completed.

Nevertheless there had been several mishaps in the course of the experiments and practice, even when carried on in the neighbourhood of Vienna, and, mostly, under the personal superintendence of the Director. The strength of the cotton was still uncertain and its ignition occasionally incomplete; the bore was still injured; it was reported that some of the charges had taken fire during the loading, and some of the shells had burst in the bore. Still it was thought that part of these objections would be overcome, and that the rest were no worse than those to which the use of powder was equally subject, happening sometimes from the untrained awkwardness of the men. Many of the advantages were important and undisputed, and although artillerists generally regarded the substance with mistrust and dislike, its pre-eminence in the service seemed to be established.

Suddenly there came a change, greater than any that had yet happened to the prospects of gun-cotton, and almost unparalleled in the history of any other invention.

In preparing to introduce gun-cotton for small arms two sorts had been provided for practice: one of them, Lenk's, gave such bad results that the opinions of commanding officers of corps were unanimous against its being used, and the other sort, which showed itself altogether superior, met with no appreciation. It was to be expected that the adversaries of gun-cotton

* These calibres are now in use; if, however, the names given to the pieces expressed the weight of the heaviest projectiles they would be called 5½-prs., 7-prs., and 12½-prs.; and, allowing for the difference between the Austrian pfund and the English pound, they are equivalent to 7-prs., 9-prs., and 16-prs.

should make the most of such expressed opinions, but we must confess that its best supporters had almost provoked this unfavourable disposition by the secrecy in which they had hitherto kept the whole subject. Any artillerist who was not immediately interested in the cotton side could procure no satisfactory explanation of the present state of things; he could neither learn the improvements which had undoubtedly been made to the manufacture, nor find out the cause of the existing defects.

Almost simultaneously with the above unfavourable reports there occurred some slight accidents at Vienna, Verona, and Pola, such as the exploding of filled shells, and, in one case, of a mining charge which was in course of preparation. Lastly came an explosion at Simmering, near Vienna, in a magazine which contained considerable quantities of gun-cotton and gunpowder. The cause of the explosion was never conclusively ascertained, but the general belief was that the cotton, still rather damp and closely compressed, had taken fire spontaneously. The error of this opinion was shown by many authorities both at home and abroad, but it held its ground, certain journals supported it, and the opponents of gun-cotton turned it to the best advantage.

It is hard to decide whether these mishaps or the imperfections of the system caused the new artillery to be laid aside. There is still some obscurity about this point. But it is quite clear that too much importance was attached either to the first successes or the late events. If there were objections of so serious a nature as to entail the rejection of the system, they must have shown themselves strongly enough and early enough to have saved the useless expense of equipping so many as thirty batteries.

The gun-cotton, and the gun-cotton guns were abandoned; the manufacture was stopped; the experiments and practice were discontinued; the batteries were withdrawn from the army and replaced by smooth-bores; some of the matériel was even broken up. The Artillery Committee was instructed to proceed with the construction of new guns for powder charges, but was at the same time charged with the further trial of gun-cotton. The "Gun-cotton Direction" remained in existence, but its inactivity was almost equivalent to a complete extinction.

The industry of the Artillery committee was great, and the plans which they tried were numerous, but they had found none to suit their requirements when Baron von Lenk made one more effort in support of his long cherished object. A favourable opinion from the Engineer Committee as to the keeping qualities of the gun-cotton aided his endeavours and led to a new commission being appointed. It consisted principally of scientific men from civil professions, including the most able professors of the University and the Polytechnic Institution at Vienna, but its president was a military man, General Baron von Kempen; he was not connected with the Artillery or the Engineers, but was held to be a man of shrewd judgment and impartial feeling.

The members of the Commission began their work with laudable zeal; they put the qualities of Lenk's cotton to every kind of proof; and it narrowly escaped being once more and for ever condemned.* For as

* "Es fehlte wenig dass die Schiesswolle auch dieses Mal und dann wahrscheinlich für immer bei Seite gelegt wurde." The writer, who is evidently in favour of replacing gunpowder by some kind

matters stood there could scarcely be a doubt about their decision. The great improvements in the cotton had been admiringly acknowledged, the probability of greater improvements had been admitted, and the advantages attending its use for certain purposes had been fully set forth; but at the same time it was indisputable that gun-cotton was still far short of that condition which would qualify it to supersede powder or to be generally used for warlike purposes.

If this opinion had been formally pronounced it would have been a final blow for gun-cotton; there had been so many disappointments that men were weary of trusting to the prospects of further improvement. But before delivering their report the attention of the Committee had happened to fall on a fresh point, and to be diverted in a direction highly favourable for the substance generally, though not for Lenk's preparation of it.

The question arose whether the method hitherto followed in cleaning the cotton and in the other steps of the process was the best.* The answers were generally to the prejudice of Lenk's cotton, but it appeared also that authorities were not agreed as to its actual qualities or the essential properties which it ought to possess.

A new preparation was however laid before the Committee. It was the production of many years' study and experiments, the author of which, one of the best known gunmakers (einer der berühmesten Waffentechniker), advancing by a different course and on different principles, had arrived at a far more satisfactory result. The little which has at present transpired about it shows that it is an incomparably more perfect preparation; and especially the inventor seems to have succeeded in obtaining uniformity in its rate of combustion,—in controlling the amount of force which it exerts,—and in mastering the tendency to too easy ignition.

There is scarcely a doubt that gun-cotton will now come into use. Its introduction for Artillery will be slow on account of the opposition it must encounter from the advocates of powder, and the expense of manufacturing ordnance best fitted to it. But in small arms it will have no such obstacles to overcome, and the experimental practice by the inventor, although unnoticed at the time, guarantees the best results. The necessary alterations to the muskets will be slight, and the cost trifling, whilst the advantages will be comparatively much greater than for ordnance. Amongst them may be mentioned that the loading will be more quickly and easily performed; the ramrod will be dispensed with, the weight of the ammunition pouch will be lessened, and the range of the bullet increased. Add to these the absence of smoke, the slightness of recoil, and the safety in manufacture which this preparation possesses in common with other gun-cotton, and there can be no doubt that its adoption will immediately attract attention from the Artilleries of Foreign States.

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of gun-cotton, appears very unwilling to allow Baron von Lenk any credit for the practical success of the invention.

* Es wurden die Fragen aufgeworfen ob der bisherige Vorgang bei der Ausbildung des Schiesswollwesens der richtige gewesen, ob die Schiesswolle zu der Zeit, als man sie zur Grundlage eines neuen Artillerie-Systems gemacht habe, schon die hierzu nöthige Vollkommenheit besessen, und ob nicht vielmehr ihre Zusammensetzung, oder der Vorgang bei ihrer Bereitung, sowie die Methode ihrer weiteren Bearbeitung einer wesentlichen Verbesserung bedürftig gewesen sei.

With this prophecy the article concludes. It will be observed that the gun-cotton whose future the writer thus predicts is not (according to him) due to the improvements of Baron von Lenk, but to the invention of a person whose name he refrains from giving. Nevertheless the qualities which he attributes to it are precisely those which Lenk's cotton is said to possess, and which constitute its claims to our consideration. I have not met with any notice of these statements elsewhere, but the inference to be drawn from the terms of the report which the Austrian Professors made to Baron von Kempen in June 1863,* would be opposed to them; and the fact that Baron von Lenk was permitted by the Emperor to come over to England and France with the view of furnishing information on the subject, is also adverse to the supposition that a more creditable agent might have been sent. At any rate it would be unwise to accept the assertions as facts until they are supported by some evidence. Baron von Lenk's visit to England is mentioned in the article, and some surprise is expressed that any gun-cotton which *he* had made should get so good a reception.† In France however he has been equally well received; gun-cotton is being made in England on his system for experiments there, and the Emperor Napoleon has, within the last few weeks, acknowledged his services by conferring upon him the decoration of a Commander of the Legion of Honour.

Baron von Lenk's visit to this country arose from the subject of gun-cotton being taken up by the British Association, to whom Major-General Sabine, R.A. President of the Royal Society, had suggested its consideration in 1862. The Report of the Committee appointed to inquire into it was presented to the next meeting of the Association, it was also brought under the notice of Government, and the importance of the facts which it brought forward led to the institution of the present Official inquiry.

Manufacture of Gun-cotton.

Among the other advantages offered as inducements for using gun-cotton instead of gunpowder, the comparative ease with which it is manufactured and the absence of any danger throughout the operation are specially mentioned. The latter statement appears at first sight to be at variance with what occurred at Feversham in 1847, but it may be explained by the experience which has been gained since that time. The report of the Austrian chemists, already noticed, declares that the manufacture "consists of a number of perfectly harmless operations," and that if fire is not actually applied explosion is impossible. The cotton which is being subjected to any handling is always in so damp a state that it must be free from that source of risk, and in the last stage of the process, when it has to be thoroughly dried, arrangements are easily made for communicating the heat with perfect safety.

At Hirtenberg, the Austrian establishment, no accident has occurred

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* Vide Vol. III. p. 367.

† Obgleich er eben nur *seine* Schiesswolle mitbrachte, so fand dieselbe eine unerwartet günstige Aufnahme.

during a course of twelve years' work. In Prussia, a drying chamber once blew up, but the accident is attributed to there being a stove with an iron smoke-pipe inside the room. At Hirtenberg the pipes which distribute heat are of earthenware, and the stoves are situated outside the drying room. Another case of explosion, which occurred near Vienna, happened in a magazine where gunpowder was stored as well as gun-cotton, and there was nothing to show that the latter had any share in the cause of it.

Of complicated machinery the manufacture of gun-cotton requires none. A sort of wheel or cylinder turned by steam power, and used to free the cotton from wet, by centrifugal action, is the only machine that is used. Stoneware bottles and vessels constitute the main part of the apparatus, and plain iron instruments serve for handling the cotton when it is fresh from saturation in the acids.

The cotton is obtained in the form of thread, spun to different degrees of texture and thickness according to its future application. For making artillery cartridges it is very loose and thick; for small-arms it is very close and fine; and for explosive purposes it is of an intermediate description.

The acids must be pure and of prescribed specific gravities; they are measured out in proper proportions (3 of sulphuric to 1 of nitric) and are mixed by being poured simultaneously into a stoneware vessel, and well stirred for some minutes afterwards. During the act of mixing some heat is produced, the temperature being raised upwards of 30°; when it is complete the mixture is put aside in a cool place and never used until at least twenty-four hours afterwards, in order that it may become quite cold.

The cotton is made into skeins, each skein weighing from 4 to 6 oz. if the quality is coarse, and from 3 to 4 oz. if the yarn is fine. In order to clean it from seed and other impurities it is first washed in a dilute solution of carbonate of potassa, and it is then thoroughly washed in plain water to get rid of that solution. When properly purified it is dried and put away for use.

About 12 hours before being required for immersion in the acid the cotton is hung up in a warm and well ventilated drying room, to expel the moisture which cotton ordinarily absorbes; at the end of that time it is taken down and put into stoneware jars with tightly fitting lids, whilst a proper quantity of the mixed acid is measured into a stoneware pan with an iron lid. Part of this acid is transferred into another deep stoneware jar, open at the top, but fitted with a perforated iron ledge and surrounded by cold water, and in this second pan the cotton is immersed by small quantities at a time. Each separate quantity is stirred about in the acid for two or three minutes; when fully saturated it is raised on the ledge, and pressed, to make the superfluous acid run off; this done it is put back into a covered jar similar to the one from which it was taken.

Fresh acid is transferred from the covered pan to the open one to replace what each quantity of cotton absorbs, and when a sufficient number of skeins (six of the coarse or nine of the fine) have been put into one jar they are pressed down and fresh acid is poured in until it completely covers them. The jar is then closed, put into a vessel of cold water, and allowed to remain in a cool building for forty-eight hours.

The object of having the water round the immersion pan, and the jars of saturated cotton, is to carry off the heat evolved by the action of the acids upon the cotton. In the immersing part of the process the water is highly important, for the first action of the acids upon the cotton produces a considerable degree of heat, but afterwards it is less necessary, for the cotton in the jars is not found to become seriously heated, even when no water is applied. The adding a fresh supply of acid after treating each separate quantity of cotton is found to be indispensable for securing the uniformity of the whole product.

At the end of the forty-eight hours above mentioned, the cotton is taken out of the jars with an iron hook, attached to the centrifugal machine, and whirled round until the acid is so far thrown off that the skeins are only damp. The purification then begins, and is a highly important part of the process, as the safety and permanence of gun-cotton mainly depend on its being perfectly rid of all "free" acid.

The first step is to plunge the cotton into water, agitating it in such a manner as will ensure that the penetration of the water throughout the fibres shall be immediate, for if the penetration were gradual and slow the union of the free acids with the water would cause a violent action of the nitric acid upon the cotton, and quantities of nitrous vapour would be disengaged. The next step is to wash it in a stream until no acid whatever is perceptible to the taste, and then to leave it immersed in a stream for not less than forty-eight hours, arranging the skeins so that the current may permeate freely among them.

At the end of that period the cotton is partly dried by the centrifugal machine and then boiled for a few minutes in carbonate of potassa. This done, and the superfluous liquid thrown off by the centrifugal machine, it is restored to the stream, arranged as before, and left for fourteen or eighteen days. On final removal it is washed by hand once more, to cleanse it from dirt and mechanical impurities, and, after being thoroughly dried, is fully ready for use.

When this process is compared with the various operations and the numerous machines which the manufacture of gunpowder embraces it is evident that the comparative simplicity attributed to the former has not been overstated. The ingredients of powder, after being carefully refined and prepared, have to be mixed, by a machine,—"incorporated" or ground together in another machine,—submitted to heavy pressure in a hydrostatic press,—"granulated," in an ingenious self-feeding machine, by toothed gun-metal rollers,—"dusted" by machinery,—and, in the case of fine powders, "glazed" by producing a friction of the grains against one another. Moreover, some of these operations are accompanied by so much risk of explosion that no ingenuity or caution can entirely remove the danger, and not a year passes without fresh accidents being recorded. On the other hand the manufacture of gun-cotton, when reduced to its simplest terms, consists merely of a series of soakings, washings, and dryings, repeated often enough to ensure three things. First, that the cotton be thoroughly pure and dry before it is impregnated with acid; second, that every particle of cotton shall be well saturated with acid; and lastly, that all the free or superfluous acid shall be entirely removed.

The process by which these points may be best attained is susceptible of some modification in its details. The system that has been described is the course which Mr Abel has followed at Waltham Abbey; at Hirtenberg the latter part of the process, viz. the purification from free acid, is differently managed, the cotton being left for three weeks in a stream, after which it is subjected to a further course of treatment with a solution of soluble glass. This is adopted partly with a view to retarding its rate of explosion, and partly to neutralize any lingering traces of acid which the washing may have failed to remove. It is also supposed to protect the gun-cotton by acting as a varnish upon the fibres, and making it less sensible to atmospheric influences.

The solution may be driven into the cotton by means of a centrifugal machine, to which the liquid is supplied by a central tube; or it may be put into a large tub, and the cotton may be soaked in it. After this treatment the cotton is dried, then immersed in a stream for five or six hours, and once more washed by hand previous to being finally dried and put away for use.

According to the patented process the gun-cotton is not treated with carbonate of potassa at all, but is boiled, after the first washing, in a weak solution of soluble glass, and is then immersed in a stream for about six days without any intermediate drying. Baron von Lenk attaches great importance to the treatment with soluble glass, but the examinations and analyses made by Mr Abel show that so very small a proportion of glass remains in the cotton after its final washing that it is impossible to understand how any protective effect, or any change in the rate of explosion can result therefrom. The point will probably be settled by experiments which will be made upon it.

The skeins of cotton which, as already mentioned, are of different degrees of fineness, are now ready to be made up in such forms as are most convenient for practical use. Artillery cartridges are made by winding the cotton round hollow cones of wood of such length as will ensure the most effective results from the explosion, they are then put into flannel bags or any other envelopes for protection in packing and travelling, and are usually loaded in this state, the presence of the envelope being immaterial as regards the discharge.

Bursting charges for shells are prepared by weaving the cotton into the form of a continuous hollow cylinder, or line, this being the most convenient way of inserting it through the fuze-hole. The same form is used for match lines, and also for small-arm cartridges. In making the latter however, webs of different sizes are required, so that one may be slipped on over another, and layers of paper interposed between them. This is adopted as the best arrangement for carrying out in fire-arms of this kind the object which is attained in pieces of artillery by the use of hollow cones. In Austria the most successful cartridges have been made with three layers of woven gun-cotton and two of paper. In all cases where a rammer has to be used, or a cartridge pressed into its place, the cotton must be so arranged that it will not undergo any compression, as results of considerable importance depend on the amount of space which it fills.

For mining purposes, the most useful and effective way of applying the blasting charge is to make it up as a hollow twisted rope, and if shells for artillery fire have a cylindrical chamber which can be thrown open, it is desirable to fill them likewise with pieces of twisted rope exactly adapted to the interior space.

The foregoing remarks have briefly touched upon the most striking points connected with the qualities, application and manufacture of gun-cotton, and have traced its history down to the commencement of the present inquiry. The two points which seem to be the most doubtful in connexion with the practical utility of the material are the uniformity of its action as a charge for fire-arms, and the permanence of its qualities under high degrees of heat. We have to learn whether it can be manufactured in large quantities with exactly the same degree of strength, and whether the arrangement of the cartridges and the strain under which the cotton is wound can be regulated so as to ensure a uniform result upon the piece and its projectile. We have also to ascertain whether high degrees of heat, such as ammunition must necessarily be exposed to in hot climates, have any prejudical effect on the strength of gun-cotton or give rise to any danger of its explosion. On all other points we may, I think, safely conclude, from the reports of experiments made elsewhere, that gun-cotton would be a desirable substitute for gunpowder. It requires indeed more delicate management, but it can be applied to all the various purposes for which gunpowder is used, and is capable of producing a far more powerful effect.

MUZZLE-PIVOTING GUN CARRIAGE.

By Lieut.-Col. G. SHAW, R.A.

ASSISTANT SUPERINTENDENT, ROYAL CARRIAGE DEPARTMENT.

At a time when such efforts are being made to provide our ships and forts with defensive armour, and as, in such armour, the weak points are the necessary openings for the guns to fire through, namely, the ports and embrasures, it is almost unnecessary to expatiate upon the desirability of having such openings as small as possible.

It is plain that so long as the trunnions of the gun remain the centre of oscillation for elevation and depression, the ports and embrasures in casemates cannot be of a less height than they now are, say 4 ft., and as they are 2 ft. wide, every port presents an open area of 8 ft.; and that space multiplied by the number of ports in a ship's side renders the main deck of a ship of war a very unsafe place in time of action. For this reason I turned my mind to the designing of a carriage which would enable the gun to have its centre of oscillation at the muzzle; and last autumn I submitted to the Ordnance Select Committee a drawing and specification of a casemate carriage for a 68-pr. 95 cwt. gun, which was to pivot at the muzzle, and to give 10° elevation and 5° depression, on an ordinary casemate platform. My proposal was favourably received, and I was given a 68-pr. gun, and ordered to make a carriage for it.

I will first describe briefly the general principle by which I obtain muzzle pivoting. The gun is supported on two sets of wrought-iron arcs of sufficient strength, with the centre of gravity of gun between them. The centre from which these arcs are described is at the muzzle of the gun. These arcs fit into gun-metal sockets, in the brackets of the carriage, of the same radii as the arcs. It is evident that if the gun be firmly attached to these arcs, and if these arcs be moved in the direction of the circumferences of circles due to their common centre, that centre, viz. the muzzle of the gun will remain stationary; and this is what actually takes place when elevation or depression is given in this carriage.

I will now endeavour to describe the details of construction, and with the help of the accompanying drawings, I hope to make myself intelligible.

The woodwork of the carriage is put together in the usual way. The brackets are of 7 in. teak, 3′ 6″ high, 7′ 2″ long, and the distance between them is 2′ 7″—the transom is teak, and the blocks, sabicu. The wrought-iron arcs before alluded to, which support the gun, are 6 in. wide and 2 in. thick, and are toothed on their front surfaces, and are of convenient length to suit the depth of bracket. The gun-metal sockets in which these arcs work are cast with a pinion-box and bearing for a shaft to go through to the outside of the bracket.

As the front set of arcs have a less radius than the hind set, when the gun is raised or lowered they would have a shorter distance to go through than the latter. This proportion is regulated by the diameter and number of teeth in the pinions which work the arcs. In this case the proportion is as 5 to 8; and, consequently, the front pinions have 10 teeth and a diameter of 5 in. while the hind set have 16 teeth and a diameter of 8 in. The front set of pinions are keyed on a shaft which goes through both brackets in front of the transom; on the outer ends of this shaft are worm-wheels 16 inches in diameter. The hind set of pinions are not connected by a shaft but are each attached to a worm-wheel outside the bracket by a short shaft that works in the gun-metal bearing before alluded to.

The worm-wheels are worked by a shaft passing under the hind wheels and over the fore. This shaft has a right-hand screw worm, one inch pitch, for the hind wheel and a corresponding left-hand screw worm for the front wheel. These shafts are worked by a hand wheel at each end, 2 ft. in diameter.

The whole of this machinery is geared together by the two side shafts and the shaft that connects the two front pinions. A compressor is fitted on each arc, which, when set up, takes the strain off the pinions. The degrees of elevation are marked on one of the worm-wheels, and the degrees of depression on one of the hind arcs. With a power of 30 lbs. applied to each hand wheel a weight of about 22,400 lbs. can be raised.

I now propose to explain how the gun is attached to the arcs. On the insides of these arcs, and 4 in. above and below the axis of the gun when at point blank, solid pieces of wrought-iron are forged, 8 in. high, 4 in. wide, and projecting inside the bracket 1·5″.

The gun is prepared to receive these supports by having its trunnions cut off, and having coils of suitable thickness shrunk on, and slots cut in the sides of these coils to correspond with the supports on the arcs,—these slots being cut at distances from the muzzle of the gun corresponding to the radii of the arcs. These slots are cut through from the lower part of the coil to 4 in. above the plane of the axis of the bore, where 1·5 in. of metal is left to support the gun upon the projecting pieces on the arcs.

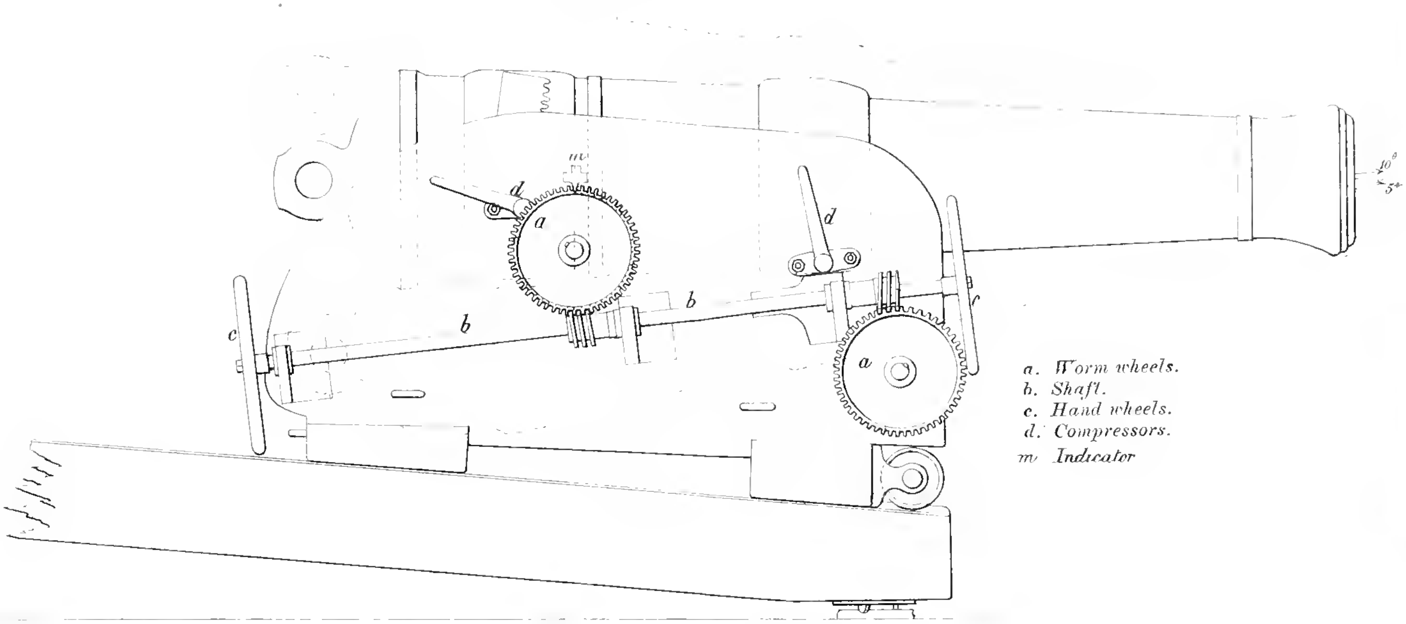
The gun when required to be mounted is slung in the usual manner, care being taken to keep it horizontal, and is lowered on to the supports on the arcs, which have been previously laid at point blank.

Owing to this carriage being altogether of a new construction, and in the absence of special machinery, much of the work had to be done by hand, special tools had to be made, and new patterns prepared, so that it was not finished till early in Spring, when the gun was mounted, and without further fitting or alteration was easily worked by four men; and it pivoted exactly on the muzzle.

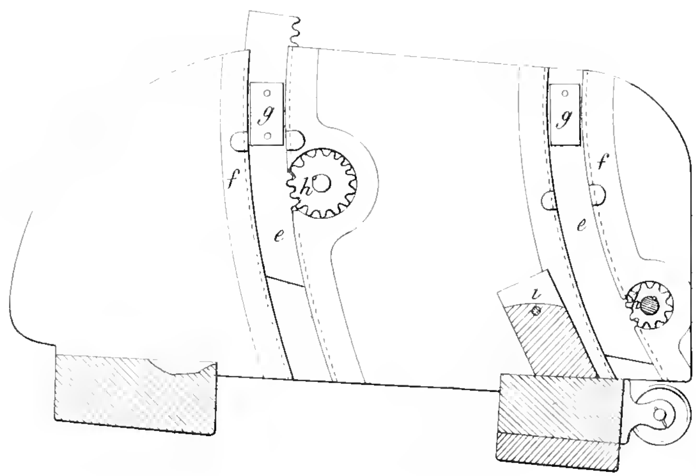
The gun and carriage were first inspected in the Pattern Room by the Select Committee, when the gun was worked several times from extreme elevation to extreme depression, and it took 2 min. 35 sec. to raise the gun from 10° to point blank. The Committee on a subsequent occasion inspected the gun at the Proof Butt, when it was fired 10 rounds, with 16 lbs. of powder and solid 68-pr. shot. The carriage was not the least shaken, and the gun was worked quite as easily after the firing as before. The gun has now been ordered to Shoeburyness for a more extended trial.

LIEUT. COL. SHAW'S MUZZLE PIVOTING CARRIAGE.

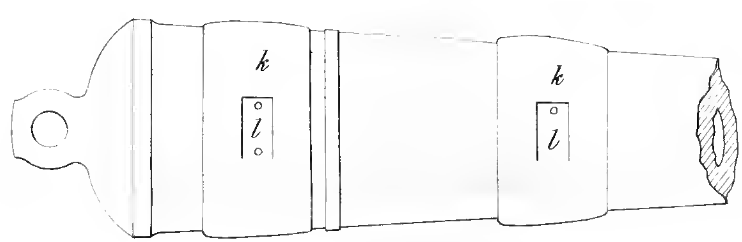
Scale, ¼ inch to a foot.



a. Worm wheels.
b. Shaft.
c. Hand wheels.
d. Compressors.
m. Indicator



e. Arcs.
f. Gun metal sockets.
g. Supports for gun.
h. Pinions.
i. Transom.



k. Coils.
l. Slots in do. for supporting the gun.

Lithographed at the Royal Artillery Institution.

This system of elevation has been objected to by naval men on account of the slowness of the operation, but I maintain it is quite fast enough for real warfare: it is seldom that an alteration of more than 2° can be required between two consecutive shots, and it must be borne in mind that as the muzzle of the gun is always the same height from the deck or ground it can be loaded at any angle of elevation or depression, and as the degrees of elevation are marked on the worm-wheel, the operations of elevating and loading can go on simultaneously, by which means much time is saved. Another advantage of this system is that when once the elevation is accurately ascertained any number of shots may be fired without any re-adjustment, which is not the case with guns elevated on the principles which now obtain in the service.

Another objection to this system, which I freely admit, is the very limited field of view; it is certain that better practice is to be made from guns *en barbette* than from guns in casemates with embrasures only a few inches larger than the muzzle of the gun, but if we expect perfect protection for our gunners from hostile projectiles we cannot expect an unlimited field of view; however, as I propose leaving a space of 4 inches over the muzzle, which will be constant, I think the field of view will be quite as good, if not better, than it is at present in our armour-plated ships, where, when firing with extreme elevation it is *nil.*

In my opinion the great objection to this carriage is the necessity of cutting off the trunnions of the gun, thereby rendering it useless for mounting in any other carriage; but I hope to do away with that difficulty in future. I am now preparing drawings of a carriage for a 12 ton gun, in which the gun can be mounted without being mutilated in any way; and however imperfect the present carriage may be, I have still every reason to be satisfied that at a first attempt I have succeeded in producing a carriage for a 68-pr. gun, that does pivot at the muzzle,—that can be easily worked by an ordinary detachment,—and that has stood 10 rounds of service charge without any signs of weakness.

NOTE.—Since writing the above, 100 rounds have been fired from the carriage at Shoeburyness, viz.:—50 at 10° elevation, and 50 at 5° and 4° depression. The carriage stood the test perfectly with the exception of the cast-iron handwheels, two of which were broken, and two cracked by the concussion; they will be replaced by wrought-iron winch handles.

REMARKS

ON THE

EMPLOYMENT OF THE SEXTANT, FOR OBSERVATIONS REQUIRING GREAT PRECISION.

By Captain R. W. HAIG, R.A.

So many books on navigation and practical astronomy have been written containing descriptions of the sextant, and explanations of the method of using it, that it may be thought presumptuous to attempt to add anything to what has been already said.

The principle which I am about to allude to must have forced itself upon the attention of many observers, but I have never seen it dwelt upon or impressed upon the beginner as of any importance, in the books that have come under my notice. It is to make observations in such a manner that the instrumental errors of the sextant must necessarily be nearly eliminated in the final results. Thus, in determining latitude on land by circummeridian observations, it is necessary, if accuracy is required, to observe objects both north and south of the zenith, and the same principle applies in the case of single altitudes for time: in this case stars both east and west of the meridian should be observed. In determining the longitude by lunar distances, the distances of objects on both sides of the moon should be measured. In all these cases as many observations should be made on one side as on the other, or if this is impracticable, as it sometimes may be, then having obtained a result from all observations upon one side and another from all upon the other side, the arithmetic mean between these two results should be adopted, without regard to the greater number of observations that may have been taken to produce one result as compared with those for the other.

Another point to be attended to as much as possible is to choose stars equally distant from the zenith or moon as the case may be.

The ordinary reconnaissance observations of daily recurrence are those for time and latitude, and the usual method adopted by travellers is to observe the sun only. Now unless they start late in the day they must halt at least twice on their journey to make the requisite observations, and then the observations for time and latitude being made at different places have to be reduced to the same place by dead reckoning or judgment. This also is the method used at sea where, as the ship's course and rate of speed are constantly recorded it is not liable to the errors occasioned by the variable circumstances of travelling on land.

The method recommended is to dispense with observations of the sun altogether, unless for occasional convenience (*e.g.* in cloudy weather where any opportunity is welcome), and rely upon stars only. The observations made should be ten altitudes of a star about the time of its culmination south of the zenith, and ten similar observations of a star north of the zenith. Five altitudes of a star as near as possible to the prime vertical east of the meridian, and a similar number of a star nearly in the same position west of the meridian.

In north latitude where the pole star is at a convenient height for observing; ten observations on it at any time may be substituted for the circummeridian observation north of the zenith. The advantage of so doing as regards economy of time is very great, as it will be perceived that the only star out of the four which requires to be observed at a fixed time is the one culminating star south of the zenith. The other stars may be observed before or after this one according to the will or convenience of the observer. The star south of the zenith will be convenient for observing for two or three consecutive weeks, and a mere glance at the observation book for two places on consecutive nights gives immediate and tolerably accurate information with regard to the northing or southing made during the day. Continuous observations of the same stars obviate the necessity of removing the telescope from the sextant in order to bring the star down, as it is called, or to make both images of the star appear in the field of the telescope.

An hour is amply sufficient to make the suggested observations, including those for index error.

In observing stars near the meridian for latitude, it is a good plan to give the slow motion screw a turn or two in either direction after each observation before making another, in order that the judgment may not be biased by knowledge of which way the star ought to have moved with reference to its last observed position. The previous observation may have been a bad one, but however good, it should have nothing whatever to do with the one following it. Every observation should in fact be truly independent. The most convenient method of observing the time star is to set the instrument at a particular reading, wait for the two star images to coincide, and note the time of coincidence. In observing with the artificial horizon, the observer should sit down either on the ground, or on anything not higher than a sextant box; he will then find that his right knee affords a firm support to his right arm near the wrist.

If the system of observing stars uniformly and of not depending on the sun be adopted, it will be advisable to have the pocket chronometer or chronometers regulated to sidereal time.

Box chronometers, such as are used on board ship, cannot be carried on shore so as to preserve anything like a uniform rate, but they are very useful in a field observatory where a transit or other telescope is the instrument observed with.

Having objected to observations of the sun as compared with those of stars, it may be well to show what increase of accuracy may be expected from the latter, always excepting equal altitudes of the sun for time. These involve the principle now advocated and give unexceptionable results, but occupy a whole day, and are therefore generally impracticable.

Besides index error sextants usually and almost invariably have other large errors arising from various causes, which it is not my intention to enter into here. They have been fully discussed by Mr W. H. Simms,* and

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* The Sextant and its Applications, 1858.—Taylor and Francis.

later by Professor Chauvenet,* Professor of Mathematics, &c., at the Washington University, St Louis. These investigations appear to exhaust the subject, but very few observers will take the trouble to make the requisite observations to determine the errors of their sextants at all angles. On the North American Boundary Commission several sextants were used by different observers, and with all of them the following fact appeared: The latitude by southern stars was always from 40″ to 80″ greater than that by northern ones, from which it is evident that there was generally an error of from 20″ to 40″ in a result from northern or southern stars only. A corresponding discrepancy was also found between the times by stars east and west of the meridian. When the altitudes of the time stars were corrected by half the difference between the latitudes and the times recomputed, they invariably agreed very closely. Moreover, sextant latitudes were frequently compared with those obtained by the zenith telescope, an instrument of undoubted power, having an aperture of three inches and a focal length of 40 inches. The greatest discrepancy in such comparisons was 6″, but in several instances it was as small as 1″. From these comparisons it became evident that with a good observer a set of sextant observations, such as are suggested, would give a latitude differing less than 5″ or 500 ft. on an average from a result obtained by the most powerful instrument. If the sun only were observed and the only correction applied to the observed altitude, that on account of index error a difference of about 30″ or 3000 ft. might be expected. Stars are somewhat but not much more difficult to observe than the sun, and to make the observations two lamps are required, one for the observer, and the other for the recorder; the oil for these lamps should be of the best quality. None but those who have experienced it can know the unsatisfactoriness and loss of time and temper consequent upon attempting to make observations with lamps that burn badly. With management and a practised recorder one lamp (Bull's eye) may be made to answer, but it is more convenient to employ two. When the observer is obliged to record his own observations and to note the chronometer times, the following method will be found accurate and simple:—Either hold the chronometer in the left hand or place it in such a position that its beats can be distinctly heard. At the moment of contact of the two objects in the field of the telescope commence counting the beats of the chronometer, beginning at 0, which beat should be that most nearly coincident with the time of contact. Before counting up to 10 there will be plenty of time to turn the attention to the face of the chronometer, and the position of the seconds hand at the tenth beat should be carefully observed. Subtract 4 seconds from this observed time (as pocket chronometers beat 10 times in 4 seconds) and you have the accurate chronometer time when the observation was made. This method of observing the time is applicable to almost every description of observation. Its only objection is that it occupies four seconds of time.

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* Spherical and Practical Astronomy, Vol. II. 1863. J. B. Lippincott and Co., Philadelphia.

ANNUAL REPORT

AND

ABSTRACT OF PROCEEDINGS OF A GENERAL MEETING OF THE ROYAL ARTILLERY INSTITUTION, HELD ON MONDAY, MAY 30, 1864.

MAJOR-GENERAL SIR R. J. DACRES, K.C.B. IN THE CHAIR.

1. THE Committee present to the General Meeting, with satisfaction, the Annual Report and Abstract of Accounts for the year ending 31st March, 1864.

It will be seen that there is an increase of Members during the year amounting to 59. The distribution of the increase and decrease, under the several Ranks, is shown in the accompanying Table.

RANK.	£	s.	d.	April, 1863.	Since joined.	Promoted or withdrawn.	Deceased.	April, 1864.
EFFECTIVE LIST.								
General and Regimental Field Officers, paying annually	1	5	0	158	+15	— 6	— 4	163
Captains	0	16	0	379	+27	—11	— 6	389
Lieutenants	0	10	0	445	+64	—15	— 7	487
Quarter-Masters	0	10	0	6	+ 2	0	0	8
Riding-Masters	0	10	0	3	0	0	0	3
Surgeons-Major	1	5	0	3	+ 1	0	0	4
Surgeons	0	16	0	5	0	0	0	5
Assistant-Surgeons	0	10	0	20	+ 2	0	0	22
Veterinary Surgeons	0	10	0	2	0	0	0	2
RETIRED LIST.								
General and Regimental Field Officers	1	5	0	18	+ 1	0	— 1	18
do. do.	0	16	0	2	0	— 1	0	1
do. do.	0	10	0	7	0	0	— 1	6
do. do.	0	7	6	7	0	0	0	7
Captains (D. W. Pack Beresford)	5	0	0	1	0	0	0	1
do.	0	16	0	12	0	0	0	12
do.	0	10	0	5	0	0	0	5
do.	0	5	0	7	0	0	0	7
Surgeons-Major	1	5	0	2	0	— 1	0	1
				1082	+112	—34	—19	1141
Honorary Members	0	10	6	26	+ 1	0	— 1	26

Although it is contrary to custom for the Committee to single out for special regret any Officer among those annually lost to the Institution by death, they feel obliged to make an exception in the case of one so closely connected with the Regiment, for many years, as the late Deputy-Adjutant-General. In recording their deep sense of the bereavement sustained by the Regiment in the loss of Colonel Charles Bingham,—whose administrative ability, large experience, and clear knowledge of details, rendered him a most valuable public servant,—they feel bound to allude to qualities of the heart possessed by him in a degree rare among men tried with all the difficulties and vexations of office.

In him the same kindness and evenness of temper were shown in time of relaxation and under the pressure of an unsparing weight of business. He was no respecter of persons, but was accessible alike to the Senior Officers of the Corps and to the youngest Subaltern.

From the time when he entered upon the duties of Brigade-Major at Woolwich in 1849 until he received, a few days before his death, the appointment of Inspector-General of Artillery with the rank of Major-General, as a mark of the high approbation of His Royal Highness the Field Marshal Commanding-in-Chief—*he worked hard*—so hard that he was never destined to enjoy the honors of his last appointment.

The Crimean war, the re-organization of the Regiment upon the Brigade system, the Indian Mutiny, and finally the Amalgamation of the Services which sprang out of it, found him at his post, and taxed both mind and body, so that his health gave way just as the prospect of lighter labour was held out to him.

With a wise discernment and freedom from prejudice he sought to foster, without partiality, whatever aimed at advancing the interests of the Corps; and, as meeting this design—in one direction at least—he gave full encouragement to this Institution.

2. Turning to the financial condition of the Institution, the Committee are glad to observe that the outlay bears a safe relation to the Funds; though, while the income increases, and while each year brings with it additional work, it is but natural the expenditure should increase with it.

The General Abstract will show the separate items of income and expenditure. The Dr. and Cr. account will show the balance in favour of the Institution.

3. *Printing and Publication.*—Volume III of the Proceedings has been completed; and the Committee are glad to acknowledge that the appeal made to Members for written contributions has been answered. The different Papers with the names of the contributors will be found in the following list. To these gentlemen the Committee express their thanks.

List of "Proceedings," printed during the Year.

Account of Experiment of 29th December, 1862, continued, on Capt. Inglis's Second Shield, at Shoeburyness, 3rd March, 1863. Contributed by Capt. E. J. Bruce, R.A.

Report of an Experiment carried on by the Special Committee on Iron, at Shoeburyness, 17th March, 1863, to test three rolled Armour Plates, supplied by Messrs Brown and Co. of Sheffield. Contributed by Capt. E. J. Bruce, R.A.

General Abstract of the Income and Expenditure of the Royal Artillery Institution,

From 1st April, 1863, to 31st March, 1864.

Dr.

	£	s.	d.
Printing and Publication. — Wages	174	3	0
Printing and Publication. — Paper	100	0	0
Printing and Publication. — Type and Materials	105	18	2
Printing and Publication. — Wood Cuts	12	17	0
Printing and Publication. — Lithography	34	19	3
Chemistry	44	10	11
Photography — Chemicals and Apparatus	85	9	1
Photography — Printing, Mounting, &c.	123	5	1½
Drawing	37	4	10
Lectures	48	4	2
Taxidermy	7	19	9
Library, Books, &c.	82	17	6½
Museum	55	0	0
Instruments	0	2	6
Carpenter, — Materials	142	19	3
Carpenter, — Wages	37	14	4½
Insurance on £2500 (to 31st March, 1864)	10	0	0
Furniture and Repairs	125	5	6
Subscriptions to Societies	5	5	0
Stationery	158	18	5
Postage and Parcels	33	17	9
Wages, Clerks and Orderlies	102	3	6
Incidental	46	18	5
Cash in hand, 31st March, 1864	26	8	0¼
	£ 1602	1	6¾

Cr.

	£	s.	d.
Cash in hand, 1st April, 1863	100	3	3¾
Dividend on £1200 Consols (to 5th Jan. 1864)	34	19	0
Subscriptions	941	15	0
General Printing	220	19	1
Chemistry	13	10	9
Photography — Chemicals and Apparatus	27	1	0
Photography — Printing, Mounting, &c.	104	16	8
Drawing	23	15	6
Taxidermy	7	16	9
Library, Books, &c.	20	0	2
Carpenter, Wood, &c.	15	4	6
Stationery	80	5	3
Postage and Parcels	11	14	7
	£ 1602	1	6¾

DEBTOR AND CREDITOR ACCOUNT, 31st MARCH, 1864.

	£	s.	d.
Outstanding Debts, 31st March, 1864	249	7	4
Balance Creditor	1262	17	2¼
	£ 1512	4	6¼

	£	s.	d.
Balance Creditor, — Consols Stock	1200	0	0
Balance Creditor, — Cash in hand, 31st March, 1864.	26	8	0¼
Approximate value of Books and Stationery, for Sale.	100	0	0
" " Printing Paper, on Stock	38	0	0
Amount owing by Officers	147	16	6
	£ 1512	4	6¼

May 30, 1864.

E. J. BRUCE, Capt. R.A.,
Secretary and Treasurer, R. A. I.

On the "Time of Burning" of Fuzes under different Atmospheric Pressures. Extracted from Comptes Rendus hebdomadaires des Séances de l'Académie des Sciences. Vol. LV. No. 21. Translated from the French of M. Dufour (of Lausanne). By Major FitzHugh, R.A.

Results of Experiments made to test various Forms of Rifling. By John Anderson, Esq., Assistant Superintendent, Royal Gun Factories. (Communicated by the Secretary R.A.I.)

Experiments performed in the Royal Gun Factories with "Sterro Metal." By John Anderson, Esq., Assistant Superintendent, Royal Gun Factories. (Communicated by the Secretary R.A.I.)

The Lock or Turn of Carriages and their Turning Angles. By Lieut.-Col. H. H. Maxwell, R.H.A.

Annual Report and Abstract of Proceedings of a General Meeting of the Royal Artillery Institution, held on Tuesday, May 12, 1863. Major-General Sir R. J. Dacres, K.C.B. in the Chair.

"On the Change of Form assumed by Wrought-Iron and other Metals when Heated and then Cooled by partial immersion in Water." By Lieut.-Col. H. Clerk, R.A., F.R.S.

Account of an Experiment carried on at Shoeburyness, 27th April, 1863, against a Target proposed by Mr Chalmers, and constructed at the Millwall Ironworks. Contributed by Captain E. J. Bruce, R.A.

On a Curious Instance of Electrolytic Action. By F. A. Abel, Esq., F.R.S. (Communicated by the Secretary R.A.I.)

Report of Ordnance Select Committee, No. 2685, dated February 6, 1863. On Competitive Rifled Cast-iron Guns. Communicated by direction of the Secretary of State for War.

Report on Baron Lenk's Gun Cotton, by Professors Dr Redtenbacher, Dr Schrötter, and Dr Schneider. To His Excellency Field-Marshal Johann Freiherr Kempen von Fichtenstamm, President of the Royal Imperial Commission on Gun Cotton, June 1863. With some comments furnished by F. A. Abel, Esq., F.R.S., Chemist to the War Department. (Communicated by the Secretary, R.A.I.)

On the Products of the Combustion of Gun Cotton and Gunpowder under circumstances analogous to those which occur in practice. By Lieut. von Karolyi. From Philosophical Magazine, October, 1863.

Report of Experiments instituted by the Assistant Superintendent of the Royal Carriage Department, at the suggestion of the Royal Engineer Committee, and sanctioned by the Director of Ordnance, 29th August, 1863, to ascertain the actual vertical pressure exerted by the various natures of Field and Siege Artillery, when passing over Pontoon Bridges; and also whether the maximum pressure is occasioned by the Horses or Carriage. By Lieut.-Col. G. Shaw, R.A., Assistant Superintendent, Royal Carriage Department.

On the Validity of General Shrapnel's claim to the Invention of Shells in which the true principle of Shrapnel fire was first enunciated and applied. By Captain Vivian Dering Majendie, R.A., Captain Instructor, Royal Laboratory.

Note on the Ratio between the Forces tending to produce Translation and Rotation in the Bores of Rifled Guns. By Captain Noble, late R.A. From Philosophical Magazine, September, 1863.

Account of a preliminary trial of a 600-pr. 13·3 in. M. L. Wrought-iron, 10 Grooved Shunt Armstrong Rifle Gun, under the direction of the O. S. Committee, Shoeburyness, 19th November, 1863. By Captain E. J. Bruce, R.A.

From Shore Batteries on Elevated positions, to find the Distances of Objects at Sea, by the aid of the Armstrong Gun. By Captain A. W. Drayson, R.A.

Some considerations respecting the Practical Value of Shells of the Shrapnel Class. By Captain Vivian Dering Majendie, R.A., Captain Instructor, Royal Laboratory.

On two large English Cannon of the Fifteenth Century, preserved at Mont S. Michel in Normandy. By Brigadier-General Lefroy, R.A., F.R.S.

Mons Meg, the ancient Bombard, preserved at Edinburgh Castle. (Extracted from No. 37 of the Archæological Journal, with the consent of the Council of the Archæological Institute, and with the permission of the author, J. Hewitt, Esq., War Office).

Account of an experiment carried on at Shoeburyness, 8th December, 1863, by the Special Committee on Iron, on a target (20′ 9″ × 8′ 6″) constructed to represent a portion of the "Bellerophon" iron-cased Frigate. Furnished by Captain E. J. Bruce, R.A.

Despatch by Lieutenant A. F. Pickard, "C" Battery, 4th Brigade, R.A., relative to an Engagement with the Maoris, at Rangariri, New Zealand, on the 20th November, 1863. Forwarded by Major H. Strover, R.A. Communicated by the Deputy Adjt.-Gen., Royal Artillery.

Recent Gunnery Experiments upon Iron Armour. By Captain Inglis, R.E. Extracted, with the consent of the Editor, from Vol. XII. of R.E. Corps Papers; and with the permission of the Author.

Account of Experiment carried on at Shoeburyness, on 12th and 13th Nov. 1863. Contributed by Capt. E. J. Bruce, R.A.

4. *Library.*—A Sub-Committee has been formed for the purpose of re-arranging, and reforming a Catalogue of, the Books in the Library; this Committee was also charged with the duty of removing any useless Books to make way for others of real value.

Books of Reference are to be withdrawn from the Library shelves, and placed, for greater convenience, in cases in the Reading Room.

The Reading Room itself has been made, by the introduction of a few other improvements, a place of more frequent resort.

The sale of War-Office photographs continues to increase, the number sold last year being upwards of 1900.

The following is the list of Books, Plans, &c., purchased and presented during the year.

Lithographic sketches of Badajos	2	Brig.-Gen. J. H. Lefroy, R.A.
Woodcut to accompany Brigadier-General Lefroy's paper in the R.A. Institution Proceedings, on "the large English Guns in Normandy."	1	
Essai sur la Fortification Moderne	1	Captain E. J. Bruce, R.A.
Histoire Critique et Militaire des Guerres de la Revolution. 4 vols. and plates. Jomini	5	
Danish Artillery Journal. Vols. III. and IV.	2	Maj. H. de Jonquieres, Danish Artillery.
Treatise on Compound Ordnance, by Capt. W. Palliser, 18th Hussars.	1	The Author.
Artillery Equipment, by Major F. Miller, V.C., R.A.	1	The Author, by desire of the Director Topo. Department.
Belgian Artillery Plates, 1 Vol.	1	Colonel R. Burn, R.A.

Proceedings of the Geological Association. Vol. I. No. 9.	1	J. Tennant, Esq., F.R.S.
Journal of the Royal United Service Institution. Vol. VI.	1	The Council Royal United Service Institution.
Madras Artillery Records. Vol. I. to XV.	15	Colonel B. W. Black, R.A. through Lt. R. P. L. Welch, R.A.
Report on the application of Gun Cotton to Warlike purposes, by F. A. Abel, Esq., F.R.S.	1	The Author.
Essay on Magnetism, date 1795	1	Colonel G. R. Kennedy, R.A.
Address of Major-General E. Sabine, R.A., at the Anniversary Meeting of the Royal Society, 30th Nov. 1863.	1	Major-Gen. E. Sabine, R.A., President Royal Society, &c.
German Works on Fortification	2	Maj. G. H. L. Milman, R.A.
Russian Artillery Journal. Nos. 1 to 12, 1863, and No. 1, 1864. Russian Small Arms Journal, Nos. 3 and 4, 1862; and 2, 3, and 4, 1863	18	Colonel N. de Novitzky.
Standing Orders, General Police Force, Mauritius	1	Captain A. E. H. Anson, R.A.
Pamphlet "Fortification *versus* Forts," by Colonel Cunliffe Owen, C.B., R.E.	1	Lt.-Col. H. Y. D. Scott, Royal Engineers, Chatham.
Lectures, 1, 2, 3, 4 and 5, Royal Engineer Establishment, Chatham	5	Lt.-Col. H. Y. D. Scott, Royal Engineers, Chatham.
Papers 3, 4, 5 and 6, Vol. III. Royal Engineer Establishment, Chatham	4	Lt.-Col. H. Y. D. Scott, Royal Engineers, Chatham.
F. Baucher's Method of Horsemanship	1	Riding-Mast. W. Donald, RA.
Chromo. Lithograph of Royal Artillery	1	J. Hewitt, Esq.
Contributions towards the History of Mediæval Weapons, and Military Appliances in Europe, by J. Hewitt, Esq.	1	J. Hewitt, Esq.
"Fortifications *versus* Forts," by Colonel Cunliffe Owen, C.B., R.E.	1	Major C. H. Owen, R.A.
Our Garrisons in the West, or Scenes in British North America, by Lieut. F. Duncan, R.A.	1	The Author.
Examination Papers, Royal Military Academy, June, and December, 1863.	2	The Inspector of Studies, Royal Military Academy.
War Office Photographs	105	Photographic Establishment of the War Department.
Lecture on "The Origin of Brahmanism," by Martin Haug, Ph. D.	3	The Council, United Service Institution of Western India, Poona.
Lecture on "Confucius the Sage of China," by Martin Haug, Ph. D.	3	The Council, United Service Institution of Western India, Poona.
Lecture on "Strategy," by Lt.-Col. Hon. F. A. Thesiger, 95th Foot.	4	The Council, United Service Institution of Western India, Poona.
Professional Papers, Royal Engineers. Vol. XII.	1	Capt. C. S. Hutchinson, R.E.
Heat considered as a mode of motion, by J. Tyndall, F.R.S.	1	Major G. P. Colley, 2nd Foot.
Smithsonian Report, 1861	1	The Council, Smithsonian Institution, Washington, U.S.

Examination of Candidates for admission to the Staff College	1	The Council of Military Education.
Examination of Candidates for admission to the Royal Military College, 1863	1	
Examination of Candidates for admission to the Royal Military Academy, Jan. 1864	1	
Examination Papers, used at Examination of Candidates for direct Commissions ...	1	
Report of the Council of Military Education, 1860	1	
First Report of the Council of Military Education on Army Schools, 1862	1	
Report of the Ordnance Select Committee, 1863. On the Relative penetration into earth of projectiles from Rifled and smooth bored guns, and on several varieties of Percussion Fuzes	1	The Secretary of State for War, through the Director of Ordnance.
Extracts from the Reports and Proceedings of the Ordnance Select Committee, 6 Copies each of Nos. 1, 2, 3, 4, and 5	30	
Transactions and Report of the Special Committee on Iron	1	
Report on Ballistic Experiments, by Lieut. W. H. Noble, R.A.	1	
Appendix to, and General Report of the Commission for the Sanitary Improvement of Barracks and Hospitals	1	
Army Estimates for 1864, 65	1	
Full-sized Drawing of 110-pr. Armstrong Gun	1	
Tracings of heavy and light 110-pr. Guns do O. P. and N. P. 40-pr. do do L. S. and S. S. 20-pr. do do 9-pr. gun do 6-pr. do do L. S. N. P. and S. S. 12-pr. gun	10	
Colonel Simmons' Report on the Federal Swiss Army	10	
North America, Despatch of Civil War	1	The Secretary of State for War, through the Librarian to War Office.
Barracks and Hospitals, Appendix and Report	1	
Topographical Department, Report for 1862...	1	
Grant's Cooking Apparatus Report	1	
Employment of Soldiers in Trades, Report ...	1	
British Fisheries, Report for 1862	1	
Royal Academy, Report of Commissioners ...	1	
Commons' Papers, Session 1863. Nos. 13, 16, 21, 28, 51, 55, 58, 72, 73, 83, 85, 86, 91, 105, 116, 125, 127, 139, 141, 142, 149, 173, 181, 185, 190, 194, 196, 200, 206, 221, 237, 244, 299, 329, 332, 344, 345, 350, 432, 438, 455, 462, 465, 476, 487, 497, 501, 516, 522, 547.		

Plan of the city of Puebla, and its environs...	2	The Director Topographical Department, War Office.
Plan of the district around Shanghai	2	
Two maps, illustrating the late action in New Zealand	4	
Map of the Island of Alsten, in Denmark...	2	
Map of Jutland, No. 8.	2	
Sketch of the Fortress of Fredericia and neighbourhood, Jutland	2	
Chromo. Lithographs of Laboratory Stores. (framed)	18	Royal Laboratory.
Notes on Matériel as at present issued from the Royal Laboratory for smooth-bored guns, small arms, &c., &c., by Captain G. H. J. A. Fraser, R.A.	12	
do do	1	The Author.
Die Allgemeine Industrie. Ausstellinig zu London, by Peter Rittunger	1	Chevelier de Scwarz, Imperial Austrian Commissioner, International Exhib., 1862.
The antiquities of Yevering Bell, and Three-stone Burn, among the Cheviots in Northumberland	1	The Duke of Northumberland, through Col. Sir D. E. Wood, K.C.B. R.H.A.
The bridges which have been constructed over the Vistula near Drischan, and over the Nogat near Marenburg, by Lentze.	1	Through Major C. H. Owen, R.A.
Report of Colonel J. D. Graham, U.S. Topo. Engineers, on Mason and Dixon's Line................	1	The Author.
Solling's German Literature	1	The Author.

Books purchased.

The Geological evidences of the Antiquity of Man. By Sir Charles Lyle, F.R.S.	1
Heat considered as a mode of Motion. By J. Tyndall, F.R.S.	1
Mallet, on the Construction of Artillery	1
Professor H. T. Huxley, F.R.S., on "The Origin of Species."	1
Byrne's Dual Arithmetic	1
The Earth and its Mechanism. By H. Worms	1
Manual of Field Artillery Exercises	1
Twelve Photographs of the Moon. By Warren De La Rue, F.R.S.	1
Map of London (in case)	1
Evidence as to Man's place in Nature. By Professor H. T. Huxley, F.R.S....	1
Juke's Geology	1
Report of the Select Committee on Ordnance, Nov., 1863	1
The comparative merits of a Rifled Gun and Rotary Rockets	1
Ganot's Physics	1
Custs Wars of the 18th Century, 5 vols. / ,, 19th ,, 4 ,, ...	9
Chromo' Lithographs of Canadian Scenery. By Captain C. Hardy, R.A.	2
Twisden's Practical Mechanics	1
Post-Office London Directory	1
,, London Suburban Directory	1
Price's Treatise on Infinitesimal Calculus, Vol. IV.............................	1
The Great Art of Artillery of Casimir Simeonowicz, 1729	1

The Story of the Guns. By Sir James Emerson Tennent	1
Nautical Almanack, 1864	1
Hewitt's Ancient Armour and Weapons in Europe. 3 vols.	3
Hutton's Mathematical Tables	1
English and Danish Dictionary	2
Etudes sur L'Artillerie. Vol. III. and IV	2
Les Marines de la France et de L'Angleterre	1
Revue de Technologie Militaire ou Recueil International. 2 vols.	2
Etudes sur la Defense des Etats et sur la Fortification. Par A. Brialmont. 3 vols. and atlas	4
Glossaire de la Langue Romaine. 3 vols.	3
Birds of Asia. No. 15	1
Birds of Great Britain. Nos. 3 and 4	2
The Principles of War, or Elementary Treatise on higher Tactics and Strategy	1

Publications received Periodically.

Comptes Rendus.
Le Spectateur Militaire.
Journal de Mathématiques.
Journal des Sciences Militaires.
Journal des Armes Speciales.
Journal of the Society of Arts.
The British Journal of Photography.
The Photographic News.
Proceedings of the Palæontographical Society.
The Ibis, a Magazine of general Ornithology.

5. *Museum.*—The whole of the fossils and minerals have been thoroughly examined, and carefully classified, by Mr Davies of the British Museum, who has also prepared numbered catalogues both of the minerals and of the fossils, which greatly facilitate reference to the original specimens. These catalogues (a specimen sheet accompanies this Report) have been printed at the Institution, and will be sent free to any Member who may apply for them. It is hoped that, by the wants in the Collection thus becoming known, many of the deficiencies will be supplied.

Several interesting additions have been made to the Orinthological part of the Museum during the past year. They include a choice collection of birds from Malta, collected by Captain O. Carr, R.A., very interesting on account of being, for the most part, species that are also found in Great Britain.

From J. K. Lord, Esq., a second gift of animals, birds, eggs, and insects from British Columbia has been received; also the collection of insects from India, mentioned in last year's report as expected from Lieut. Hime, has arrived, the Lepidoptera mostly in fine condition, the Coleoptera damaged to some extent. It is however the most numerous as well as the most valuable collection of insects that the Institution has yet received. It may not be out of place here to mention that Coleoptera travel best packed between sheets of wadding without pins in them. They may also be safely sent if put in bottles, with spirits, dividing the bottles, according to size, with layers of cotton wool. Great care must be taken that the bottles are quite full, to avoid any shaking of the insects.

The collection of British birds remains the same, no additions having been made during the year, which is much to be regretted. Any Members of the Institution—and no doubt there are many who would gladly assist in completing this collection—can be furnished, on application, with a list of species most wanted.

Additions have been made to the collection of British birds'-eggs, and two orders, the Raptores and Rasores are now complete.

Six handsome cases have been made at the Institution, which occupy the space formerly filled with the old Laboratory specimens. They contain, among other things, uniforms of the Regiment during different periods, showing the various changes that have occurred in course of years—also many miscellaneous objects of interest presented by Members; these when in the Natural History Museum were out of place; but now, being grouped conspicuously in the new cases, they are better seen. It may be noted here, in passing, that the item in the accounts under the head of carpenter—which is exceptionally large—includes, among other things, the materials for these large cases, and also the extensive alteration made in the Lecture Theatre in the way of new and commodious seats or benches.

Presentations to the Museum.

Collection of Geological specimens from the Crimea; Collection of Chalk Fossils from Dover	...	Colonel H. Aylmer, R.A.
Brainstones from Bermuda	3	Lieut. A. O. Molesworth, R.A.
Criolite from Greenland	1	Lieut. A. O. Molesworth, R.A.
Bottle of Wine, made from the grapes of the Vines that grow on Mount Lebanon	...	Captain J. Barton, R.A.
Elephant's Skull and lower jaw	1	The late Ordnance Medical Department, General Hospital, Woolwich. Through Surg.-Major J. M. S. Fogo, R.H.A.
Walrus' do do	1	
Turtle's do	2	
Alligator's do	1	
Shark's Jaws	2	
Whale's Vertebræ	1	
Turtle Shells	2	
Tortoise do	1	
Fish-skins	3	
Bow from Melville Island	1	
Hide Shield	1	
Collection of old English Silver Coins	46	Lt.-Col. J. Desborough, R.A.
Piece of Oak-beam from the Tower of London, eaten by White Ants	1	Colonel G. R. Kennedy, R.A.
Chromo-Lithograph of Officer R.A., 1828; do Artilleur-Anglais, do.	...	Lieut. L. Gye, R.A.
Ancient Copper Coins	15	Capt. N. S. K. Bayly, R.A.
Collection of Fossils	...	Capt. J. N. P. Dadson, R.A., and Capt. W. P. Dadson.
Oil Painting, "First Riding-Master, Royal Artillery"	1	Lieut. W. Boylin, R.A.
Geological Specimens (old red sandstone)	2	J. Tennant, Esq., F.R.S.
Pair of Austrian Cavalry Pistols. Pattern 1856.	2	Lieut. E. Marshall, R.A.
Specimen of Silver Ore from Norway	1	Captain E. Staveley, R.A.

Collection of Sea Shells ...	...	Colonel R. Burn, R.A.
Chinese Model, Gun and Carriage ...	1	Lieut. C. E. B. Leacock, R.A.
do Tilted Cart with one Horse ...	1	
do Water-Cart with three Horses.	1	
Tartar Bow and Arrows ...	17	
Russian Pendulum ...	1	Colonel C. S. Henry, R.A.
Specimens of different woods from the Bombay Presidency, India ...	12	Lieut. G. B. B. Hobart, R.H.A.
"Passport" issued during the war, by the Federal Government of N.S. America ...	1	Col. F. Eardley-Wilmot, R.A.
Geological Specimen, from St Paul's Island...	1	Rev. M. R. Scott.
Double Cocoa-nut ...	1	Lieut. J. C. Robinson, R.A.
Gilt Breast-Plate, date 1833 ... Brass do Staff-Serjeants, 1822 ...	2	Qr.-Mr. W. R. Kirkman, R.A.
1 lb. Cake of "Brick" Tea, as prepared by the Chinese for the Russian market ...	1	Major R. J. Hay, R.A.
Plaster Figures, illustrating the Costumes of Natives of the Bombay Presidency, India	6	Captain W. R. Lluellyn, R.A.
Chaco for Battalions Royal Artillery. Pattern 1833 ...	1	The Principal Military Storekeeper, Royal Arsenal.
Birds from Malta ...	38	Capt. O. Carr, R.A.
Bird (Chaja Screamer) ...	1	Lieut. L. Gye, R.A.
Insects from India ...	386	Lieut. H. W. L. Hime, R.A.
Roselle Parrot ...	1	Captain E. Gibbs, R.H.A.
Undress Frock Coat, R.H.A., prior to 1854	1	Captain E. J. Bruce, R.A.

6. *Languages.*—The classes for the study of French and German have been more numerously attended than in former years.

7. *Surveying and Practical Astronomy.*—The Instructor reports that, in addition to the Artillery Officers who have worked with him, some of the Officers of the Staff College, attached to this Garrison for instruction, have qualified themselves in the use of the Sextant and Transit, and have made considerable progress in Practical Astronomy.

8. *Photography.*—Many improvements have been made in the Photographic Department; and, by sanction of the Committee, the Serj.-Major in charge is allowed to devote certain hours during two days of the week, to take likenesses of Members and their friends. A plan is also formed for affording to Officers the opportunity, during the summer months, of taking Photographic pictures in the country.

9. *Chemistry.*—By an arrangement which will work advantageously for the Members of the Institution, the Officers engaged under the Director of Artillery Studies will practice chemistry in the excellent working Laboratory of the building. Mr Bloxam has expressed his readiness to superintend and direct, without additional fee, the investigations of other Officers, not belonging to the Special Class, who may wish to study during the same hours.

10. *Lectures.*—The following Lectures have been delivered during the year.

F. A. Abel, F.R.S., Chemist to War Department	On Gun-cotton, with Experimental Illustrations.
Charles Bloxam, F. C. S., Lecturer on Chemistry, Royal Military Academy	Modern Transmutation—a comparison between the achievements of Chemistry and the aspirations of Alchemy.
Frank Buckland, M.A., F.Z.S. (late Asst. Surgeon 2nd Life Guards)	On "Fish-hatching," shewing the advantage of the propagation of Salmon and Trout, by Artificial Means.
W. B. Waterhouse Hawkins, F.L.S., F.G.S.	*Graphic Lecture,* on Natural History.
Professor Huxley, F.R.S.	On "Man's place in Nature."
T. Rymer Jones, F.R.S., Professor of Comparative Anatomy, King's College, London	On the Mechanics of Nature as illustrated by the structure and history of the various forms of Acalephæ or Jelly-fishes.
Dr Gottfried Kinkel, F.R.G.S., (formerly Professor of the History of Art and Literature in the University of Bonn)	Art with the Ancient Egyptians.
Dr Lancaster, F.R.S.	On the nature of FOOD.
Professor Pepper, F.C.S.	On Light, Optics, and Optical Illusions.
F. A. Schwarzenberg, B.A.	On the Life and Achievements of Alexander von Humboldt.

11. The Committee still invite Officers who have not sent their Photographic likenesses to the Regimental collection to do so. Thanks are due to the following Officers for views of Foreign Stations, &c., contributed as under :—

Four Photographic views of Malta	...	Lieut. H. M. Burgess, R.A.
Large water-color painting of Gibraltar, by Captain P. Jackson, R.A.; Lithographic Drawing from the above	...	Captain P. Jackson, R.A.
Photograph of Tein-Tsin, China, taken from East Gate, looking west; do do looking south	2	Lieut. C. E. B. Larcom, R.A.
Sixteen Photographic Portraits of different Castes in India	2	Captain M. H. Fitzmaurice, R.A.
Frame containing 20 Cartes-de-Visite of Officers	...	Lt.-Col. J. Desborough, R.A.

12. *Model Room.*—A few additions have been made to the Model Room consisting of—

Model of Lieut.-Col. E. M. Boxer's Parachute Light	1	Royal Laboratory, Royal Arsenal.
Model of a Gun-wheel, used by the late Madras Artillery; Ditto invented by Col. B. W. Black, R.A.	2	Colonel B. W. Black, R.A., late Madras Artillery, through Lieut. R. P. L. Welch, R.A.
Model of a 56-pr. Gun, on Dwarf Traversing Platform, made by the Donor	1	Captain F. A. Whinyates, R.A.
Small Brass Gun, covered with leather	1	Colonel G. R. Kennedy, R.A.
Pieces of cast-iron, broken in the machine for testing the strength of Metals, in the Royal Gun Factory, Royal Arsenal	2	Captain E. J. Bruce, R.A.

The following Resolutions were passed :—

1. *Proposed by Major-General Sir R. J. Dacres, seconded by Major J. Campbell, and carried,*—

"That the Report of the Committee be adopted and printed."

2. *Proposed by the Committee, and carried,*—

"That the property of the Institution, now insured for the sum of £2500, be insured, from this time, for the sum of £5000."

3. *Proposed by Captain Yonge, seconded by Captain Keate, and carried,*—

"That the Annual Statement of Accounts be printed, in future, and circulated for general information, at home stations, at least 14 days before the date of the Annual General Meeting."

4. *Proposed by Lieut.-Colonel Field, seconded by Major-General Sir R. J. Dacres, and carried,*—

"That the Serj-Major in charge be allowed, during certain hours, on certain days in the week, and at charges regulated by the Committee, to give private* instruction in Photography to such Members as wish to practice the art."

5. *Proposed by Major-General Sir R. J. Dacres, seconded by Captain Keate, and carried,*—

"That the Committee, in future, when the probability arises of a vacancy occurring in the Office of Secretary, shall make it known through the proper Channel, to the Regiment at large—and that Members be invited, in that way, to send their Names as Candidates for the appointment. The Committee to abstain from acting upon Rule V. until proper time has passed for applications to be received."

6. A vote of thanks was passed to the Committee and the Secretary.

In accordance with a modified application of Rule IV.—in consequence of the number of Officers leaving the Committee on removal from the Garrison —Lieut. W. G. Stirling withdraws from the Committee.

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* The Serj-Major in charge has, on former occasions, instructed *classes* of officers: the object of the present resolution is to meet the case of officers wishing to practice independently.—E. J. B.

The following Officers were elected, viz :—

Colonel S. E. Gordon.	Captain W. R. Lluellyn.
Major C. H. Owen.	Lieut. G. B. B. Hobart.
Captain E. Keate.	,, E. Marshall.

to serve on Committee, in place of the under-mentioned Officers who have left the Garrison, or withdrawn in accordance with Rule IV.

Lt.-Col. C. V. Bowie.	Captain H. A. Doyne.
,, J. Desborough.	,, H. Edmeades.
Major H. T. FitzHugh.	Lieut. W. G. Stirling.

The Committee for the current year will stand thus :—

PATRON AND PRESIDENT:

Field Marshal H.R.H. the Duke of Cambridge, K.G.

VICE PRESIDENTS:

The Commandant.
The Deputy-Adjutant-General.

MEMBERS:

The Assistant-Adjutant-General.
The Secretary Ordnance Select Committee.
The Brigade-Major.
The Director of Artillery Studies.

Colonel J. Travers.	Captain C. B. Brackenbury.
,, J. H. Smyth, C.B.	,, E. Keate.
Lt.-Col. J. R. Gibbon, C.B.	,, W. R. Lluellyn.
,, G. T. Field.	,, V. D. Majendie.
Colonel S. E. Gordon.	Lieut. F. S. Stoney.
Surg.-Major J. M. S. Fogo.	,, G. B. B. Hobart.
Major C. H. Owen.	,, E. Marshall.

Captain E. J. Bruce, *Secy. and Treasurer.*

(Signed) R. J. DACRES, Major-General,
Vice-President, in the Chair.

May 30, 1864.

Birds from Malta, presented by Captain O Carr, R.A.

Cat. No.	Species.	Sex.	Locality.	Orig No.	Common Name.	Date.
624	Falco subbuteo	♀	Malta.	...	Hobby	April 27, 1863.
625	Circus cyaneus	♀	,,	13	Hen harrier	,, 15, ...
626	,, æruginosus	♀	,,	12	Marsh harrier	,, 8, ...
627	,, pallidus	♂	,,	18	Pallid harrier	,, 13, ...
628	,, do	♀	,,	20	do	,, 17, ...
629	Scops aldrovandi	♂	,,	47	Scops-eared owl	,, 29, ...
630	do	♀	,,	...	do	,, 23, ...
631	Lanius rutilus	♂	,,	17	Woodchat shrike	,, 12, ...
632	do		,,	...	do	,, 20, ...
633	Oriolus galbula	♂	,,	19	Golden Oriole	,, 16, ...
634	do	♀	,,	...	do	May 2, ...
635	Petrocincla saxatilis	♂	,,	...	Rock thrush	April 29, ...
636	Motacilla neglecta	♂	,,	10	Grey-headed wagtail	,, 3, ...
637	do	♀	,,	...	do	May 3, ...
638	Anthus rufescens		,,	...	Tawny pipit	,, 4, ...
639	Coracias garrula	♂	,,	23	Roller	April 20, ...
640	do	♀	,,	66	do	May 4, ...
641	Merops apiaster	♂	,,	70	Bee-eater	,, 2, ...
642	do		,,	...	do	,, 8, ...
643	Coturnix vulgaris	♂	,,	5	Common quail	Mar. 8, ...
644	Œdicnemus crepitans	♂	,,	34	Great plover	April 24, ...
645	Ardea purpurea	♂	,,	...	Purple heron	May 18, ...
646	,, comata	♀	,,	...	Squacco heron	,, 5, ...
647	Botaurus minutus	♀	,,	71	Little bittern	,, 7, ...
648	Nycticorax gardeni	♂	,,	...	Night heron	April 22, ...
649	do	♀	,,	...	do	May 18, ...
650	Ibis falcinellus	♂	,,	...	Glossy ibis	,, 18, ...
651	Machetes pugnax	♀	,,	...	Ruff	,, 15, ...
652	Tringa subarquata	♂	,,	76	Curlew sandpiper	,, 9, ...
653	,, minuta	♀	,,	...	Little stint	,, 13, ...
654	Glareola torquata	♂	,,	...	Collared pratincole	April 28, ...
655	Crex pratensis	♀	,,	...	Landrail	May 7, ...
656	,, porzana	♂	,,	...	Spotted crake	April 28, ...
657	,, do	♀	,,	74	do	May 9, ...
658	Larus tridactylus	○	,,	1	Kittiwake gull	Feb. 3, ...
659	,, fuscus	♂	,,	72	Lesser blackbacked gull	May 9, ...
660	,, do	○	,,	4	do	Mar. 3, ...
661	Sterna leucoptera	♀	,,	...	White-winged black tern	May 15, ...

Presented by Lieut. Gye, R.A.

662	Opistolophus chavaria	Paraguay.	...	Chaja Screamer	....

Insects from India, presented by Lieut. Hime, R.A.

Diurnal Lepidoptera	172	Orthoptera	6
Nocturnal do	140	Hemiptera	15
Coleoptera	48	Neuroptera	5

List of Birds collected by J. K. Lord, F.Z.S., and presented by the British North American Boundary Commission to the Royal Artillery Institution.

Whilst making the Zoological collection for the British Museum, it was suggested by Captain Haig, R.A., Chief Astronomer to the Commission, that any duplicates would be valued by the Royal Artillery Institution. Colonel Hawkins, R.E., Chief Commissioner, kindly and readily gave his consent. The following list contains the birds collected by myself, and by direction of Colonel Hawkins presented to the Institution.

The Mammals and Insects will appear in a future list.

Falco sparverius.—(Linn).

The Sparrow Hawk. Range, from the coast to the Rocky Mountains; nests in May and June. This hawk is very abundant, especially on Vaucouver Island, feeds principally on insects, and congregates in large numbers on the open prairies where the locusts and grasshoppers are plentiful; arrives at the island in May and June, and at Colville about the same time. Where the Spokan river winds through the Spokan prairies, small patches of timber here and there grow on the bank of the stream. About midsummer I noticed vast numbers of these hawks, young and old, congregated on the patches of timber, they were feeding on the field cricket (*Acheta nigra*), and must have nested in the adjoining pine forest.

Astur atricapillus.—(Wilson).

The Goshawk. I first shot this hawk at Boundary Creek in September. I also saw it at Osoyoos Lake and on the Shemilkameen river, but never on the west side of the Cascade Mountains. It arrives in the interior in May and June, nests early, choosing crevices in high rocks as its breeding place, leaves again in October to go south. Dr Suckly mentions it (Natural History, W. Territory, Vol. I.) as being common on the Nesqually plains.

Circus hudsonius.—(Linn.)

The Marsh Harrier. Very abundant from the coast to the summit of the Rocky Mountains; arrives in May and June, nests early, and always on the ground; nest built of grass, sticks, leaves, and root fibre, eggs laid at long intervals. I have often seen one young bird nearly fit to leave the nest when the smallest is but just hatched out, the young are fed principally on snakes and lizards; they generally have two broods, the second as late as August. This hawk is also very common on Vancouver Island.

Pandion carolinensis.—(Gmelin).

The American Osprey. The osprey is found on nearly every river and lake from the coast to the west slope of the Rocky Mountains; it is also quite as plentiful on the lakes and streams in Vancouver Island. They quit the streams inland on the approach of severe winter weather, and retire to the coast or go south. The nest of the osprey is a most conspicuous object, and can be seen from a long distance; it is invariably built on the extreme summit of a dead pine tree, made of dry sticks, and in size as large as an imperial bushel. The ospreys use the same nest year after year; the number of young usually three. There was a particularly large nest in the centre of a small prairie through which the trail ran, leading from Sumass to the Chilukweyuk prairies, it was placed on the top of a dead pine tree that was at least 150 ft. high, and as straight and bare of branches as a flag-staff; at the base of the tree the trail forked, the other trail leading to Sweltza, the turn off was known as the Eagle's Nest. Two other specimens I shot, in August, on the stump of a dead tree hanging over the Kootanie river. I felt desirous of obtaining specimens from that locality. Specimens were also obtained at Sumass, Vancouver Island, and Colville, and there can be no doubt there is but one species common to the entire district.

Bubo virginianus, (var.) *pacificus.*—(Cassin).

The Great Horned Owl. Common along the coast east and west of the Cascades, and on the west slope of the Rocky Mountains: very plentiful also on Vancouver Island; nests in May on a bare ledge among high rocks or in a hollow tree; remains at Colville during the winter. I saw this owl at the trading post of the Hudson Bay Company, in mid-winter, when the temperature was 15° below zero, some tame pigeons attracted him.

Nyctale acadica.—(Gmelin.)

Saw-Whet Owl. I procured several specimens of this beautiful little owl at the H. B. Company Station at Colville. The winter was unusually cold, temperature 30° below zero, they evidently came into the old out-buildings for protection. What their range may be I dont know, as I never saw them at any other time, or in any other place.

Surnia ulula.—(Linn.)

The Hawk Owl. The first time I killed this owl I was on a high ridge of land between Rock Creek and Osoyoos Lake. The owl was coming towards me with such a rapid hawk-like flight that I imagined when I fired that it was a *hawk.* I also shot another at Colville, and a third west of the Rocky Mountains. I am not sure whether it is ever seen on Vancouver Island or on the west slope of the Cascades; I certainly never met with it, or heard of its being seen at either place.

Picus harrisii.—(Aud.)

Harris's Woodpecker. This woodpecker is by far the most abundant species in the district, collected. It is found on Vancouver Island, and along the entire course of the Boundary line, south through Oregon and California, north to Fort Simpson: a few remain at Colville during the winter, but the greater number retire to the coast and return in April and May. In May they pair, and bore out a hole in a dead tree; they use no lining for the nest, but lay the eggs on the bare wood. Their favourite haunt is on the stumps of trees growing round swamps or prairie land.

Picus gairdneri.—(Aud.)

Gairdner's Woodpecker. The same remarks apply to this woodpecker as to the preceding *Picus harrisii,* it differs slightly in habit, generally hunting for insects on the maples, alders, and stunt oak rather than on the pine trees. Specimens of both species were shot on Vancouver Island, Sumass prairies, Colville, and west slope of the Rocky Mountains, at an altitude of 7000 feet above the sea level.

Picus albolarvatus (Baird).

White-headed Woodpecker. The only place I ever saw this very rare bird was in the open timbered country about the Colville valley and Spokan river: why it should be confined to such a limited area I am somewhat at a loss to imagine, except it be that this woodpecker almost invariably haunts the *Pinus ponderosa*, and never retires into the thick damp forest. It arrives in small numbers at Colville in April, and disappears again in October and November, or as soon as the snow begins to fall. Although I did not succeed in obtaining its eggs I saw a pair nesting in a hole bored in the branch of a very tall pine tree, (*Pinus ponderosa*), this was in May. Seldom flies far, but darts from tree to tree with a short jerking flight, and always whilst flying utters a sharp clear chirping cry. The specimens sent home were shot in the Colville valley.

Picoides arcticus.—(Swainson).

Black-backed three-toed Woodpecker. I obtained this bird once only, it was on the summit of the Cascade Mountains. It was late in September and getting cold; the bird was alone and flying restlessly from tree to tree, but not searching for insects: both when on the wing and when clinging against a tree it continually utters a shrill plaintive cry. Its favourite tree appears to be the *Pinus contorta*, which only grows at great altitudes. I do not think this woodpecker is found except at great altitudes. In the valleys and lower plains it is replaced by the banded three-toed woodpecker (*Picoides hirsutus*).

Hylatomus pileatus.—(Baird).

Log Cock. Not often seen, and difficult to obtain from its shy habits, always hiding in the dark pine forests, the silence of which is often broken by the tremendous noise this bird makes, rapping on the dead trees. It has a wide range, common east and west of the Cascades, and on the west slope of the Rocky Mountains; I have seen it north as far as Fort Rupert,—Vancouver Island,—and south through Oregon and California. Whether they migrate south I dont know, but I obtained them at Colville during the winter. Nests in May, generally in a tall dead pine tree at a great height.

Melanerpes torquatus.—(Bonap.)

Lewis' Woodpecker. Not found as far as I know west of the Cascades, but is very abundant between the Cascades and Rocky Mountains, it here frequents the open timber. Its habits and modes of flight are not the least like a woodpecker; it flies with a heavy flapping motion much like a jay, feeds a great deal on the ground, and chases insects on the wing much like a shrike or king bird. Whilst mating they assemble in large numbers, and keep up a continual loud chattering noise; arrives at Colville in April, begins nesting in May, and leaves again in October. The nest is in a hole in a dead pine tree, usually a great height from the ground; the eggs brought home were obtained at Colville.

Colaptes mexicanus.—(Swainson).

Red Shafted Flicker. Very abundant on Vancouver Island, east and west sides of the Cascades, and up to the summit of the west slope of the Rocky Mountains. They arrive at the island about the end of March, and at Colville in April and May, nest in May, in a dead pine tree; remain at Colville until the snow begins to fall in October and November. I scarcely know a bird more plentiful than this woodpecker.

Chordeiles popetue.—(Vieill).

Night Hawk.—Bull Bat.—Musquito Hawk.—Goatsucker. I have met with only one well marked species from the coast to the summit of the Rocky Mountains. They arrive at Vancouver Island and along the coast in May, and at Colville in June. On the 7th of June I observed a great number of these goatsuckers in company with the green-backed swallow, and what I imagined to be the black swift, but as they never came within range I could not determine the matter. I succeeded in getting three swallows and one goatsucker, a male, its stomach was gorged with winged ants;—a flight of these insects had, I imagined, attracted all these birds.

When flying high this goatsucker makes a curious kind of chirp, hence the name by which they are known throughout Oregon and California as *Pisk*, and when they swoop down as they constantly do from a great height, they make a loud booming noise almost like a *roar*, or the twang of a large metal harp string, whence I suppose comes the other name of *Bull bat.*

I have noticed them 7000 ft. above the sea level, both on the Cascades and the Rocky Mountains.

They lay two eggs in July on the bare ground.

They have a curious habit of pitching on the ground just as it is getting dark, and running along like a sandpiper, chasing moths and small insects. I have often seen them pitch close to my feet.

Tyrannus carolinensis.—(Baird).

King-Bird.—Bee Martin. Common from the coast to the summit of the Rocky Mountains, arrives at Vancouver Island, and along the coast about the end of March, and at Colville in the beginning of April, begins building in May.

Leaves Colville again in September, frequents valleys and open timbered lands. I have never seen it more than 2000 feet above the sea level. Specimens brought home from various spots on the line.

Tyrannus verticalis.—(Say).

Arkansas Flycatcher. Common from the coast to the west slope of the Rocky Mountains; habits valleys, open prairies and banks of streams, arrives in April and leaves again in September; builds in May, and does not reach a greater altitude than about 2000 ft. above the sea level.

Specimens brought home from different localities along the line, and from Vancouver Island.

Contopus borealis.—(Baird).

Olive Sided Flycatcher. The only specimens I obtained were shot at Sumass prairie in June; it makes its first appearance in May, and leaves again in September.

It usually sits on the top of a dead tree, or on the end of a dead branch, dashing off after any insect that may chance to pass, and then returning again to its watch tower. I did not find its nest; I never saw this Flycatcher east of the Cascades.

Turdus (*Planesticus*) *migratorius*—(Linn.)

Robin. Abundant everywhere from the coast to the very summit of the Rocky Mountains. Arrives in flocks early in April, even before the snow is off the ground: it is about the first harbinger of the coming summer, leaves again in September and October.

Chooses all sorts of places for its nest. Very abundant on Vancouver Island.

Turdus (Ixoreus) naevius—(GMELIN.)

VARIED THRUSH, PAINTED ROBIN. This beautiful thrush is very abundant on Vancouver Island and along the Boundary line to the summit of the Rocky Mountains. It arrives in May, and builds in the fork of a young fir tree in June; lays from four to five eggs; leaves again in September. It is very shy in its habits, frequenting dark underbrush; creeping in the most stealthy manner through the bushes, and unless closely pressed seldom taking wing. It has not much song, but a few sweet notes, soft and plaintive, warbled by the male whilst watching his mate in her nest.

Sialia mexicana—(SWAINSON.)

WESTERN BLUE-BIRD. Common along the Boundary line, on the banks of the Fraser river, Vancouver Island, on the Sumass and Chilukweyuk prairies, on the open plains and thin timbered lands between the Cascades and Rocky Mountains. Arrives in small flocks in May and June; leaves again in September. Begins nesting about the end of June.

Sialia arctica—(SWAINSON.)

ROCKY MOUNTAIN BLUE-BIRD. I have never met with this beautiful bird on the west side of the Cascade Mountains, but it seems very abundant between the Cascades and Rocky Mountains.

They arrive in the Colville valley in May and June and leave again in September. After nesting in July they assemble in large flocks, young and old together, and feed on the open plains. I saw them in great numbers on the tobacco plains, and on the Spokan prairies; indeed, I may say on all the open land, reaching an altitude of about 2000 feet above the sea level between the Cascades and Rocky Mountains. They feed principally on small insects, occasionally eating berries and seeds; utters a low twittering cry whilst on the wing.

Regulus satrapa—(LICHT.)

GOLDEN-CRESTED WREN. Very common on Vancouver Island and along the entire course of the Boundary line from the coast to the Rocky Mountains, attaining an altitude of 6000 feet above the sea level. Arrives about May, and leaves again in September; after nesting assembles in large flocks, generally associating with the chickadees and pigmy nuthatches; builds a hanging nest at the end of a young pine branch, lays from five to seven eggs. Those I obtained were unfortunately broken.

Hydrobata mexicana.—(BAIRD.)

WATER-OUZEL—AMERICAN DIPPER. After carefully comparing a large series of specimens shot on almost every stream from the coast along the Boundary line to the summit of the Rocky Mountains, I am quite convinced that there is only one species common to this immense tract of country; and the same species as the ouzel found east of the Rocky Mountains. A few remain at Colville during the winter, but the greater number arrive in April; nests in June. I am quite sure this bird can and does swim, for I have often seen them swimming about on the large lakes just like a grebe. They vary greatly in size and colour.

Male from the Fraser measured, total length, 7½ in. Male from Colville, 6 in. Male from Ashtnolow (Cascade range), 2451 ft. above the sea level, 7 in. Male from Flat-head river, Rocky Mountains, 6¾ in. Male from Camp Kishenehu, 4150 ft. above the sea level, 6½ in.

Geothlypis trichas—(Cabanis.)

Maryland Yellow-throat. Common on Vancouver Island and along the whole course of the Boundary line to the Rocky Mountains. Arrives in April, and leaves again in September.

Frequents dark shady underbrush, and from its habit of creeping among the bushes, is difficult to obtain, and but seldom seen.

Helminthophaga celata.—(Baird.)

Orange-crowned Warbler. Common on Vancouver Island, and along the entire length of the Boundary line. Arrives in April and May; leaves again in September. Same range,—north and south as the above.

Myiodioctes pusillus.—(Bonap.)

Green Black-cap Flycatcher. Found on Vancouver Island, and along the Boundary line to the Rocky Mountains. Not at all an abundant bird; arrives at Colville in April and May, and leaves again early in September; habits dense thickets, and is always moving about in a jerking restless manner.

Pyranga ludoviciana—(Bonap.)

Louisiana Tanager. I never saw this bird west of the Cascade Mountains. It arrives at Colville in June, generally—male birds are first seen—they then perch on the tops of the highest pine trees, and continually utter a low piercing chirp. Soon after they pair and disappear into the forest. Where these birds build I cannot imagine, I have sought high and low for the nest, but never succeeded in finding it. I am inclined to think they must build on the tops of the very loftiest pine trees; it leaves again in September, never assembles in flocks. It ranges south through Oregon and California; how far north of Colville I had no means of finding out.

Hirundo thalassina.—Swainson.

Violet-green Swallow. This beautiful swallow is common on the coast on Vancouver Island, and along the entire course of the Boundary line to the summit of the Rocky Mountains. It is one of the earliest visitors at Colville, arriving in small flocks in March, but in greater numbers in May and June; nests in June, making the nest in holes in dead trees as high up as they can get. I did not procure the eggs as the trees had to be felled in which the nests were, and the eggs were invariably broken by the fall; they flock and leave again in September.

Hirundo bicolor—(Vieill.)

White-bellied Swallow. This swallow is common on Vancouver Island and along the Boundary line to the summit of the Rocky Mountains. Arrives in May, and makes its nest in holes in the cotton wood trees, or in old willow trees; the hole is lined with grass and feathers. Assembles in large flocks, and leaves again in September.

A great number of these swallows nest in the old willow stumps on the Sumass and Chilukweyuk prairies.

Hirundo lunifrons.—(Say.)

Cliff Swallow. I never saw this bird on the west side of the Cascades, but it is very abundant between the Cascades and Rocky Mountains; arrives at Colville in May and June in very large flocks. They choose the flat surface of a cliff or rock, and build all over it, the nest is of mud, built very much like a *retort*, with the neck broken off; very often a large clump of nests 8 or 10 in number, are built under a ledge over one another. They assemble after nesting in large numbers, young and old, and leave again in September.

Cotyle serripennis.—(Bonap.)

Rough-winged Swallow.—This swallow arrives about the same time as the sand martin and has just the same habits and distribution, but differs in its nesting place. This bird always nests in holes in the cotton-wood trees, generally selecting dead ones and going as high up as possible, lines the holes with grass and feathers.

I never obtained the eggs. They assemble in large flocks, and leave again in September.

Ampelis garrulus—(Linn.)

Wax-wing, Bohemian Chatterer. These birds I have only met with twice, and on both occasions at Colville, in November, I never saw them in the spring. They arrived in very large flocks, young and old together. All the leaves were gone, and deep snow on the ground, and these birds were feeding on the haws remaining on the thorn bushes.

They remained only two or three days, and then suddenly disappeared. I am convinced they go much further north to breed.

Ampelis cedrorum—(Baird.)

Cedar Bird. I have never seen these birds in any number west of the Cascades, but a few are occasionally seen about the Sumass, and Chilukweyuk prairies. But between the Cascades and Rocky Mountains they are very abundant. They arrive in small flocks in May, soon pair, and nest along the banks of the Columbia river. They build in the white-thorn bushes; the nest always lined with a black hair-like moss or lichen.—This moss is used extensively as an article of food by the Indians.—They leave again in September. At Siniakwateen they also breed in vast numbers.

Myiadestes townsendii.—(Cabanis.)

Townsend's Flycatcher. I met with these rare birds once only and that was at Colville, it was towards the end of November; deep snow was on the ground, all the leaves were fallen, and it was intensely cold. My attention was first attracted by hearing a low sweet song, not unlike our English song-thrush, which at this time of year was a most unusual sound, on looking round I saw about twenty of these birds perched on the top sprays of some white-thorn bushes; in their mode of darting off and returning again to the spray they put me in mind of the shrike. I shot six of them, and could detect no material difference in plumage between males and females. In the stomachs of those I opened were the remains of some small Coleopterous insects and a few haws. They left the next day, and I never saw them again.

Collyrio borealis—(Baird).

Great Northern Shrike Butcher Bird. Found at Vancouver Island and along the Boundary line to the Rocky Mountains; I at first imagined I had two species, but a more careful comparison of a large series of specimens convinces me I have but this one. The males of one, and those of two years old, differ so much from each other, and so widely from the adult bird as to have led to great confusion.

They arrive in March, and I have shot them at Colville as late as November.

I have often examined the contents of their stomachs, but never saw the remains of lesser *birds*, generally spiders and beetles, and I believe they are solely insect feeders.

A male killed at Colville in November measured 10½ in.

One on a high divide above the Osoyoos lakes 9¼ in.

A male on the Sumass prairies measured 9 in., killed in June.

Mimus carolinensis.—(Gray.)

Cat Bird. It is somewhat curious I never saw this bird west of the Cascades; but it is very abundant between the Cascades and Rocky Mountains. They arrive at Colville in May and June in twos and threes, and make the underbrush vocal with their peculiar cat-like cry. They begin nesting in June—build a loose nest of grass and dead leaves very near the ground. Very shy and skulking in their habits, seldom flying in the open. They leave again in September.

Cistothorus (Telmatodytes) palustris.—(Cab.)

Long-billed Marsh Wren. Very common on Vancouver Island and along the Boundary line, frequenting pools and lakes where the bulrushes grow: it climbs up and down the stalks much like a nuthatch; song very sweet. They arrive about Sumass prairies and at Colville in May and June, and leave again in September. Builds a hanging nest among the bulrushes, made of fine grass, and lined with the down from the seed pod of the rush. Specimens brought from Sumass, Colville, and Osoyoos lakes.

Troglodytes parkmanni.—(Aud.)

Parkman's Wren. This beautiful little wren is common in the woods about Sumass prairies and Chilukweyuk lake, also east of the Cascades along the Boundary line to the west slope of the Rocky Mountains. Their habit of keeping so closely to the heavy timber renders it next to impossible to watch its periods of migration.

Troglodytes (Anorthura) hyemalis.—(Vieill.)

Winter Wren. This wren has just the same range and distribution as *Troglodytes parkmanni*, and the same remarks will equally apply to both.

Sitta aculeata.—(Cassin.)

Slender Bill Nuthatch. This nuthatch is very abundant in the pine forests from the coast to the Rocky Mountains; never seen in large flocks, but usually alone or in twos and threes. Remained about Colville during the winter, when the temperature was 30° below zero. Nests in holes in the branches of the tallest pine trees, so high as to render getting the eggs almost an impossibility. They nest early in June.

Sitta canadensis.—(Linn.)

Red-bellied Nuthatch. Very common on Vancouver Island and on the Sumass prairies, but rather a rare bird between the Cascades and Rocky Mountains. I have seldom seen more than one or two together, and then generally in dark swampy places. Nests in holes in dead trees; eggs laid on the dust made in working out the hole. (Eggs sent home).

Sitta pygmaea.—(Vigors).

California Nuthatch.—An abundant little bird along the entire length of the Boundary line from the coast to the Rocky Mountains, also common on Vancouver Island; you always see these little fellows in large flocks in company with the chickadees, except during the nesting time, which is in June. A few remain about Colville during the winter, but the greater portion leave in November and December: they continually fly from tree to tree, having a low twittering cry, and run along the under sides of the branches searching for insects. Nests in June, making a hole in the dead branch of a pine tree; no lining in the hole, but the eggs are laid on the dust made in enlarging or boring the hole.

They range north to Fort Simpson, and south through Oregon and California. This applies to all three species.

Parus occidentalis.—(Baird.)

Western Titmouse. Common on Vancouver Island and along the whole course of the Boundary line to the summit of the Rocky Mountains. A few remain during the winter at Colville, but the greater portion leave in November and arrive again in April; nests in June, choosing a hole in a dead tree, lines the nest with grass and feathers; after the nesting time they assemble in large flocks and feed in company with the mountain tit and the golden-crested wrens, they keep together until they take their departure south.

Parus montanus.—(Gambel.)

Mountain Titmouse. This bird has just the same range and distribution as the preceding, and exactly agrees with it in habit, periods of migration, and nesting time, but it is not nearly as plentiful.

Parus rufescens.—(Towns.)

Chestnut-backed Titmouse. This little fellow is very abundant on the Sumass prairies, and along the banks of the Fraser river, but rare between the Cascades and Rocky Mountains; I met with it only twice, once at Colville in company with a flock of golden-crested wrens, and once at Siniakwateen; hence I am disposed to think it is more common along the coast line than in the interior. It arrives in May, and leaves again in September. I never found its nest. The northern range of these tits is about Fort Simpson, and south through Oregon and California.

Eremophila cornuta.—(Baird.)

Sky-lark—Shore-lark. A few of these birds remain along the sea shore at Vancouver Island during the winter, but I first observed them at Colville in flocks, in April and May; they remained only a few days, went north, and returned again in September, going south. These birds breed in large numbers on the sandy plains, laying between the Spokan river and the Dalls; they begin nesting before the snow is off the ground, and I saw young birds in May. On our first trip from the Dalls to Colville, we camped at a place called Cedar springs; the only water within a long distance of us was a small stream that spouted out from a bank in the midst of a sandy desert. It was curious to see these shore-larks actually coming in among the legs of the men and mules to drink; intense thirst appeared to dispel all sense of fear. Having carefully compared a large series of specimens shot at different periods of the year and at different camps along the *line*, I am quite convinced there is but one species, and that species the same in every particular as the Eastern bird.

Carpodacus cassinii.—(Baird.)

Cassin's Finch. This bird arrives at Colville in April and May in small flocks, soon pairs, and begins nesting in June. It appears to take the place of the western finch in the district, laying between the western slope of the Rocky Mountains, and eastern slope of the Cascades. I have seen it 6000 ft. above the sea level.

Chrysomitris pinus.—(Bonap.)

Pine-finch. I have only shot this bird on Vancouver Island, and on the Chilukweyuk river, never between the Cascade and Rocky Mountains; I cannot tell anything about the periods of its arrival or departure, or range north and south.

Curvirostra americana.—(Wilson.)

Red Crossbill. Common on Vancouver Island, and along the entire course of the Boundary line. It arrives at Colville early in March, but I am nearly sure a few remain during the winter; they keep generally to the timber on the hill tops, as high as 7000 ft. above the sea level. If they leave they leave very late, for I shot them in the Colville valley at the end of November. Where they build I cannot imagine, for I have searched again and again for their nests, but never found one.

I have very carefully sought the white-winged crossbill, but never found it west of the Rocky Mountains.

Plectrophanes nivalis.—(Meyer.)

Snow Bunting. This bird is entirely a winter resident at Colville; they arrive in October and November, and remain until March, and then go north to breed. They utter a sweet twittering kind of song when flying, and perch freely on bushes, rails, and the top of the H. B. Company's trading post at Fort Colville.

At Sumass prairies, on the west side of the Cascades, they arrive and depart about the same periods. They vary wonderfully in colour, if you shoot twenty from one flock you will never find two coloured alike. The last winter, at Colville, although the temperature was 32° below zero, these birds did not appear to suffer the least from cold, and large flocks of them frequented some wheat stubbles belonging to the H. B. Company's post, and the coral (an enclosure for cattle); they dug down through the snow for grain and seeds like ptarmigan.

Passerculus savanna.—(Bonap.)

Savannah Sparrow. I obtained this bird at Vancouver Island, and at the Sumass prairies, and feel sure I must have seen it if it had been at all common between the Cascades and Rocky Mountains, hence I think it is almost entirely confined to the coast and adjoining islands. It arrives at the island early in April, and leaves again in September. Breeds on Vancouver Island, and coast range.

Zonotrichia gambelii.—(Gambel.)

Gambel's White-crowned Sparrow. This bird is widely distributed, extending along the whole course of the Boundary line from the coast to the very summit of the Rocky Mountains: very plentiful also on Vancouver Island, where it breeds, nesting early in June. Arrives at Colville in April, in small flocks, and soon pairs; leaves again in September. Shy and retiring in its habits, keeping in thick underbrush.

Junco oregonus.—(Sclater.)

Oregon Snow-bird. I know of no bird so widely distributed or in greater numbers than this one on Vancouver Island and along the entire length of the Boundary line, from the coast to the very summit of the Rocky Mountains. In spring and autumn they are in immense flocks, and only separate when they pair for nesting; where they build I am at a loss to imagine; I have hunted and watched them, and tried every means to find their nests, but always without success. I am convinced in my own mind they build on the ground, although, of course, it is but an assumption. They arrive early in April at Colville, and leave again towards the end of September.

Spizella monticola.—(Baird.)

Tree Sparrow. One of the very earliest of the spring visitors; arrives at Colville in small flocks early in March, and keeps on the tops of the tallest pine trees. Common also on Vancouver Island, and along the whole course of the Boundary line. Pairs in May and begins building early in June, generally choosing the fork of a young pine tree for the site of its nest. After nesting they again assemble in flocks, young and old together, and join company with the chipping sparrow, and take their departure about the end of September.

Spizilla socialis.—(Bonap.)

Chipping Sparrow. In its period of arrival, general distribution and habits, it almost exactly coincides with *Spizella monticola.* It differs somewhat in its nest, as it selects the end of a branch, and uses more moss in the construction of its nest; the eggs are paler and not so much blotched.

Pipilo oregonus.—(Bell.)

Oregon-ground Robin. This bird is very abundant, and extends from the coast to the summit of the Rocky Mountains; it is also very common on Vancouver Island. They arrive in April and May, and frequent dark woods and thick under-brush; very stealthy and shy in its habits, makes a curious noise or cry much like that of the cat-bird, and *scrapes* amongst the dead leaves like a *fowl.*

The only nest I ever found was built of fine root fibres, and lined with deer's hair, and most artfully concealed. They assemble in small flocks, and leave again in October; some few of them winter on Vancouver Island.

Agelaius phoeniceus.—(Vieillot.)

Swamp Blackbird—Red Wing. Very common from the coast to the Rocky Mountains, and in the Colville valley. A few remain during the winter. The great mass of them arrive in April and May, and begin building early in June, generally selecting low bushes round swampy places. After nesting, young and old assemble in flocks, and leave in October; a few only remaining about the farm yards.

Sturnella neglecta.—(Aud.)

Western Meadow Lark. Arrives at Colville very early in April before the snow is off the ground, and frequents open grassy plains; ranges from the coast to the Rocky Mountains; builds early, makes its nest on the ground. Very early in the spring, on their first arrival, the male bird sits on the top of a small bush, and warbles out his love song,—a few notes rapidly repeated, but exquisitely sweet and plaintive.

Icterus bullockii.—(Bon.)

Bullock's Oriole. A few of these birds reach as far north as Colville, and I have met with some stragglers on the west side of the Cascades; but at Fort Dalls they are very plentiful. They build in the scrub oak, and arrive about the beginning of May;—build a tightly woven hanging nest. I saw one large oak tree on the Shasta plains standing alone, not a bush or tree within miles of it, and this tree was taken possession of by a large number of these birds; and I should think at least fifty nests hung from different branches. The bright golden yellow and black plumage of these handsome birds contrasted prettily with the bright green leaves and brown jacket of this solitary tree in the wilderness.

They assemble in small flocks after nesting, and take their departure in September. Specimens brought from Colville, the Dalls, and Sumass.

Scolecophagus cyanocephalus.—(Cab.)

Brewer's Blackbird—Western Grackler. The only place I ever saw this bird was in the Colville valley, where they remain during the winter, frequenting the barn yards and *corals* of the settlers. I never succeeded in finding their nests.

Corvus carnivorus.—(Bartram).

American Raven. This bird is widely distributed, ranging from the coast along the Boundary line to the summit of the Rocky Mountains. They pair early in March, and although I have seen their nests on the top of a lofty pine tree, never succeeded in obtaining the eggs. A great many of them remained at our head-quarters at Colville during the last winter, although the temperature was often 32° below zero, and deep snow everywhere. They were very bold and fearless, coming down among the dogs, and pitching close to the men when killing cattle. They remain during the winter in great numbers at Vancouver Island and along the sea coast.

Picicorvus columbianus.—(Bon.)

Clarke's Crow. I do not think this bird is found west of the Cascade Mountains, at least I never met with it, but is very abundant along the Boundary line, from the very summit of the eastern slope of the Cascades to the top of the Rocky Mountains, about 7000 ft. above the sea level. It feeds almost entirely on the seeds of the different pine trees, that of the *Pinus ponderosa* appears to be its favourite food; it feeds like a chickadee, or crossbill, hanging head downwards from a cone or small branch and working out the seeds from the bracts. I do not think they ever eat animal food, for I have opened their stomachs at all periods of the year, and I never found the remains of insects or any kind of animal matter. They arrive at Colville about April in large flocks, and just hop about from branch to branch making the woods ring again with their cry, which is a harsh discordant scream rapidly repeated.

Where they build I am at a loss to imagine, unless it be on the summit of the very lofty pine trees. I searched in vain for their nests, but never found one.

I believe the long sharp powerful claw and foot is for clutching tightly whilst getting out the pine seeds. They leave again in September and October.

Pica hudsonica.—(Bonap.)

Magpie. Very common along the Boundary line from the coast to the summit of the Rocky Mountains. Although the cold was most severe, a few remained about the barracks at Colville during the winter. They are dreadfully destructive to mules and horses, pitching on them if they have sore backs, and keep continually picking at the wound. They winter in large numbers along the coast, and on Vancouver Island.

They begin nesting very early in March, build a strong nest of sticks lined with mud, placing it in the centre of a thick thorn bush; (eggs sent). Assemble in large flocks soon after nesting time.

Cyanura stelleri.—(Swainson.)

Steller's Jay. Common and abundant everywhere from Vancouver Island to the summit of the Rocky Mountains. A few remain at Colville during the winter, but the greater number leave in October and November, and arrive again early in April. They build in a young pine tree, the nest composed of moss and small twigs thickly woven, and lined with deer's hair; lay about seven eggs.

Ectopistes migratoria.—(Swainson.)

Passenger Pigeon. Extends along the Boundary line from the coast to the summit of the Rocky Mountains. It arrives at Colville about April, and leaves again in October; lays two white eggs in June on the bare ground, generally on a sandy bank on the edge of a stream; (eggs sent). I have never seen them here in large flocks, perhaps twenty or thirty being the greater number seen together.

Zenaidura carolinensis.—(Bonap.)

Carolina Dove. This dove arrives about the same time as the pigeon, and has much the same range; builds a loose nest, composed of bits of dry stick, in the fork or on the branch of a pine tree. Lays two white eggs. Some few remained at Colville during the winter, but the greater part of them left in October.

Tetrao obscurus.—(Say.)

Dusky Grouse. This grouse figured and described by Sir John Richardson, F.B.A., is found on the western side of the Rocky Mountains; arrives at Vancouver island, at Nesqually, and along the banks of the Fraser river about the end of March and beginning of April. The male bird, on its first arrival, sits on the top of a tall pine tree, or on the summit of a rock, and announces his arrival by a kind of love song, a sort of booming noise repeated at short intervals, and so deceptive is the sound that I have often stood under the tree where the bird was and imagined the sound some distance away. It is extremely difficult to see this bird when you know he is in the tree, so much does he resemble a knob or the end of a dead branch. Soon after their arrival they begin to pair, but during the whole nesting time the male continues the booming noise. The young are a good size in August, but never afford much sport, as they pitch in the trees immediately after being flushed.

Between the Cascades and Rocky Mountains this grouse seems to be replaced by *if not a distinct species* a very well marked variety. In size it is a trifle smaller, but the great mark of distinction is the entire absence of white at the end of the tail. Finding in some mature birds a trace of white, I hesitate as to making it a new species. The young nestlings, eggs, and mature male and female birds, from east of the Cascades, are in the British Museum, as well as others from the west or coast slope. In habits, periods of arrival and departure, or perhaps "disappearance" would be better, the two species are such if they be not in every respect similar to each other. Where they go during the winter I cannot imagine, the Indians say they go to sleep in the pine trees; I do not think they migrate, but only retire into the very thickest pine trees, and living on the pine bracts pass the winter in the bush.

Tetruo franklinii.—(Douglas.)

Franklin's Grouse. I believe this bird is but rarely found, and when met with is always at a great altitude west of the Cascades, but on the eastern side and along the whole district laying between the Cascades and Rocky Mountains it is tolerably abundant, always keeping up in the mountains, and as high as 7000 ft. above the sea level. It is the most stupid bird imaginable, and when five or six are flushed together they fly up into the nearest pine tree and there sit, and you may throw sticks and stones at them, until you are tired, and they will not be frightened. I have often killed one or two in a tree where others were sitting without their attempting to fly away. They remain in the deep woods and sheltered places during the winter, and feed on the leaves of the pine tree. They begin nesting in May, and in proceeding from Colville to the Rocky Mountains I saw lots of chicken in June and July not long from the nest. I do not think these birds pair, in the strict sense of the word, but from the large number of females compared to males, I am disposed to think that *one* cock has the run of several hens. I never succeeded in obtaining the eggs, but the mature birds and chicken are set up in the British Museum. This grouse appears to represent *Tetrao canadensis* of the eastern side, and in habits and distribution is very similar.

Pedioecetes phasianellus.—(Baird.)

Sharp-tailed Grouse. This handsome bird I met with only between the Cascades and Rocky Mountains, and to the prairies and sand plains here, is just what the pinnated grouse or prairie hen is to the prairies on the eastern side. In August and September before they begin to pack, and when in coveys or broods, they afford admirable sport, rising boldly out of the grass with a loud whirring noise, and go away straight and sharp as an arrow; but about October they commence packing and pitch on fence rails, or trees, but at all times shy and wary, and not very easily approached. They live on the open sand plain and grassy prairies, especially liking the banks of little streams thinly skirted with timber. Round the Osoyoos lakes I found them in great abundance: their flesh is brown, but very delicious. I never got their eggs, but I saw the old nests in the grass on the tobacco plains near the Kootanie river; it was just a hole scraped out in the sand, lined with a few straggling grass fibres and feathers. I should say the average number of young was from 10 to 15. These birds remain all the winter in some sheltered gorge, their thickly feathered feet enabling them to run easily on the snow. They have a curious call, rapidly repeated when first flushed or frightened. They run with great rapidity, and so much does the back of the bird resemble sand and brown leaves and grass that when squatted down it is almost impossible to make them out.

Bonasa sabinii.—(Baird.)

Oregon Grouse—Ruffed Grouse. This grouse is common on Vancouver Island and along the whole course of the Boundary line to near the summit of the Rocky Mountains. It is delicious eating, but affords but very indifferent sport as a game bird, perching in a tree immediately it rises and crouching down the long way of the branch, most effectively conceals itself from notice; they are not easily frightened, and often two or three may be shot on a tree without the others flying off. There is one well-marked variety of this grouse, although it is scarcely entitled to be made a new species, as I sometimes find traces of intermediate gradation of colour—the marked difference is in the colour of the tail feathers, the one being reddish brown, the other ash colour—but the transverse markings are the same. I shot adult males and females with ash-coloured tails, but nearly always in the same flock as the red-tailed. On the Sumass and Chilukweyuk prairies these birds are very abundant (along the edges of the bush), as well as on Vancouver Island, and small islands adjacent to it. They remain all the winter, and begin nesting in May, simply digging out a hole under a projecting piece of rock, and laying the eggs on the bare ground; the broods average from 10 to 14.

About pairing time and during the period when the female is setting, the male bird sits on an old log near by, and by rapidly fluttering its wings makes a loud noise aptly called drumming, he repeats it about every four or five minutes, and it often leads to his destruction, for the Indians guided by the noise creep stealthily upon him and bowl him over.

Gallinago wilsonii, (Temm.)—Bon.

Wilson's Snipe. This snipe appears to be scattered everywhere along the entire length of the Boundary line, and is also common on Vancouver Island. I have seldom seen them in any numbers, but a few here and there in spring and autumn on a wet swampy spot. They arrive in April and May, and leave again in October and November. Breed in all the valleys inland. I shot specimens on the island at Sumass and at Colville.

Macrorhamphus scolopaceus (Say).—Lawrence.

Red-breasted Snipe. This snipe arrives in small flocks in April and May in the Colville valley, remains only a few days, going further north to breed; returns again, old and young together, in August and September, frequenting the edges of pools and swampy places. I have compared a great number of specimens, and cannot satisfy myself as to a second species.

Tringa bonapartii.—(Sch.)

Shot at Colville in April. A small flock frequented the edge of a pool and were busily employed in picking up small insects, remained only a day or two. I never killed or saw any on the island or mainland coast, but I have no doubt it visits the west side of the Cascades in its migrations.

Tringa wilsonii.—(Nuttall).

Least Sandpiper. Arrive in great numbers along the coast and bays of Vancouver Island in April and May; remains a short time and goes inland to breed. I saw lots of them in the Colville valley in September, young and old together; returning south, they remain only a few days, frequent the edges of pools and river banks; they breed along the banks of the small mountain streams in June and July.

Gambetta flavipes.—(Gmi.)

Yellow Legs. Common east and west of the Cascades, arriving at Colville in April, and a little earlier on the coast. I believe it goes north to breed, returning again in September and October, young and old together; they remain a short time in the Colville valley in the spring and Autumn.

Actiturus bartramius.—(Wils.)

Bartram's Sandpiper. I first observed this bird in the Colville valley, on the 18th of June, and then had not the most remote idea what bird it was. When I first spied him out he was sitting on the extreme top of a young fir tree, continually uttering a sharp shrill whistling cry; he was terribly shy and wary, and would not allow me to come within anything like gun-shot, flying off when I attempted to approach, and always again pitching on a tree top; whilst on the wing unceasingly uttering the same shrill cry. For a good two hours I dodged my friend and eventually shot him; I subsequently found this plover on the Spokan prairies, and then it was a month later in the year and nesting time, his habit now was to live in the grass, and flushed much like a snipe, flying a short distance then suddenly alighting in the grass. The nest I found was on the ground in a hole, lined with dry grass and leaves, 3 eggs were in it.

Numenius longirostris.—(Wilson.)

Long-billed Curlew. This curlew appears to me to be only a straggler on the west side of the Cascades, but very common between the Cascades and Rocky Mountains. They arrive at Colville, and on the Spokan prairies in small flocks of three and four, in April; nest on the ground, the nest being a hole scraped out in the earth with a few bits of grass and dead leaves scattered loosely about (three eggs the usual number laid), they leave again in October. I noticed a curious habit this bird had in the fall of the year, that of pitching on the very top of the tallest pine trees, and uttering a strange prolonged and discordant cry. I never saw them attempt to perch at any other period of the year.

Anas boschas.—(Linn).

Mallard. This duck is common everywhere on the Island, along the coast east and west of the Cascade mountains, on every stream and lake; they breed here and remain in the bays and harbours during the winter.

Dafila acuta.—(Jenyns).

Pintail Duck. This duck is found in the spring and fall on most of the streams and lakes inland, both east and west of the Cascades. It is also common on Vancouver island, arrives in April and breeds north; dives a great deal for its food, and is not nearly as shy or difficult to approach as the mallard.

Nettion carolinensis.—(Baird).

Green-Winged Teal. This teal is most abundant, arriving in April in large flocks, and going north to breed, although a few breed inland along the course of the Boundary line; returns in the Colville valley, young and old together, in September and October, alighting on small streams and pools to feed, but remaining only a few days.

Spatula clypeata.—Wilson.

Shoveller Duck. Very common, and a constant visitor along the coast on the Island and on the lakes and streams inland, east and west of the Cascades; arrives on its northern route in April, returning again in September and October. A fishy duck, and not at all good for the table.

Mareca americana.—Stephens.

American Widgeon. An abundant duck everywhere, on the coast and on the Island, and on every lake and inland stream east and west of the Cascade mountains, arrives and departs about the same periods as the preceding.

Mergus americanus.—(Cassin).

Sheldrake Goosander. These birds are found in summer in every lake and mountain stream, east and west of the Cascades and on the western slope of the Rocky Mountains; they breed on the rushy banks of the inland lakes and streams, assembling in large flocks in September. They remain inland very late; I shot one on the Columbia, 800 miles from the sea in October, but as the cold weather comes on they retire to the coast, returning to the streams again in March and April.

Lophodytes cucullatus.—(Reich).

Hooded Merganser. I obtained this bird in winter in Esqimault Harbour and it is found, though not abundantly, in the inlets and bays on both the island and mainland coasts; but inland in the summer, east and west of the Cascades, and on the west slope of the Rocky Mountains. It may be seen in every stream, lake, and pool, where it breeds, returning coastward when the frost sets in, and returning again early in March.

Colymbus torquatus.—(Brunn).

The Great Northern Diver.—The Loon. This magnificent bird is found at all periods of the year (except perhaps in the very depth of winter), both east and west of the Cascades, and up to the very summit of the Rocky Mountains. In nearly all the lakes, rivers, and pools may be seen the loon, dozing idly by the sedgy margins, or busily diving after its finny prey; and at sundown and daybreak his call, loud, plaintive and sad, like the wail of some water-elf or goblin grim, peals over the still water.

I hardly know a sound that falls with such mournful cadence on the ear of the lonely wanderer in a primeval wilderness, as the cry of the loon, and it is rendered a thousandfold more impressive inasmuch as it comes pealing through the silence of the twilight when nature goes to sleep.

They breed on the sedgy and marshy margins of inland lakes and pools; nests early in the year, the nest being placed in a tuft of rushes close to the water (eggs sent home), seldom laying more than two eggs. The female specimen sent with eggs was shot on her nest. It is perfectly wonderful the distance this bird will go under water when frightened or slightly wounded. I have known them go quite half a mile; they use their wings underneath the water, much after the fashion they use them in the *air*, and literally and veritably fly through the water. During the very cold months of midwinter comes down to the coast, frequenting still bays and harbours.

Podiceps cornutus.—(Gm).

Horned Grebe. The horned grebe is somewhat rare, and found but sparingly on the inland streams and lakes; it arrives at Colville about April in full summer livery, generally in small flocks of three or four, pairs and nests in the rushes round the margin of small saline lakes. The female when leaving the nest always *dives* and comes up some distance from it. They get together in flocks before leaving for the coast, a few remain about Vancouver island, but the greater number go much further south.

BRITISH BIRDS

REQUIRED TO

COMPLETE THE ROYAL ARTILLERY INSTITUTION COLLECTION.

Griffon vulture.
Egyptian vulture.
Golden eagle.
White-tailed eagle.
Osprey.
Gyr falcon.
Peregrine falcon.
Hobby.
Red-footed falcon.
Merlin.
Goshawk.
Sparrow hawk.
Kite.
Common buzzard.
Honey buzzard.
Rough-legged buzzard.
Marsh harrier.
Hen harrier.
Montagu's harrier.
Eagle owl.
Long-eared owl.
Short-eared owl.
Barn owl.
Tawny owl.
Snowy owl.
Hawk owl.
Little owl.
Tengmalm's owl.
Great grey shrike.
Pied flycatcher.
Common dipper.
Ring ousel.
Alpine accentor.
Blue-throated warbler.
Black redstart.
Dartford warbler.
Parrot crossbill.
White-winged crossbill.
Raven.
Carrion crow.
Hooded crow.
Nutcracker.
Great black woodpecker.
Green woodpecker.
Great spotted woodpecker.
Lesser spotted woodpecker.
Hoopoo.
Pheasant.
Capercaillie.
Quail.
Great bustard.
Little bustard.
Cream-coloured courser.
Golden plover.
Dotterel.
Kentish plover.
Little-ringed plover.
Peewit.
Turnstone.
Sanderling.
Oyster catcher.
Common heron.
Great white heron.
Little egret.
Buff-backed heron.
Little bittern.
Common bittern.
White stork.
Black stork.
Spoonbill.
Curlew.
Whimbrel.
Spotted redshank.
Green sandpiper.
Wood sandpiper.
Spotted sandpiper.
Greenshank.
Avocet.
Black-winged stilt.
Black-tailed godwit.
Bar-tailed godwit.
Ruff.
Woodcock.
Great snipe.
Jack snipe.
Brown snipe.
Knot.
Little crake.
Moorhen.
Coot.
Grey phalarope.
Red-necked phalarope.
Bean goose.
White-fronted goose.
Pink-footed goose.
Bernical goose.
Brent goose.
Red-breasted goose.

Egyptian goose.
Spur-winged goose.
Canada goose.
Hooper.
Bewick's swan.
Polish swan.
Common shelldrake.
Gadwall.
Pintail duck.
Bimaculated duck.
Wild duck.
Garganey.
Teal.
Wigeon.
King duck.
Velvet scoter.
Common scoter.
Surf scoter.
Red-crested duck.
Pochard.
Ferruginous duck.
Scaup duck.
American scaup.
Tufted duck.
Long-tailed duck.
Golden eye.
Smew.
Hooded merganser.
Goosander.
Scalvonian grebe.
Guillemot.
Black guillemot.
Little Auk.
Puffin.
Razor bill.
Cormorant.
Green cormorant.
Gannet.
Caspian tern.
Sandwich tern.
Roseat tern.
Common tern.
Arctic tern.
Whiskered tern.
Gull-billed tern.
Lesser tern.
Black tern.
Noddy tern.
Little gull.
Black-headed gull.
Ivory gull.
Iceland gull.
Lesser black-backed gull.
Herring gull.
Great black-backed gull.
Glaucous gull.
Common skua.
Pomerine skua.
Richardson's skua.
Buffon's skua.
Fulmar petrel.
Greater shearwater.
Manx shearwater.
Bulwer's petrel.
Wilson's petrel.
Fork-tailed petrel.
Storm petrel.

ON SOME PHENOMENA EXHIBITED BY GUN-COTTON AND GUNPOWDER UNDER SPECIAL CONDITIONS OF EXPOSURE TO HEAT.*

BY F. A. ABEL, F.R.S.

[COMMUNICATED BY THE SECRETARY, R.A.I.]

The experiments upon which I have been engaged for some time past, in connexion with the manufacture and properties of gun-cotton, have brought under my notice some interesting points in the behaviour of both gun-cotton and gunpowder, when exposed to high temperatures, under particular conditions. I believe that these phenomena have not been previously observed, at any rate to their full extent, and I therefore venture to lay before the Royal Society a brief account of them.

Being anxious to possess some rapid method of testing the uniformity of products obtained by carrying out General von Lenk's system of manufacture of gun-cotton, I instituted experiments for the purpose of ascertaining whether, by igniting equal weights of gun-cotton of the same composition, by voltaic agency, within a partially exhausted vessel connected with a barometric tube, I could rely upon obtaining a uniform depression of the mercurial column, in different experiments made in atmospheres of uniform rarefaction, and whether slight differences in the composition of the gun-cotton would be indicated, with sufficient accuracy, by a corresponding difference in the volume of gas disengaged, or in the depression of the mercury. I found that, provided the mechanical condition of the gun-cotton, and its position with reference to the source of heat, were in all instances the same, the indications furnished by these experiments were sufficiently accurate for practical purposes. Each experiment was made with fifteen grains of gun-cotton, which were wrapped compactly round the platinum wire; the apparatus was exhausted until the column of mercury was raised to a height varying from 29 inches to 29·5 inches. The flash which accompanied the deflagration of the gun-cotton was apparently similar to that observed upon its ignition in open air; but it was noticed that an interval of time always occurred between the first application of heat (or incandescence of the wire) and the flashing of the gun-cotton, and that during this interval there was a very perceptible fall of the column of mercury. On several occasions, when the gun-cotton, in the form of "roving," or loosely twisted strand, was only laid over the wire, so that it hung down on either side, the red-hot wire simply cut it into two pieces, which fell to the bottom of the exhausted vessel, without continuing to burn. As these results appeared to indicate that the effects of heat upon gun-cotton, in a highly rarefied atmosphere, differed importantly from those observed under ordinary circumstances, or in a very imperfect vacuum, a

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series of experiments, under variously modified conditions, was instituted, of which the following are the most important.

It was found in numerous experiments, made with proportions of gun-cotton varying from one to two grains, in the form of a loose twist laid double, that in highly rarefied atmospheres (the pressure being varied from 1 to 8 in inches of mercury) the gun-cotton, when ignited by means of the platinum wire, burned very slowly, presenting by daylight an appearance as if it smouldered, with little or no flame attending the combustion. I was at first led by these results to conjecture that this peculiar kind of combustion of the gun-cotton was determined solely by its ignition in atmospheres rarefied beyond a certain limit; and I was induced, in consequence, to institute a number of experiments with the view of ascertaining what was the most highly rarefied atmosphere in which gun-cotton would burn as in the open air—with a flash, accompanied by a body of bright flame. In order to ensure uniformity in the degree of heat applied to the cotton in these experiments, the platinum wire employed was sufficiently thin to be instantaneously melted on the passage of the voltaic current. About fifty different experiments were made with equal quantities of gun-cotton (0·2 grain), placed always in the same position, so that the platinum wire rested upon the material. A tolerably definite limit of the degree of rarefaction was arrived at, within which the gun-cotton was exploded instantaneously, as in the open air. When the pressure of air in the apparatus was reduced to 8·2 in inches of mercury, the gun-cotton still exploded with a flash, but not quite instantaneously; on reducing the pressure to 8 in., the cotton underwent the slow kind of combustion in the majority of cases; on a few occasions it exploded with a flash of flame. The same occurred in a succession of experiments, until the pressure was reduced gradually to 7·7 in., when instances of the rapid explosion of gun-cotton were no longer obtained.

Although these results were moderately definite when the conditions of the experiments were as nearly as possible uniform, it was found that they could be altered by slight modifications of any one particular condition (such as the quantity of gun-cotton, its mechanical condition, its position with reference to the source of heat, the quantity of heat applied, and the duration of its application). In illustration of this, the following results may be quoted.

If the gun-cotton was wrapped round, instead of being simply placed across the wire, its instantaneous combustion was effected in atmospheres considerably more rarefied than with the above experiments.

In employing a small piece of gun-cotton (0·3 of an inch long and weighing 0·3 to 0·4 of a grain) loosely twisted, laid across the wire, or upon a support immediately beneath the latter so that the wire rested upon it, the slow combustion established in it by the heated wire, under greatly diminished atmospheric pressure (amounting to 0·6 inch in this and the following experiments), proceeded uniformly towards each end of the piece of twist, until the whole was transformed into gas. But if a piece of the same twist, of considerably greater length (say 4 in. long and weighing about 2 grs.), was exposed to heat in an atmosphere of the same rarefaction, the gun-cotton being laid over the wire and hanging down on either side, it was cut through by the passage of the current, and the two pieces, falling to the bottom of the vessel, ceased to burn almost immediately. Of a piece of gun-cotton weighing 2·17 grs., there remained unchanged 1·80 gr.; the quantity burned amounted therefore to 0·37 gr., and corresponded closely to the quantity which was completely burned in the preceding experiments. (The depression of the mercurial column in this experiment, by the gases generated from the gun-cotton, amounted to 0·2 in.)

A piece of the twist, $1\frac{1}{2}$ in. long, was placed across the wire, and supported by a plate of plaster of Paris, fixed immediately beneath it. The current was established to an extent just sufficient to heat the wire to the point of ignition of the gun-cotton, and then interrupted. The twist burned slowly in both directions until about a quarter of an inch was consumed on either side of the wire, when the combustion ceased. The same result was obtained in repetitions of the experiment, the wire being at once raised to a red heat, and thus maintained until the gun-cotton ceased to burn. But upon increasing the battery-power, doubling the thickness of the wire, and maintaining the heat, while a similar piece of twist was burning in both directions, the slow combustion continued until the entire quantity was transformed into gas. The same result was obtained by repeating this experiment with similar and larger quantities of gun-cotton, placed in the same position as before with reference to the wire.

In the next experiment, the mass of cotton exposed at one time to heat was increased by doubling a piece of the twist (4 in. long) and laying it thus doubled across the wire, as before. The current was allowed to pass until the wire was heated just sufficiently to ignite the gun-cotton, and then interrupted. In this case the slow combustion proceeded throughout the entire mass of the cotton. The permanent depression of mercury in this experiment was 0·6 in. It was particularly noticed on this occasion, that, as the decomposition of the gun-cotton crept slowly along the mass, the burning portions or extremities of twist were surrounded by a beautiful green light, more like a phosphorescence than a flame, and in form something similar to the brush of an electric discharge.

Eight inches of the twist were laid fourfold over the wire, which was heated just sufficiently to ignite the cotton. The decomposition proceeded, as before, gradually throughout the mass of the gun-cotton, but became somewhat more rapid towards the end, when the green glow, observed at first, was superseded by a pale yellowish lambent flame, very different in appearance from the flame which accompanies the combustion of gun-cotton under ordinary conditions. The permanent depression of the column of mercury in this experiment was 1·2 in.

The various modifications in the nature and extent of combustion which gun-cotton may be made to undergo, as demonstrated by the above experiments, when exposed to heat in highly rarefied atmospheres under variously modified conditions, are evidently due to the same causes which affect the rate of combustion of fuzes under different atmospheric pressures, and which have already been pointed out by Frankland* in his interesting paper on the influence of atmospheric pressure upon some of the phenomena of combustion. The heat furnished by an incandescent or melting platinum wire is greatly in excess of that required to induce perfect combustion in

* Vide Vol. III. p. 14.

gun-cotton which is actually in contact with, or in close proximity to it; and the heat resulting from this combustion, which is contained in the products of the change, will suffice to cause the transformation of the explosion to proceed from particle to particle. But if the pressure of the atmosphere in which the gun-cotton is submitted to the action of heat be reduced, the gases resulting from the combustion of the particles nearest to the source of heat will have a tendency, proportionate to the degree of rarefaction of the air, to pass away into space, and thus to convey away from proximity to the cotton, more or less rapidly and completely, the heat necessary to carry on the combustion established in the first particles. Thus, when the heated wire is enveloped in a considerable body of gun-cotton, the ignition of the entire mass is apparently not instantaneous, if attempted in a highly rarefied atmosphere, because the products of the combustion first established in the centre of the mass of gun-cotton escape rapidly into space, conveying away from the point of combustion the heat essential for its full maintenance; the gun-cotton therefore undergoes at first an imperfect form of combustion, or a kind of metamorphosis different from the normal result of the action of heat upon this material. But the effects of the gradual generation of heated gases from the interior of the mass of cotton are, to impart some of their heat to the material through which they have to escape, as well as gradually to increase the pressure of the atmosphere in the vessel, and thus to diminish the rapidity of their escape; hence a condition of things is in time arrived at when the remainder of the gun-cotton undergoes the ordinary metamorphosis, a result which is accelerated by maintaining the original source of heat. If, however, the gun-cotton be employed in a compact form (in the form of twist or thread), and placed only in contact with the source of heat at one point, the heat will be so effectually conveyed away by the escaping gases, that the material will undergo even what may be termed the secondary combustion or metamorphosis for a limited period only; so that, if a sufficient length of gun-cotton be employed, it will after a short time cease to burn, even imperfectly, because the heat essential for the maintenance of any chemical activity is soon completely abstracted by the escaping gases. These results may obviously be modified in various ways, as shown in the experiments described: thus, by increasing and maintaining the source of heat independent of the burning cotton, the slow combustion may be maintained through a much greater length of the material until the pressure of the atmosphere is increased, by the products disengaged, to an extent sufficient to admit of a more rapid and perfect metamorphosis being established in the remainder of the material; or the same result may be attained, independently of the continued application of external heat, by employing a thicker mass of cotton, or by using the material in a less compact form. In these cases the maintenance of the chemical change is favoured either by radiation of heat to the cotton, and provision of additional heat, from an external source, to the gases as they escape and expand, or by establishing the change in a greater mass of the material, and thus reducing the rapidity with which the heat will be conveyed away by the escaping gases, or, finally, by allowing the gases, as they escape, to pass to some extent between the fibres of the cotton, and thus favouring the transmission of heat to individual particles of the material.

In the description of the two experiments last referred to above, I have stated that some peculiar phenomena were observed to attend the imperfect kind of combustion induced in the gun-cotton in rarefied atmospheres.

In order to examine these phenomena more closely, I instituted a series of experiments, in a darkened room, with equal quantities of gun-cotton ($\frac{1}{2}$ in. of twist = 0·3 gr.) placed always in the same position, across the platinum wire, the only varying element in the experiment being the pressure of the atmosphere in the vessel, which was gradually increased. The following were the results observed:—

Experiment I. Pressure = 0·62 in. The wire was heated just sufficiently to ignite the material; the current was then interrupted. The gun-cotton burned very slowly in both directions, emitting only the small green phosphorescent flame, or brush, already described.

Experiment II. Pressure = 1 in. In addition to the green glow which surrounded the burning ends, a very faint yellowish flame was observed hovering over the gun-cotton.

Experiment III. Pressure 1·5 in. The cotton burned a little faster, and the faint yellowish flame was of a more decided character; indeed two separate flames were observed, each following up the green light as the cotton burned in the two directions.

Experiment IV. Pressure = 2 in. The results were the same as in the preceding experiment, excepting that the yellowish flames became more marked.

Experiment V. Pressure = 2·5 in. The same phenomena, the cotton burning considerably faster.

Experiment VI. Pressure = 3 in. The same phenomena, the yellow flames increasing in size.

Experiment VII. Pressure = 4 in. The rapidity of combustion of the cotton increased again considerably; the other phenomena observed were as before.

Experiment VIII. Pressure = 6 in. The pale yellow flame had increased in size considerably, no longer forming a tongue, as in the preceding experiments, but completely enveloping the burning ends of the gun-cotton. The green glow, though much reduced, was still observed immediately round the burning surfaces.

Experiment IX. Pressure = 8 in. The green glow was only just perceptible in this instance, and the cotton burned very rapidly, almost with the ordinary flash; but the flame was still of a pale yellow. In the preceding experiments clouds of white vapour were observed after the decomposition of the gun-cotton; in this and the following experiments this white vapour was produced in much smaller proportion.

Experiments X. to XV. inclusive. Pressure = 10, 12, 14, 18, 20, 24 in. The phenomena observed in these experiments did not differ in any important degree from those of Experiment IX.

Experiment XVI. The same pressure (24 in.) was employed as in the last experiment, but the piece of gun-cotton-twist was laid double across the wire. In this instance the gun-cotton burned with a bright yellow flash, as in open air.

Experiment XVII. Pressure = 26 in. The gun-cotton was laid singly over the wire, as in all experiments but the last. It burned with a flash of bright light, as in open air.

It appears from these experiments that gun-cotton, when ignited in small quantities in rarefied atmospheres, may exhibit, during its combustion, three distinct luminous phenomena. In the most highly rarefied atmospheres, the only indication of combustion is a beautiful green glow or phosphorescence which surrounds the extremity of the gun-cotton as it is slowly transformed into gases or vapours. When the pressure of the atmosphere is increased to one inch (with the proportion of gun-cotton indicated), a faint yellow flame appears at a short distance from the point of decomposition; and as the pressure is increased this pale yellow flame increases in size, and eventually appears quite to obliterate the green light. Lastly, when the pressure of the atmosphere and consequently proportion of the oxygen in the confined space is considerable, the cotton burns with the ordinary bright yellow flame. There can be no doubt that this final result is due to the almost instantaneous secondary combustion, in the air supplied, of the inflammable gases evolved by the explosion of the gun-cotton. It was thought that the pale yellow flame described might also be due to a combustion (in the air still contained in the vessel) of portions of the gases resulting from the decomposition of the gun-cotton; but a series of experiments, in which nitrogen, instead of air, constituted the rarefied atmosphere, showed that this could not be the case. The results obtained in these experiments corresponded closely to those above described, as far as relates to the production of the green glow and of the pale yellow flame. With rarefied atmospheres of nitrogen ranging down to one inch of pressure, the green flame was alone obtained; and the pale yellow flame, accompanying the green, became very marked at a pressure of 3 in., as in the experiments with air.

It would seem probable from these results, that the mixture of gaseous products obtained by the peculiar change which heat effects in gun-cotton in highly rarefied atmospheres, contains not only combustible bodies, such as carbonic oxide, but also a small proportion of oxidizing gas (possibly protoxide of nitrogen, or even oxygen), and that when the pressure of the atmosphere is sufficiently great this mixture, which has self-combustible properties, retains sufficient heat as it escapes, to burn, more or less completely, according to the degree of rarefaction of the atmosphere.

A series of experiments instituted with gun-cotton in highly rarefied atmospheres of oxygen, showed that the additional proportion of this gas thus introduced into the apparatus, beyond that which would have been contained in it with the employment of air of the same rarefaction, affected in a very important manner the behaviour of the explosion under the influence of heat. If eight or ten grains of gun-cotton are placed round the platinum wire, and the pressure of the atmosphere of oxygen in the vessel be reduced to four or three (in inches of mercury), the cotton explodes instantaneously, with an intensely bright flash, when the wire is heated. In a series of experiments made under gradually diminished pressures, oxygen being used instead of air, it was found that the gun-cotton exploded instantaneously, with a bright flash, until the pressure was reduced to 1·2 in.; from this pressure to that of 0·8 in. it still burned with a flash, but not instantaneously; and at pressures below 0·8 in. it no longer burned with a bright flash, but exhibited the comparatively slow combustion, accompanied by the pale yellow flame, which has been spoken of as observed when gun-cotton was ignited in air rarefied to pressures ranging from 1 in. to 24 in.

The interesting phenomena exhibited by gun-cotton in highly rarefied atmospheres, induced me to make some experiments of a corresponding nature with gunpowder. The same apparatus was used as in the preceding experiments, but a small glass cup was fixed immediately beneath the platinum wire, so that, by bending the latter in the centre, it was made to dip into the cup, and could be covered by grains of gunpowder.

Two grains' weight of small grain gunpowder were heaped over the wire, and the pressure of air in the apparatus was reduced to 0·65 in. The wire being heated to redness, three or four grains, in immediate proximity to it, fused in a short time and appeared to boil, evolving yellowish vapours, no doubt of sulphur. After the heat had been continued for eight or ten seconds, those particular grains deflagrated, and the remainder of the powder was scattered by the slight explosion, without being ignited. No appreciable depression of the mercurial column occurred during the evolution of the yellowish vapours; the permanent depression, after the deflagration, was only 0·15 in.

The experiment was repeated with small-grain gunpowder, amounting to four grains, and the same phenomena were observed, with this difference, that a second slight deflagration followed shortly after the first, probably in consequence of a grain or two of the powder falling back into the cup.

A single piece of gunpowder, weighing 14 grns., so shaped as to remain in good contact with the wire, was placed over the latter, being supported by the cup. The pressure of air in the apparatus was, as before, equal to 0·65 inch of mercury. There was no perceptible effect for a short time after the wire was first heated to redness; vapours of sulphur were then given off, and slight scintillations were occasionally observed; after a time the wire became deeply buried in the superincumbent mass of gunpowder, which fused, and appeared to boil, where it was in actual contact with the source of heat. After the lapse of three minutes from the commencement of the experiment, the powder deflagrated. The permanent depression of the mercury column amounted to 1·35 inch.

The experiment was repeated with a similar piece of powder, weighing 16 grns.; the same phenomena were observed; and five minutes elapsed between the first heating of the wire and the deflagration of the powder.

The experiments were continued with fine-grained gunpowder, and under pressures gradually increased, in successive experiments, from 0·7 to 3 in inches of mercury. The same weight of gunpowder (4 grns.) was used in all the experiments. In those made under a pressure of 1 in., the results observed were similar to those obtained in the first experiments; single grains of gunpowder were successively deflagrated, burning very slowly, and scattering but never igniting contiguous grains of powder. Eventually, after the lapse of from ten to twenty seconds, 3 or 4 grns. were deflagrated at once, the remainder of the powder being thereby projected from the cup. At a pressure of 1·5 in., the same phenomena were observed, but the successive deflagrations of fused grains of powder followed more quickly upon each other, and the final ignition of several together occurred in about ten seconds after the wire was first heated. At a pressure of 2 in., at first only one or two of the fused grains were ignited, singly; and several were deflagrated together after the lapse of five seconds. A larger quantity of the powder was burned, but a portion was projected from the cup as in preceding experiments. At a pressure of 3 in., no grains were ignited singly; the combustion of the powder was effected after an interval of about four seconds, and the greater portion was burned; the combustion, though it had gradually become more similar to that of gunpowder in open air, was still very slow.

Experiments made with gunpowder in highly rarefied atmospheres of nitrogen furnished results quite similar to those described; nor was any important difference in the character of the phenomena observed when oxygen was substituted for air, except that the scintillations and deflagrations of the powder-grains were in some instances somewhat more brilliant.

The above experiments show that, when gunpowder is in contact with an incandescent wire in a highly rarefied atmosphere, the heat is, in the first instance, abstracted to so great an extent by the volatilization of the sulphur, that the particles of powder cannot be raised to the temperature necessary for their ignition, until at any rate the greater part of that element has been expelled from the mixture, in consequence of which the portions first acted upon by heat will have become less explosive in their character, and require, therefore, a higher temperature for their ignition than in their original condition. The effect of the continued application of heat to the powder thus changed is, to fuse the saltpetre and to establish chemical action between it and the charcoal, which, however, only gradually and occasionally becomes so energetic as to be accompanied by deflagration, because the gas disengaged by the oxidation of the charcoal continues to convey away much of the heat applied, in escaping into the rarefied space. For the same reason, the grains of unaltered powder which are in actual contact with the deflagrating particles are not ignited by the heat resulting from the combustion, but are simply scattered by the rush of escaping gases, at any rate until the pressure in the vessel has been so far increased by their generation as to diminish the rapidity and extent of their expansion at the moment of their escape. The disengagement, first of sulphur-vapour and then of gaseous products of chemical change, unattended by phenomena of combustion, when gunpowder is maintained in contact with a red-hot wire in very highly rarefied atmospheres, are results quite in harmony with the observations made by Mitchell, Frankland, and Dufour, with regard to the retarding influence of diminished atmospheric pressure upon the combustion of fuzes. The phenomena described are most strikingly exhibited by operating upon single masses of gunpowder, of some size, in the manner directed above, when the application of the red-hot wire may be continued from three to five minutes (the gases disengaged during that period depressing the column of mercury from 0·5 to 0·7 inch) before the mass is ignited. There is no doubt that the products of decomposition of the gunpowder, obtained under these circumstances, differ greatly from those which result from its explosion in confined spaces or in the open air under ordinary atmospheric conditions. In all the experiments conducted in the most highly rarefied atmospheres (at pressures of 0·5 to 1·5 in inches of mercury), the contents of the vessel, after the final deflagration of the powder, always possessed a very peculiar odour, similar to that of horseradish, due to the production of some sulphur-compound; nitrous acid was also very generally observed among the products. It is readily conceivable that the chemical action established between the constituents of gunpowder, under the circumstances described, must be of a very imperfect or partial character, the conditions under which it is established being unfavourable to its energetic development.

In describing the phenomena which accompany the ignition of gun-cotton in atmospheres of different rarefaction, I have pointed out that, at pressures varying from one to twenty-four in inches of mercury a pale yellow flame was observed, which increased in size with the pressure of the atmosphere; and that a flame of precisely the same character was produced in rarefied atmospheres of nitrogen. The experiments instituted in nitrogen show that the explosion of loose tufts of gun-cotton in atmospheres of that gas, even at normal pressures, was always attended with a pale yellow flash of flame, quite different from the bright flash produced by igniting gun-cotton in air. The same result was observed in atmospheres of carbonic acid, carbonic oxide, hydrogen, and coal-gas. In operating with pieces of gun-cotton-twist or thread of some length instead of employing the material in loose tufts, the results obtained in the two last-named gases were very different from those observed in atmospheres of nitrogen, carbonic acid, and carbonic oxide. When ignited by means of a platinum wire (across which it is placed) in vessels filled with either of those two gases, and completely closed or open at one end, the piece of twist burned slowly and regularly, the combustion proceeding much more deliberately than if the same piece of gun-cotton had been ignited in the usual manner in air, and being accompanied by only a very small jet or tongue of pale yellow flame, which was thrown out in a line with the burning surface when the gun-cotton was ignited. The same result was obtained in currents of those gases when passed through a long, wide glass tube, along which the gun-cotton-twist was laid, one end being allowed to project some distance into the air. The projecting extremity being ignited, as soon as the piece of twist had burnt up to the opening of the tube through which the gas was passing, the character of the combustion of the gun-cotton was changed from the ordinary to the slow form above described. On repeating this form of experiment in currents of hydrogen and of coal-gas, the ignited gun-cotton burned in the slow manner only a very short distance inside the tube, the combustion ceasing altogether when not more than from half an inch to one inch of the twist had burnt in the tube. The same result was observed when the current of gas was interrupted at the moment that the gun-cotton was inflamed. It was at first thought that this extinction of the combustion of gun-cotton by hydrogen and coal-gas might be caused by the very rapid abstraction of heat from the burning surface of gun-cotton in consequence of the diffusive powers of those gases; but when the experiments were made in perfectly closed vessels, the piece of gun-cotton-twist being ignited by means of a platinum wire, the combustion also ceased almost instantaneously. The effects, therefore, can only be ascribed to the high cooling-powers, by convection, of the gases in question. It was found, by a succession of experiments, that when nitrogen was mixed with only one-fifth of its volume of hydrogen the combustion of gun-cotton-twist in the mixture was very slow and uncertain (being arrested after a short time in some instances), and that a mixture of one volume of hydrogen with three of nitrogen prevented its combustion, like coal-gas.

The slow kind of combustion of gun-cotton, in the form of twist, which is determined by its ignition in currents or atmospheres of nitrogen, carbonic acid, &c. may also be obtained in a powerful current of atmospheric air, the thread of cotton being placed in a somewhat narrow glass tube. If, however, the air is at rest, or only passing slowly, the result is uncertain. In employing very narrow tubes into which the gun-cotton fits pretty closely, the combustion passes over into the slow form when it reaches the opening of the tube, and occasionally it will then continue throughout the length of the tube. In that case, while the gun-cotton burns slowly along the tube, with a very small sharp tongue of pale flame, a jet of flame is obtained at the mouth of the tube, by the burning of the gas evolved by the decomposition of the gun-cotton. Sometimes, and especially when wider tubes are employed, the slow combustion will proceed only for a short distance, and then, in consequence of the ignition of a mixture of the combustible gases and air within the tube, the gun-cotton will explode with great violence, the tube being completely pulverized, and portions of unburnt cotton scattered by the explosion. If still wider tubes are employed, the cotton will flash into flame almost instantaneously throughout the tube directly the flame reaches the opening : in these cases the explosion is not violent; sometimes the tube escapes fracture, and at others is broken in a few places, or torn open longitudinally, a slit being produced in the tube directly over the gun-cotton. By using narrow tubes and gradually shortening the tube through which the gun-cotton was passed, pieces of the twist being allowed to project at both ends, it was found, upon inflaming the material which projected on one side, that the slow form of combustion, induced in it as soon as it burned into the tube, was maintained by that portion which burned in the open air on the other side, when the combustion had proceeded through the tube. Eventually, by the employment of a screen of wood or card-board containing a perforation of the same diameter as that of the gun-cotton-twist, through which the latter was partially drawn, the alteration of the combustion of the material from the ordinary to the slow kind was found to be invariably effected. On the one side of the screen, the gun-cotton burned with the ordinary flame and rapidity, until the combustion extended to the perforation, when the flame was cut off and the material on the opposite side of the screen burned only slowly, emitting the small-pointed tongue of pale yellow flame.

These results indicate that if, even for the briefest space of time, the gases resulting from the first action of heat on gun-cotton upon its ignition in open air are impeded from completely enveloping the burning extremity of the gun-cotton-twist, their ignition is prevented; and as it is the comparatively high temperature produced by their combustion which effects the rapid and more complete combustion of the gun-cotton, the momentary extinction of the gases, and the continuous abstraction of heat by them as they escape from the point of combustion, render it impossible for the gun-cotton to continue to burn otherwise than in the slow and imperfect manner, undergoing a transformation similar in character to destructive distillation.

These facts appear to be fully established by the following additional experimental results:—

(1) If, instead of employing in the above experiments a moderately compact gun-cotton-twist, one of more open structure is used, it becomes difficult or even impossible to effect the desired change in the nature of the combustion, by the means described, because the gases do not simply burn at, or escape from, the extremity of the twisted cotton, but pass readily between the separated fibres of the material, rendering it difficult or impossible to divert them all into one direction; and hence they at the same time transmit the combustion from particle to particle, and maintain the heat necessary for their own combustion.

(2) If a piece of the compactly twisted gun-cotton, laid upon the table, be inflamed in the ordinary manner, and a jet of air be thrown against the flame, in a line with the piece of cotton, but in a direction opposite to that in which the flame is travelling, the combustion may readily be changed to the slow form, because the flame is prevented from enveloping the burning cotton, and thus becomes extinguished, as in the above experiment.

(3) Conversely, if a gentle current of air be so directed against the gun-cotton, when undergoing the slow combustion, that it throws back upon the burning cotton the gases which are escaping, it will very speedily burst into the ordinary kind of combustion. Or, if a piece of the gun-cotton-twist, placed along a board, be made to burn in the imperfect manner, and the end of the board be then gradually raised, as soon as the material is brought into a nearly vertical position, the burning extremity being the lowest, it will burst into flame.

By applying to the extremity of a piece of the compact twist a heated body (the temperature of which may range from 135° C. even up to a red heat), provided the source of heat be not very large in proportion to the surface presented by the extremity of the gun-cotton, the latter may be ignited with certainty in such a manner that the slow form of combustion at once ensues, the heat applied being insufficient to inflame the gases produced by the decomposition of the gun-cotton. By allowing the gun-cotton thus ignited to burn in a moderately wide tube, closed at one end, the inflammable gases produced may be burned at the mouth of the tube, while the gun-cotton is burning in the interior; or they may be ignited and the gun-cotton consequently inflamed, by *approaching* a flame, or a body heated to full redness, to the latter, in the direction in which they are escaping.

It need hardly be stated that these results are regulated by the degree of compactness of the gun-cotton, the size of the twist, and the dimensions of the heated body. Thus a small platinum wire heated to full redness, or the extremity of a piece of smouldering string, will induce the slow combustion in a thin and moderately compact twist; but a larger body, such as a thick rod of iron, heated only to dull redness, will effect the ignition both of the gun-cotton and of the gases evolved by the combustion of the first particles, so that the material will be inflamed in the ordinary manner. Similarly the red-hot platinum wire, or a stout rod heated to redness barely visible in the dark, if they are *maintained* in close proximity to the slowly burning surface of gun-cotton, will eventually cause the gases evolved to burst into flame. The more compact the twist of the gun-cotton, the more superficial is the slow form of combustion induced in it, and a condition of things is readily attainable, under which the gun-cotton-twist will simply smoulder in open air, leaving a carbonaceous residue; and the heat resulting from this most imperfect combustion will be abstracted by the gases evolved more rapidly than it is generated, so that in a brief space of time the gun-cotton will cease to burn at all in open air.*

The remarkable facility with which the nature of combustion of gun-cotton in air or other gases may be modified, constitutes a most characteristic peculiarity of this substance as an explosive, which is not shared by gunpowder or explosive bodies of that class, and which renders it easily conceivable that this material is susceptible of application to the production of a comparatively great variety of mechanical effects, the nature of which is determined by slight modifications in its physical condition, or by what might at first sight appear very trifling variations of the conditions attending its employment.

There is little doubt that the products of decomposition of gun-cotton vary almost as greatly as the phenomena which attend its exposure to heat under the circumstances described in this paper. A few incidental observations indicative of this variation were made in the course of the experiments. Thus, in the instances of the most imperfect metamorphosis of gun-cotton, the products included a considerable proportion of a white vapour, slowly dissolved by water, as also small quantities of nitrous acid and a very large proportion of nitric oxide. The latter gas is invariably formed on the combustion of gun-cotton in air or other gases; but the quantity produced appears always to be much greater in instances of the imperfect or slow combustion of the material. The odour of the gases produced in combustions of that class is powerfully cyanic, and there is no difficulty in detecting cyanogen among the products. I trust before long to institute a comparative analytical examination of the products, resulting from the combustion of gun-cotton under various conditions; meanwhile I have already satisfied myself, by some qualitative experiments, of the very great difference existing between the results of the combustion of gun-cotton in open air, in partially confined spaces, and under conditions precisely similar to those which attend its employment for projectile or destructive purposes. I have, for example, confirmed the correctness of the statement made by Karolyi in his analytical

* By enclosing in suitable cases solid cords, made up of two or more strands, and more or less compactly twisted, I have succeeded readily in applying gun-cotton to the production of fuzes and slow-matches, the time of burning of which may be accurately regulated.

account of the products of decomposition of gun-cotton, that no nitric oxide or higher oxide of nitrogen is eliminated upon the explosion of gun-cotton under considerable pressure, as in shells. Coupling this fact with the invariable production of nitric oxide when gun-cotton is exploded in open air or partially confined spaces, there appears to be very strong reason for the belief that, just as the reduction of pressure determines a proportionately imperfect and complicated transformation of the gun-cotton upon its exposure to heat, the results of which are more or less essentially of an intermediate character, so, conversely, the greater the pressure, beyond the normal limits, under which gun-cotton is exploded—that is to say, the greater the pressure exerted by it, or the resistance presented at the first instant of its ignition, the more simple are the products of decomposition, and the greater are the physical effects attending its explosion, because of the greater energy with which the chemical change is effected.

CONCLUSIONS FROM THE RESULTS OF EXPERIMENTS ON WROUGHT-IRON AND STEEL.

By Mr David Kirkaldy.

[COMMUNICATED BY MAJOR C. H. OWEN, R.A., PROFESSOR OF ARTILLERY, R. M. ACADEMY].

At the present time when every effort is being made to obtain wrought-iron and steel for both ordnance and armour plates, it is very desirable to have some reliable information respecting these materials; this may be found in a work* written by Mr David Kirkaldy, who carried out an elaborate series of experiments to ascertain the comparative tenacity and other properties of iron and steel.

As Mr Kirkaldy observes, "It seems remarkable that whilst we have the results of many important and reliable experiments on cast-iron, extremely few have been made, or at least published, on wrought-iron, and almost none on steel." The conclusions therefore, drawn from the results of his own carefully conducted experiments, which in some instances do not altogether agree with several generally received opinions, will no doubt be acceptable to many officers who may not have had an opportunity of reading the work. Mr Kirkaldy's book contains a number of well arranged tables with suitable remarks upon them, and the opinions of many eminent engineers on the points under investigation. Dr Percy mentions the work in the following terms: "An excellent digest of information published on this subject is contained in Mr David Kirkaldy's recent valuable work on the tenacity, or, as it is now termed, *tensile strength* of iron and steel;† and the author appears to have arrived at nearly the same conclusions as myself," and further on in a note,‡ "This excellent work, which ought to be in the possession of every civil engineer."

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* Results of an Experimental Enquiry into the comparative Tensile Strength and other properties of various kinds of Wrought-iron and Steel. London, 1862.

† Metallurgy of Iron and Steel. London, 1864.

‡ Ibid. note 11, p. 862.

The conclusions drawn by Mr Kirkaldy from the results of his experiments are as follows:—

(1) The breaking strain does *not* indicate the quality, as hitherto assumed.

(2) A *high* breaking strain may be due to the iron being of superior quality, dense, fine, and moderately soft, or simply to its being very hard and unyielding.

(3) A *low* breaking strain may be due to looseness and coarseness in the texture, or to extreme softness, although very close and fine in quality.

(4) The contraction of area at fracture, previously overlooked, forms an essential element in estimating the quality of specimens.

(5) The respective merits of various specimens can be correctly ascertained by comparing the breaking strain *jointly* with the contraction of area.

(6) Inferior qualities show a much greater variation in the breaking strain than superior.

(7) Greater differences exist between small and large bars in coarse than in fine varieties.

(8) The prevailing opinion of a rough bar being stronger than a turned one is erroneous.

(9) Rolled bars are slightly hardened by being forged down.

(10) The breaking strain and contraction of area of iron plates are greater in the direction in which they are rolled than in a tranverse direction.

(11) A very slight difference exists between specimens from the centre and specimens from the outside of crank-shafts.

(12) The breaking strain and contraction of area are greater in those specimens cut lengthways out of crank-shafts than in those cut crossways.

(13) The breaking strain of steel, when taken alone, gives no clue to the real qualities of various kinds of that metal.

(14) The contraction of area at fracture of specimens of steel must be ascertained as well as in those of iron.

(15) The breaking strain, *jointly* with the contraction of area, affords the means of comparing the peculiarities in various lots of specimens.

(16) Some descriptions of steel are found to be very hard, and, consequently, suitable for some purposes; whilst others are extremely soft, and equally suitable for other uses.

(17) The breaking strain and contraction of area of *puddled*-steel plates, as in iron plates, are greater in the direction in which they are rolled; whereas in *cast*-steel they are less.

(18) Iron, when fractured suddenly, presents invariably a crystalline appearance; when fractured slowly, its appearance is invariably fibrous.

(19) The appearance may be changed from fibrous to crystalline by merely altering the shape of specimen so as to render it more liable to snap.

(20) The appearance may be changed by varying the treatment so as to render the iron harder and more liable to snap.

(21) The appearance may be changed by applying the strain so suddenly as to render the specimen more liable to snap, from having less time to stretch.

(22) Iron is less liable to snap the more it is worked and rolled.

(23) The "skin" or outer part of the iron is somewhat harder than the inner part, as shown by appearance of fracture in rough and turned bars.

(24) The mixed character of the scrap-iron used in large forgings is proved by the singularly varied appearance of the fractures of specimens cut out of crank-shafts.

(25) The texture of various kinds of wrought-iron is beautifully developed by immersion in dilute hydrochloric acid, which, acting on the surrounding impurities, exposes the metallic portion alone for examination.

(26) In the fibrous fractures the threads are drawn out, and are viewed externally, whilst in the crystalline fractures the threads are snapped across in clusters, and are viewed internally or sectionally. In the latter cases the fracture of the specimen is always at right angles to the length; in the former it is more or less irregular.

(27) Steel invariably presents, when fractured slowly, a silky fibrous appearance; when fractured suddenly, the appearance is invariably granulated, in which case also the fracture is always at right angles to the length; when the fracture is fibrous, the angle diverges always more or less from 90°.

(28) The granulated appearance presented by steel suddenly fractured is nearly free of lustre, and unlike the brilliant crystalline appearance of iron suddenly fractured; the two combined in the same specimen are shewn in iron bolts partly converted into steel.

(29) Steel which previously broke with a silky fibrous appearance is changed into granular by being hardened.

(30) The little additional time required in testing those specimens whose rate of elongation was noted, had no injurious effect in lessening the amount of breaking strain, as imagined by some.

(31) The rate of elongation varies not only extremely in different qualities, but also to a considerable extent in specimens of the same brand.

(32) The specimens were generally found to stretch equally throughout their length until close upon rupture, when they more or less suddenly drew out, usually at one part only, sometimes at two, and in a few exceptional cases, at three different places.

(33) The ratio of ultimate elongation may be greater in short than in long bars in some descriptions of iron, whilst in others the ratio is not affected by difference in the length.

(34) The lateral dimensions of specimens forms an important element in comparing either the rate of, or the ultimate, elongations—a circumstance which has been hitherto overlooked.

(35) Steel is reduced in strength by being hardened in water, while the strength is vastly increased by being hardened in oil.

(36) The higher steel is heated (without of course running the risk of being burned) the greater is the increase of strength, by being plunged into oil.

(37) In a highly converted or hard steel the increase in strength and in hardness is greater than in a less converted or soft steel.

(38) Heated steel, by being plunged into oil instead of water, is not only considerably *hardened*, but *toughened* by the treatment.

(39) Steel plates hardened in oil and joined together with rivets are fully equal in strength to an unjointed soft plate, or the loss of strength by riveting is more than counterbalanced by the increase in strength by hardening in oil.

(40) Steel rivets fully larger in diameter than those used in riveting iron plates of the same thickness being found to be greatly too small for riveting steel plates, the probability is suggested that the proper proportion for iron rivets is not, as generally assumed, a diameter equal to the thickness of the two plates to be joined.

(41) The shearing strain of steel rivets is found to be about a fourth less than the tensile strain.

(42) Iron bolts, case-hardened, bore a less breaking strain than when wholly iron, owing to the superior tenacity of the small proportion of steel being more than counterbalanced by the greater ductility of the remaining portion of iron.

(43) Iron highly heated and suddenly cooled in water is hardened, and the breaking strain, when gradually applied, increased, but at the same time it is rendered more liable to snap.

(44) Iron, like steel, is softened, and the breaking strain reduced, by being heated and allowed to cool slowly.

(45) Iron subjected to the cold-rolling process has its breaking strain greatly increased by being made extremely hard, and not by being "consolidated" as previously supposed.

(46) Specimens cut out of crank-shafts are improved by additional hammering.

(47) The galvanizing or tinning of iron plates produces no sensible effects on plates of the thickness experimented on. The results, however, may be different should the plates be extremely thin.

(48) The breaking strain is materially affected by the shape of the specimen. Thus the amount borne was much less when the diameter was uniform for some inches of the length than when confined to a small portion—a peculiarity unascertained and not even suspected.

(49) It is necessary to know correctly the exact conditions under which any tests are made, before we can equitably compare results obtained from different quarters.

(50) The startling discrepancy between experiments made at the Royal Arsenal, and by the writer, is due to the difference in the shape of the respective specimens, and not to the difference in the two testing machines.

(51) In screwed bolts the breaking strain is found to be greater when old dies are used in their formation than when the dies are new, owing to the iron becoming harder by the greater pressure required in forming the screw thread when the dies are old and blunt, than when new and sharp.

(52) The strength of screw-bolts is found to be in proportion to their relative areas, there being only a slight difference in favour of the smaller compared with the larger sizes, instead of the very material difference previously imagined.

(53) Screwed bolts are not necessarily injured although strained nearly to their breaking point.

(54) A great variation exists in the strength of iron bars which have been cut and welded; whilst some bear almost as much as the uncut bar, the strength of others is reduced fully a third.

(55) The welding of steel bars, owing to their being so easily burned by slightly over heating, is a difficult and uncertain operation.

(56) Iron is injured by being brought to a white or welding heat if not at the same time hammered or rolled.

(57) The breaking strain is considerably less when the strain is applied suddenly instead of gradually, though some have imagined that the reverse is the case.

(58) The contraction of area is also less when the strain is suddenly applied.

(59) The breaking strain is reduced when the iron is frozen; with the strain gradually applied the difference between a frozen and unfrozen bolt is lessened, as the iron is warmed by the drawing out of the specimen.

(60) The amount of heat developed is considerable when the specimen is suddenly stretched, as shown in the formation of vapour from the melting of the layer of ice on one of the specimens, and also by the surface of others assuming tints of various shades of blue and orange, not only in steel, but also, although in a less marked degree, in iron.

(61) The specific gravity is found generally to indicate pretty correctly the quality of specimens.

(62) The density of iron is *decreased* by the process of wire-drawing, and by the similar process of cold-rolling, instead of *increased*, as previously imagined.

(63) The density in some descriptions of iron is also decreased by additional hot-rolling in the ordinary way; in others the density is very slightly increased.

(64) The density of iron is decreased by being drawn out under a tensile strain, instead of increased as believed by some.

(65) The most highly converted steel does not, as some may suppose, possess the greater density.

(66) In cast-steel the density is much greater than in puddled steel, which is even less than in some of the superior descriptions of wrought-iron.

The following remarks are also worthy of notice.

"The breaking strain per square inch of wrought-iron is generally stated to be about twenty-five tons for bars and twenty tons for plates. This corresponds very nearly with the results of the writer's experiments, of which the following table presents a condensed summary :—

		lbs.		lbs.		lbs.	tons.
188 bars rolled	highest	68,848,	lowest	44,584,	mean	57,555	= $25\frac{3}{4}$
72 angle iron, &c.......	do	63,715,	do	37,909,	do	54,729	= $24\frac{1}{2}$
167 plates, lengthways,	do	62,544,	do	37,474,	do	50,737	} = $21\frac{3}{4}$
160 plates, crossways,	do	60,756,	do	32,450,	do	46,171	}

"Although the *breaking* strain is generally assumed to be about 25 tons for bars and 20 tons for plates, very great difference of opinion exists as to the amount of *working* strain, or the load which can with safety be applied in actual practice. The latter is variously stated at from a third to a tenth. It will be observed that whilst much discussion has arisen as to the amount of working strain, or the ratio the load should bear to that of the breaking strain, the important circumstance of the *quality* of the iron, as influencing the working strain, has been overlooked. The Board of Trade limits the strain to 5 tons, or 11,200 lbs. per square inch.

"It must be abundantly evident, from the facts which have been produced, that the breaking strain, when taken alone, gives a false impression of, instead of indicating, the real quality of the iron, as the experiments which have been instituted reveal the somewhat startling fact, that frequently the inferior kinds of iron actually yield a higher result than the superior. The reason of this difference was shown to be due to the fact, that whilst the one quality retained its original area, only very slightly decreased by the strain, the other was reduced to less than one-half. Now, surely this variation, hitherto unaccountably completely overlooked, is of importance as indicating the relative hardness or softness of the material, and thus, it is submitted, forms an essential element in considering the safe load which can be practically applied in various structures. It must be borne in mind that although the softness of the material has the effect of lessening the amount of the *breaking* strain, it has the very opposite effect as regards the *working* strain. This holds good for two reasons: first, the softer the iron the less liable it is to snap; and second, fine or soft iron, being more uniform in quality, can be more depended upon in practice. Hence the load which this description of iron can suspend with safety may approach much more nearly the limit of its breaking strain than can be attempted with the harder or coarser sorts, where a greater margin must necessarily be left.

"Special attention is now solicited to the practical use that may be made of the new mode of comparison introduced by the writer, viz: the *breaking strain per square inch of the* fractured *area of the specimen, instead of the breaking strain per square inch* of *the* original *area*."

THE FOLLOWING EXPERIMENT WAS CARRIED ON AT SHOEBURYNESS, ON 17TH JUNE, 1864, TO TEST THE POWERS OF RESISTANCE TO PROJECTILES OF THE "LORD WARDEN."

[CONTRIBUTED BY CAPTAIN E. J. BRUCE, R.A.]

The target 20′ by 9′, represents the ordinary construction of a wooden ship armour-plated, with the addition of a thick iron skin worked outside of the frame timbers of the ship.

The following are the scantlings: frame timbers moulded, 12½″;* iron diagonal riders connecting the frame timbers, 6″ by 1¼″; inner planking, 8″ thick; iron skin, 1½″ thick; outside planking, 8½″ thick; rolled armour plates, 20′ × 4′ 6″ × 4·5″, manufactured by the Millwall Company.

Armour plate bolts, 2½″ diameter. Iron washers were placed under the bolt-heads and rested on india-rubber washers, the latter being let into the timber.

	″ ″
Deck beams, lower..........................	15 by 12
„ upper	16 „ 16
Waterway, lower	15 „ 15
„ upper	13 „ 14
Deck planking, lower	4
„ upper	4

Iron knees to each beam—weight, 3 cwt. 2 qrs. 21 lbs.
The total weight of the target is 38 tons, 16 cwt. 13 lbs.

Range, 200 yds.

The guns used in this experiment were as follows:—

	Weight. tons	cwt.	qrs.	lbs.
One 68-pr. smooth-bore muzzle-loading gun	0	95	0	0
One 9·22″ muzzle-loading rifled gun, 11′ long, 6 grooves	6	11	2	11
One 9·22″ muzzle-loading rifled gun, 13′ 3″ long, 6 grooves...	12	2	2	0
One 10·5″ muzzle-loading rifled gun, 11′ 7″ long, 10 grooves .	11	15	2	0
One 7″ muzzle-loading rifled gun, 10′ 9″ long, 6 grooves......	6	13	3	0

The following shot and shell struck the target:—

From 10·5″ Armstrong rifled gun......	Spherical steel shot; one; weight, 168·25 lbs. Cylindrical steel shot; one; weight, 301 lbs.
„ 9·22″ rifled 12 ton gun............	Cylindrical steel shot; four; total weight, 885·5 lbs.
„ 9·22″ rifled 6½ ton gun............	Spherical steel shot; one; weight, 144·25 lbs. Spherical cast-iron shot; two; weight, 208·75 lbs. Cylindrical steel shell; two; weight, 349·5 lbs.
„ 7·0″ muzzle-loading rifled gun..	Cylindrical steel shot; one; weight, 100 lbs.
„ 68-pr. smooth-bore gun	Solid steel shot; one; weight, 71·5 lbs.

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* Occasional, spaced several feet apart, and inclined at about an angle of 45°.

Number of round.	Photographic No.	Nature of ordnance.	Projectile. Nature.	Weight in lbs.	Form and Diameter.	Length in inches.	Length after firing.	Bursting charge of shells.	Charge in lbs.	Elevation.	Range in yds.	Deflection.	Effects. Depth of indent in inches.	Diameter of indent in inches.	Bulge of plate in inches.	Ripple in inches.	Recoil.	Velocity at 510′.
					in.		″			′		′					ft. in.	
1	802	68-pr. smooth-bore gun.	Steel solid shot.	71·4	Spherical 7·94			...	16	20	200	Nil	3·6	9·5	4·1	0·5	5 0	Not observed.
2	803	9·22″ rifled 6½ ton gun.	„	114·2	Spherical 9·14			...	25	17	„	„		9·3 × 9·5			3 9	1444·
3	804	„	Steel shell.	174·5*	Cylindrical 9·14	12·46		7½	20	45	„	„					3 8	1006·6
4	805	7″ muzzle-loading rifled gun.	Steel solid shot.	100	Cylindrical 6·91	10·54	9·15	...	25	20	„	„		8·3			3 9	1507·2
5	806	10·5″ Armstrong rifled gun.	„	168·25	Spherical 10·43			...	50	6	„	„		11· × 11·5			9 3	1593·8
6	807	9·22″ 12 ton rifled gun.	„	221	Cylindrical 9·14	13·42	11·8	...	44	20	„	5 R		10·4 × 11			6 9	1461·1
7	808	9·22″ 6½ ton gun.	Captain Palliser's chilled cast-iron shot.	103·75	Spherical 9·17			...	25	30	„	Nil	6·8	13 × 11·5			4 10	1532·
8	809	9·22″ 12 ton gun.	Steel shot.	221	Cylindrical 9·14	13·38	12·93	...	30	35	„						3 11	Missed wires
9	810	10·5″ rifled gun.	Steel solid shot.	301	Cylindrical 10·46	14·07		...	45	21	„		Thro'	11 × 11·3			12† 0	1254·5
10	811	9·22″ 12 ton rifled gun.	„	221·5	Cylindrical 9·14	13·42		...	30	50	„		Thro'				4 4	1292·6
11	812	9·22″ 6½ ton rifled gun.	Steel shell.	175*	„	12·46	12·4	7½	20	45	„		Thro'				5 9	1146·6
12	813	9·22″ 12 ton rifled gun.	Steel solid shot.	222	„	13·42	11·5	...	30	42	„	5 R	Thro'				5 9	1351·5
13	814	9·22″ 6½ ton rifled gun.	Captain Palliser's chilled cast-iron shot.	105·437	Spherical 9·18			...	25	35	„	Nil		9 × 8			5 0	1448·3

REMARKS.

Struck 20″ from top of target. Bottom of indent cracked completely round its circumference. Edge of indent 2·5″ from bolt-hole, crack 1″ long from bolt. Shot rebounded 15 yds. from target and broke into two large and several small pieces. At the back, one backing-bolt started 3″.

Struck 12″ from bottom of target, penetrated plate, depth to nearest point of shot, 5″; portion of plate turned over top of shot; slight ripple round half the circumference of hole; two armour-plate bolts at 12″ and 14″ from hole started 0·8″ and 0·5″ respectively. No crack on plate. At the back, maindeck "waterway" broken across; planking just above it started; oakum started out of seams; one rivet-head off iron knee, 2′ from break in "waterway"; india rubber washer of through bolt (2′ from seat of blow), compressed; small splinter off back plank. Shot remained in hole unbroken.

Struck the upper plate 5″ from bottom and 2′ 6″ from left side; hole in plate 12·5″ × 11·5″ and 6·5″ deep. Upper edge of hole on a bolt; crack 3″ long from bolt-hole; two bolts started 0·4″. Upper plate forced up from lower 0·6″, commencing at left side of target to within 12″ of right side. At the back, shelf-piece sprung; inner planking rent over area of 4′ × 2′; one through bolt slightly thrust back; iron and india rubber washers of three others bent and compressed; one small plank bolt started 1¾ in.; two inner beams of planking splintered. Shell broke in two pieces.

Struck 10½″ from top of target and 12″ from left side on a bolt; bolt 14″ from hole started 1″, and one at 3′ 6″ started 0·5″; timber backing for 12″ (vertical) by 24″ (lateral), driven out; shot penetrated to skin, passed out at top of target, and was picked up at 20 yds. to the right front; the inner skin was started from timber 0·9″ at top and 0·5″ at bottom, at left side of target; depth of indent on skin, 1″, and buckle 3½″ in length of 2′. Plate laminated round circumference of hole. The shot struck too high to judge the effect at the back. Shot unbroken; diameter after firing 7·345″.

Struck upper plate 10″ from bottom and 9′ 6″ from left side on a bolt, penetrated the armour plate, making a hole in the plate 11·5″ × 11″; depth to surface of shot, 12″, plate driven in, 1·8″ at bottom. Plate laminated round circumference of hole. At the back, shelf-piece half through; damage over area, 6′ wide by 3′ high; through bolt driven back 10″; iron knee cracked across joint or bend; lower limb of it bent out from side of ship; one knee rivet-head off; three rivets started; two inner timbers rent and splintered and thrust out, fragments projecting about 1′. Shot remained in hole, apparently whole.

Struck the upper plate 2′ from top and 3′ 7″ from right side and penetrated target above shelf-piece; hole in plate, 11″ × 10·4″. Upper baulk of timber backing splintered for length of 10″ (horizontal). At the back daylight through; aperture about 7″ × 8″; shelf-piece rent and splintered, projecting 10″, broken to shivers right through; general break round shot-hole, 1′ 6″ × 1′ 6″; iron knee adjoining started 0·8″; four rivets slightly started; one rivet-head off. Shot picked up 500 yds. beyond target and measured 10″·005 in diameter at head.

Struck lower plate 5″ from top and 5′ 9″ from right side, 2″ of diameter of hole being on upper plate; lower plate cracked at 2·5″ from circumference of hole and parallel to it. At the back, rivet of knee (of which head was off before), thrust out 1·5″; beam inside started 0·4″. Shot broke up.

Grazed sloping plate at foot of target (making a groove on it 0·6″ in depth), and struck 8·5″ from bottom of lower plate partly on a bolt; broke away portion of armour plate, 15″ × 9″; inner skin exposed. At the back "waterway" cracked across. Shot driven back under foot plate and measured 9·56″ in diameter at head.

Struck at junction of plates at 5′ 10″ from left of target; penetrated target; bolts at 15″, 13″ and 14″ from hole started 0·8″, 0·7″, and 0·4″ respectively; both plates laminated round circumference of hole and two small cracks on front of lower plate from edge of hole. At the back iron knee broken right off, and lower limb (4′ long with three bolts in it) driven 50′ to the rear. Area of damage, 8′ × 4′; five or six plank bolts started and heads off; inner timbers rent in fragments and thrust out 1′6″; large splinters of wood scattered all around. Shot struck a large block of granite in rear and broke itself into four pieces.

Struck just below 807 and penetrated the target; diameter of two holes in armour plate measured 17·5″. At the back, shelf piece between two knees driven out in splinters, and inner timber planking driven out and destroyed over 3′ 9″ × 2′ 3″; splinters of wood and skin scattered 20 yds. beyond target. Shot went out to sea and was not recovered.

Struck just below 806; diameter of two holes, 16″; plate broken away at botton for a length of 6″; the shell penetrated but did not burst, the bursting charge being merely blown into the target; 6′ × 3′6″ (vertical) of inner planking destroyed and blown out in splinters; diagonal rider broken in two and projecting 19″ to the rear; one of the backing bolts driven firmly into timber supporting baulk; portion of skin picked up at rear; timber backing ignited. Shell picked up behind the target and measured 9·54″ in diameter at head.

Struck to the right of No. 807 and No. 811; greatest diameter of holes 2′; crack 4″ long from edge of hole; bolt 17″ from hole started 0·3″; at the back, area of damage much enlarged. Shot picked up 500 yds. beyond target, and measures 10·18″ in diameter at head.

Struck lower plate 5½″ from top and 17″ from right side, 6″ from bolt-hole; through plate and penetrated to depth of 10″; crack 11″ long through bolt-hole; inner surface of armour plate forced back on skin; timber planking between armour plate and skin destroyed for 12″ (vertical) by 15″ (horizontal). At the back one bolt in iron knee forced out. Shot broke up.

METHOD OF OBTAINING THE DISTANCE OF OBJECTS AT SEA, (FROM ELEVATED SHORE BATTERIES), WITHOUT THE USE OF THE SPIRIT-LEVEL, AND WITHOUT HAVING TO MAKE ANY CALCULATIONS WITH TABLES OF NATURAL TANGENTS, ETC.

By Lieut. H. A. TRACEY, R.A.

This method, without obtaining the accuracy of the one, suggested by Captain Drayson, R.A.,* is still sufficiently good for most purposes; and in actual practice from elevated batteries, I have found it give very useful results.

It is only necessary to have a pocket sector and a pair of compasses (already in the possession of almost every officer in the regiment) to enable the range to be made out from the following data.

A, height of gun in yds. above the mid-tide level. (Which is that now marked on the Ordnance Surveys).

B, apparent dip of horizon for that height. (A comprehensive table of apparent dips is given in the 3rd Vol. Mathematical Course, R.M.A. Appendix, p. 8.)

The tangent scale of the gun is set as nearly as possible to the angle of the dip, and the gun is laid carefully on the horizon, in the direction of the target whose range is required.

The bore is then level.

Raise the tangent scale until the sights bear on the object.

We have then the required angle of depression.

Now measure off, with the compasses, on any scale of equal parts (that on the edge of the sector answers best), the number of yards in the height of the battery. Open the sector until the transverse distance, on the line of tangents (marked *T*), at the number of degrees and minutes forming the angle of depression, is equal to the distance measured on the scale.

Then, measure with the compasses, the distance between the ends of the line (where there is generally a metallic stud let in);

And you have the required range—as read off on the scale of equal parts previously used.

N.B. From experience, I find it better to multiply the very small angle of depression by ten, and make the transverse measurement there, when of course, the last measurement has also to be multiplied by ten. But being taken off a decimal scale, that entails no trouble.

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* Vide page 1.

Example.

In the "Shoulder of Mutton" battery, Dover Castle, the height of the left-hand gun (110-pr.) is 165·5 ft., say 55 yds. (Dip for that elevation, 12′ 20″).

Observed angle of depression to target 1° 50′.

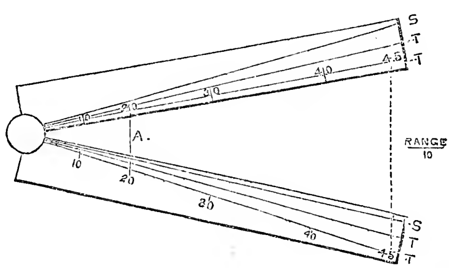
I measure off 5·5 of the small subdivisions of the scale on the edge of the sector, and open the legs until the distance between the points of the compass, and that between the spots marking 18° 20′ (viz. 1° 50′ × 10) on the line of tangents, coincide. Then, taking off with the compasses, the distance between the two metallic spots at the end of the line of tangents and referring it to the scale on the edge, I find it measures about 16·9 of the smaller divisions, I therefore gave the range as 1690 yds.

In effect, the range calculated by Capt. Drayson's more accurate method was 1719 yds.

This plan can be applied to smooth-bore guns. As with the assistance of the sector, the distance on their tangent scales can also be taken off to minutes. For instance,

In the "East Demi-Bastion," Dover Castle, whose height above the mid-tide level is 97 yds. (Dip 16′ 10″). The tangent scale was set to the required elevation, to level the gun, thus: The sector was opened until the distance between the points 60 and 60 on the line of lines (marked *L*), coincided with the length of one degree on the brass tangent scale (32-pr.). 60 of course is chosen as that is the number of parts we wish to divide the degree into.

The distance between the points 16 and 16, on the same lines, gave the required length for 16′, which was marked off by the compasses on the brass scale. In this case the angle of depression read off, by means of the line of lines, was 3° 5′, when by the steps described before, the range was approximately found, and nearly enough for most purposes.



A, height of battery measured at the angle multiplied by ten.

Range, to be read off on the decimal scale and multiplied by the same number as the angle.

ON THE CAUSES WHICH LED TO THE SUPERSESSION OF THE ORIGINAL SHRAPNEL SHELL, AND THE ADOPTION OF THE DIAPHRAGM PATTERN.

BY CAPTAIN VIVIAN DERING MAJENDIE, R.A.

CAPTAIN INSTRUCTOR, ROYAL LABORATORY.

I HAVE already discussed the validity of General Shrapnel's claim to the invention of the class of shells which bears his name,[1] and I have attempted to establish in a general way the practical value of shells which fall under the common denomination of "Shrapnel."[2] I now propose to discuss the relative merits of individual shells of this class—"Shrapnel," "Improved Shrapnel," and "Diaphragm Shrapnel;" and to do this the most convenient plan will be to explain in the present paper the causes which led to the original Shrapnel shells being superseded by the "Improved" and Diaphragm" Shrapnel, describing so much of the construction of the two last named projectiles as may be necessary; and reserving for a succeeding paper an examination into the merits and alleged demerits of the Diaphragm construction.

The valuable properties of the original Shrapnel shell were neutralized to a great extent by one very serious defect, viz. a liability to explode prematurely.[3] Before the introduction of Boxer's fuze this defect was attributed principally to "the setting down of the fuze composition, caused by its own *vis inertia,* together with the concussion of the air, both tending to cause the same effect at the time of the explosion of the charge;"[4] it was also thought to arise in some cases from the shell being too weak to withstand the shock of the discharge.[5]

Although this defect was obviated to some extent by thickening the shell, and in a greater degree by the introduction of Boxer's fuze, it was not

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[1] See "Proceedings," Royal Artillery Institution, Vol. III. p. 398.

[2] *Vide,* p. 4.

[3] For proof of the existence of this defect, see *Synopsis Ordnance Select Committee Reports on Shrapnel Shell,* pp. 35–8–9, 66–9, 70–8, &c., &c.; also Colonel Boxer's *Remarks on Diaphragm Shrapnel Shell,* p. 2, &c.

[4] *Synopsis of O. S. C. Reports on Shrapnel Shell,* pp. 66, &c. In the old pattern fuze the composition was exposed and unsupported at the bottom, and it is easy to understand how the effect mentioned in the text might be produced by the shock of the discharge—particularly when the shortness of these fuzes (one inch) is considered; evidently also the liability to accidental premature explosion would increase as the range decreased, owing to the shorter length of fuze which would be used for the shorter ranges.

[5] *Synopsis of O. S. C. Report on Shrapnel Shell,* p. 8, &c.

entirely removed by these measures;[6] and it became evident therefore that the failures arose from other causes.

The main causes that were assigned for these premature explosions were, either,—

1st. That the fuze was driven out by the reaction of the bullets in the shell, thus enabling the flash of the discharge to communicate with the bursting charge; or,

2nd. That the percussion, or friction of the bullets evolved sufficient heat to ignite the bursting powder.[7]

From a large number of experiments which were carried on it was incontestably proved that to the last cause the failures were almost wholly attributable.[8] Attempts were made to remedy this in one or two ways:—by coating the interior of the shell with a cement, to diminish the fric-

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6 "It was proved beyond doubt, that, however perfect the fuze might be premature bursting would still happen."—*Remarks on Diaphragm Shrapnel Shell*, p. 3.

"It further became evident that the shell was sufficiently strong, in itself, to withstand the shock received from the powder in the gun."—*Ibid*, p. 3.

7 *Remarks on Diaphragm Shrapnel Shell*, p. 3. *Ibid. Appendix O. S. C. Report on Shrapnel Shell*, pp. 84, 89.

8 "There cannot be a question that this is the principal cause of failure, for I have myself seen several shells which were filled with balls and the bursting powder, but without fuzes, (the hole being plugged with wood), explode on striking the butt, and in these cases the powder could only have been ignited by the action of the bullets in the interior."—*Remarks on Diaphragm Shrapnel Shell*, p. 3. 8-in. 32-pr. and 24-pr. Shrapnel shells carefully selected were prepared as follows, and fired with charges of 10 lbs., 10 lbs. and 8 lbs. respectively:—

(1) Filled with bullets and *the bursting powder*, and with a solid plug of wood firmly driven into the fuze hole.

(2) Filled with bullets, but *without the bursting powder*, and with a solid piece of wood firmly driven into the fuze hole.

"*Nearly the whole of the shells with the bursting powder exploded in the gun, but there was not* ONE *breakage with the shells* WITHOUT THE BURSTING POWDER.........These results led me to the following conclusions:............That by the shock which the projectile received at the 'discharge,' sufficient heat was evolved in some *part* of the interior of the shell, by friction, or condensation, to ignite the bursting powder."—*Ibid, Appendix.*

"If there be any fact in regard to artillery matters which has been thoroughly and completely established by actual experiments it is this,—that a separation is absolutely necessary in order to the efficiency of the Shrapnel shell............The results of a series of experiments in 1852, 3, 4, undertaken chiefly for the purpose of ascertaining the cause of this defect (premature explosion) *left no doubt on the mind of all who witnessed the practice that it was mainly attributable to the mixture of the powder with the balls.*"—*Remarks upon Memorandum*, p. 2; also *Memorandum by O. S. C. on Diaphragm Shrapnel shell*, p. 7, where these words also occur. See, also, table of practice carried on in 1853, with a view to "discovering the real cause of failure" given at pp. 31, 32 of Colonel Boxer's *Remarks on Diaphragm Shrapnel Shell.* Also *Synopsis of O. S. C. Reports, &c.*, pp. 89, 191. "It appears to the Committee that............the separation of the bursting powder has prevented *premature bursts, a great point gained over the original Shrapnel.*"—*Report of General Brereton's Committee*, Dec. 14, 1858. It is important to dwell upon this point, the main cause of failure of the Shrapnel shell, because, as will presently be seen, the value of Colonel Boxer's improvements in this projectile as effected in the Diaphragm Shrapnel shell cannot be fully appreciated, nor, indeed, the necessity for introducing such improvements, or of superseding the original Shrapnel in any way, recognized, if this point be not first incontestably established.

tion;[1] by fixing the balls with pitch, sulphur, plaster of Paris, and other materials;[2] and by reducing the charge of the guns; these attempts, however, were attended with unsatisfactory results;[3] and in the meantime Colonel Boxer suggested the separation of the bursting charge from the bullets, "as the *only* means of securing success."[4] This separation he proposed (in 1852) to effect by means of a wrought-iron partition or diaphragm.[5]

The experiments which were carried on with shells constructed on this pattern were most satisfactory,[6] and in 1853,[7] the Committee recommended the manufacture of a large number of the shells "with a view to their introduction into the service."[8] This recommendation was adopted, and the Diaphragm shell provisionally approved.[9]

It is more than probable that in *some* cases the premature explosions arose from other minor causes, such as the splitting of the fuze in ramming home, and the partial withdrawal of the shell by the rammer, the head of the fuze being nearly the same size as the hole in the head of the rammer. Respecting the occurrence of explosions from this latter cause, see *Synopsis of Reports and Experiments by the O. S. C. Shrapnel Shells*, p. 229, where the following passage occurs. "One, very serious defect I observed, however, with regard to the rammer head, the hole in the centre is almost exactly the same size as the head of the fuze; the consequence was that the shell was withdrawn with the rammer head, until I filled up the hole. This may perhaps account for some of the failures." That *some* of the premature explosions resulted from these minor causes is, as I have said, more than probable, but that the *main* cause of failure was the heat generated by the percussion or friction of the bullets seems conclusively established by the passages and experiments above quoted.

1 "Some shells so prepared were fired, but with the most unsatisfactory results."—*Remarks on Diaphragm Shrapnel Shells, Appendix.*

2 "In some of the continental artilleries this has been effected by fixing the balls with sulphur, pitch, plaster of Paris, or other materials."—*Synopsis of Ordnance Select Committee Report on Shrapnel Shell*, p. 289.

3 *Remarks on Diaphragm Shrapnel Shell, Appendix.* The latter remedy even if it had proved successful, would have been objectionable from the reason that its adoption would have impaired the efficiency of the shell in direct proportion to the decrease in the initial velocity which would necessarily result from any reduction in the charge.

4 *Remarks on Diaphragm Shrapnel Shell. Appendix.* This was in 1849 (see *Remarks on Diaphragm Shrapnel Shell*, p. 2), and in September of the same year an experiment was made "with Shrapnel shell having the bursting charge enclosed in canvas bags, so as to separate it from the balls. This mode of preparation was suggested by Captain Boxer, to prevent liability to premature explosion by the friction of the balls within the shells."—*Report of the Committee*, see *Synopsis of Ordnance Select Committee Reports on Shrapnel Shell*, p. 287.

"This experiment appears to have been very successful".—*Ibid*, p. 287.

5 "I have the honor to propose............that............the powder be separated from the balls by means of *a wrought-iron partition*." Letter from Colonel Boxer to Secretary of Master-General of Ordnance, dated 10th May, 1852.—*Remarks on Diaphragm Shrapnel Shell*, p. 2. *Ibid. Appendix.* "In consequence of the favourable result of the experiment (referred to in preceding note) Captain Boxer, on the 10th May, 1852, proposed that Shrapnel shells, from the 24-pr. upwards, should be constructed with a wrought-iron plate for the purpose of separating the powder and the balls." —*Synopsis of Ordnance Select Committee Reports on Shrapnel Shells*, p. 287.

6 "The Committee consider that the result of this experiment is highly satisfactory............The Committee desire to congratulate Captain Boxer on the success which has attended his efforts to improve the Shrapnel shell."—*Ibid*, p. 288. "I am to remark that Colonel Abbott appears to have overlooked the numerous failures which occurred with the original Shrapnel shell, amounting to 17 per cent. in the extensive trials of 1819, and to 22 per cent. in the trials of 1852, whereas on the latter occasion those with Captain Boxer's shells were under 6 per cent."—W. O. Letter 1st April, 1858. See *Supplement to O. S. C. Reports on Shrapnel Shell*, p. 7.

7 THE 1st OCTOBER, 1853.—*Synopsis of O. S. C. Reports on Shrapnel Shell*, p. 287, 8.

8 *Ibid*, p. 288.

9 Dated 11th October, 1853. See Master-General's letter of that date.—*Synopsis of O. S. C. Report on Diaphragm Shrapnel Shell*, p. 289.

As, however, this arrangement was not applicable to the large existing stores of Shrapnel shell, the Committee recommended that these shells should be rendered secure against premature explosion, and so made available for service, by separating the balls and powder by means of a socket and tin cylinder introduced at the fuze hole,[10] according to a former suggestion of Colonel Boxer's;[11] the recommendation was approved,[12] and all the Shrapnel shell in store were converted in this way, and designated "Improved Shrapnel Shells."[13] But no *new* shells were *manufactured* on this pattern, the arrangement being only applied to the Shrapnel shell *in store* as, admittedly, a makeshift, by means of which the one great defect of these shells—liability to premature explosion—would be overcome;[14] and the reason why the arrangement was not recommended for more general introduction was this: The construction was defective in one very important respect, "the bursting powder to cause rupture in the shell must act through the balls, and thereby cause a very great spread in all directions,"[15] an effect which, as Colonel Boxer observes, is "contrary to the fundamental principle of Shrapnel shell.[16]

Moreover, the balls were liable, in spite of an admixture of antimony with the lead, to be much disfigured by being crushed against the sides of the shell at the moment of rupture, their velocity and striking force being in consequence greatly diminished. For these reasons the cylinder arrangement was applied *only to the existing store of Shrapnel shell,* which were "Improved" in this manner.

When these shells had been converted into "Improved Shrapnel" as above described, the service was supplied with shells constructed on the Diaphragm pattern, which as I have stated, had been approved in 1853. In 1858 the details of construction were matured, and some of them were slightly altered,[17] and in that year the Diaphragm shell of the present pattern was provisionally approved.

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[10] *Synopsis of Ordnance Select Committee Reports on Shrapnel Shell,* pp. 197, 200, 201, &c. See Drawing of Shell, p. 198.

[11] "My first idea was to place the powder in a cylinder in the continuation of the fuze hole."—Colonel Boxer's *Remarks on Diaphragm Shrapnel Shell,* p. 9.

[12] 23rd March, 1854. See *Synopsis of O. S. C. Reports on Shrapnel Shell,* p. 200, but it was not until January, 1855, that the detailed instructions respecting the conversion of the existing store of Shrapnel shell were promulgated to the Royal Artillery. See *Account of Alterations and Additions in Ordnance, Carriages, &c., &c.,* 31st January, 1855, par. 29.

[13] The necessity for converting the large store of Shrapnel shell into efficient projectiles became more imperative from the fact that at this time batteries were being equipped for despatch to the East, in anticipation of the war against Russia, which shortly afterwards broke out; and the demand thus suddenly created was greater than could be met by a supply of the Diaphragm pattern.

[14] Colonel Boxer, in a letter dated 27th September, 1853, says: "As there are a great number of Shrapnel shell now in store, I beg to say that having now for so long a time turned my attention to the subject, I can with confidence undertake to prepare these shells in such a manner *as to prevent the defect of premature explosion, although it will be impracticable to make them as efficient as the Diaphragm Shell.*"—*Remarks on Diaphragm Shrapnel Shell,* p. 11.

[15] See *Remarks on Diaphragm Shrapnel Shell,* pp. 9, 10.

[16] *Ibid.* p. 10. "The fundamental principle" here referred to is the principle of preserving the balls as much as possible from the action of the bursting charge, and making their effect independent of any such action, and dependent only upon their own communicated velocity.

[17] Colonel Boxer explains the state of the case thus:—"When the Diaphragm pattern was first

The two principal features of the Diaphragm shell are,—

(1) The complete separation of the bullets from the bursting charge by means of a thin cup-shaped iron partition, or "Diaphragm;" and

(2) The peculiar arrangement of the metal of the shell adopted to ensure the shell being opened without the flight of the bullets being affected by the bursting charge.

Upon the first of these features it is unnecessary for my present purpose to dwell, though I may remind the reader that the Diaphragm is supported by four small projections or flanges on its circumference, equidistant from one another, which are cast *into* the metal of the shell, and is presented with its convex side towards the fuze hole, thus dividing the shell into two unequal parts,—the powder and bullet chambers.

But the second feature is more directly connected with the objections which have been urged against the shell, and the validity of which I propose to consider in another paper, and must therefore be noticed a little more in detail. The importance of adopting an arrangement to ensure the bursting charge opening the shell without affecting the flight of the bullets, will be appreciated when we consider that otherwise not only would General Shrapnel's "fundamental principle" be violated, but the efficiency of the shell would be injuriously affected in the highest degree, by the bullets being liable to be blown up or down, or forward or backwards, according as the fuze happened to be below or above or behind or before at the moment of explosion,[1] and the effect of the shell would thus depend in a great degree (1) upon the accidental relative position of the powder and bullet chambers at the moment of explosion, and (2) (as any great dispersion of the bullets by the bursting charge, would produce great divergence from the trajectory of the shell) upon its bursting at some exact known distance from the object fired at,—conditions which, from the difficulty of *exactly* judging the distance of an object, and the still greater difficulty of *exactly* judging the distance of the shell from that object at the moment of fracture, it would be impossible to impose. For these reasons, therefore, an arrangement of the nature that I have indicated is absolutely essential to the success of the system.

The plan adopted by Colonel Boxer is as follows: The shell is weakened in the interior by four grooves equidistant from one another, which taper

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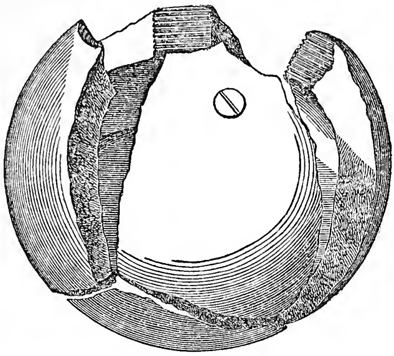
proposed I had no opportunity of making the necessary experiments, to determine various details in regard to the arrangement of the wrought-iron partition, the depth of the grooves, &c., &c., which although in appearance but trifling, are nevertheless points upon which the success of the system depends. However, as the results of the first trials at Shoeburyness in 1852 and 1853 were reported as highly satisfactory, and there was neither time nor opportunity to prosecute the enquiries in relation to the *most efficient* arrangement at a period when the shells were required for immediate service—the original designs were adhered to. *The shells in question* were supplied by contractors, the majority of whom were totally inexperienced; and owing to the peculiarity of construction, it was impossible when the shells were delivered, to test or examine them in a way, to determine whether or not the design had been correctly carried out...........owing to the above causes, the Diaphragm shells which has been issued for service are defective,—*both in design and workmanship.*—*Remarks on Diaphragm Shrapnel Shell. Appendix.*

[1] *Memo. on Diaphragm Shrapnel Shell*, p. 4.

(in width and depth) as they approach the top and bottom of the shell. These grooves form so many "lines of least resistance," along which the bursting charge takes effect, thus acting, "as it were, from the outside of the



mass of balls,"[2] and so preserving the balls from the direct action of the bursting charge and opening the shell into five or more large pieces.

But while the shell is weakened in the directions indicated by these grooves it is strengthened in another direction, for the following reasons: as the shell will inevitably burst at the line of least resistance, wherever that may be, it is evident that if there were a greater tendency to fracture at any part of the shell than in the direction of the grooves, the effect of the grooves would be, as it were, neutralized, these being no longer lines of *least* resistance; now, there is naturally, from the fact of the four little flanges by which the Diaphragm is supported being cast *into* the metal of the shell, and from the resistance offered by these flanges to the action of the powder, a great tendency to fracture round the line of junction of the Diaphragm,[3] —a greater tendency to fracture, that is to say, than in the direction of the grooves, if a special arrangement be not made to guard against it. The necessity for so guarding against it will be fully recognized if the effect of a separation round the line of junction is clearly perceived, viz. that the upper part of the shell would be liable to be blown off, thus either failing to release the bullets or injuriously affecting their flight.[4]

Two remedies, or arrangements, suggested themselves, viz. either to increase the depth of the grooves; or to reduce the strength of the flanges to a minimum, consistently with the security of the Diaphragm, at the same time thickening the metal of the shell round the line of junction; the second remedy was preferred to the first, which "would have weakened the shell, and made it less capable of withstanding the shock of a heavy charge,"[5] *and in*

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[2] *Remarks on Diaphragm Shrapnel Shell*, p. 10. The diagram here given is taken from Colonel Boxer's *Remarks on Diaphragm Shrapnel Shell*, fig. 3, and is a copy of a photograph taken of "a shell burst with the regular bursting charge."

[3] "It was found from the resistance which was offered to the action of the bursting charge by the cast-iron projection below the diaphragm that there was a great tendency to fracture through the line of junction."—*Ibid.* p. 39.

[4] "The explosion of the bursting powder would separate the shell at the part where the wrought-iron partition joins the interior surface, and the bullets would either not be relieved in the shell, or would be affected more or less in their proper course according to the relative positions of the powder and the bullets at the moment of explosion, and the force of the explosion itself."—*Remarks on Diaphragm Shrapnel Shells. Appendix.*

[5] *Ibid* p. 39.

the 1858-*pattern shells this remedy was adopted.* The arrangement, therefore, by which the bursting of the shell is accomplished without the flight of the bullets being affected consists in the four grooves, and in the tendency to fracture round the line of junction of the Diaphragm being diminished to such an extent that the grooves are actually lines of *least* resistance.

It is not necessary to dwell upon the other details and peculiarities of construction of these shells,—such as the coating of the interior with marine glue, the hardening of the balls with antimony, the introduction of coal dust between the bullets, the socket, the "loading" hole, &c., all these details being more or less subordinate to one or other of the two main features which I have spoken of; and although they severally contribute to increase the general efficiency of the shells they are not connected with the particular objections which have been urged against the shells, and which in a succeeding paper I propose to discuss.

The points which the present paper is intended to throw out into relief, and clearly establish, are as follows:—

(1) That the efficiency of the original Shrapnel shell was impaired to such a degree by its liability to explode prematurely, as to make imperative the adoption of a remedy by which the defect would be overcome.

(2) That the defect was proved by the most conclusive experiments to have been due in the vast majority of cases to the bursting charge being ignited by the percussion or friction of the bullets.

(3) That the only efficient remedy for this defect was that proposed by Colonel Boxer,—the complete separation of the bursting charge from the bullets.

(4) That Colonel Boxer proposed effecting this separation by means of an iron "diaphragm."

(5) That this arrangement proved so efficient a remedy for the defect in question as to lead to its official recommendation and adoption; a make-shift arrangement, confessedly imperfect, being applied to the existing store of Shrapnel shell.

(6) That not only was the defect of premature explosion overcome in the Diaphragm shell, but the efficiency of the shell in another important point—the preservation of the bullets from the action of the bursting charge—was carefully secured by the peculiar distribution of the metal which was adopted.

(7) That the details of this arrangement were not perfected until 1858; and therefore that the efficiency of this arrangement cannot be tested except with shells of the 1858 pattern.

These points once established—once clearly grasped and their bearing fully appreciated—the question is disembarrassed of much superflous matter, and presents itself narrowed down to a sufficiently fine issue. The Old and "Improved" Shrapnel shell disappear,—with these we need concern ourselves no longer; we have now only to deal with shells of the Diaphragm construction, and with the objections which have been urged against that particular projectile. This is the subject which I propose to discuss in my next and concluding paper on Shrapnel Shells.

REPORT

OF

ORDNANCE SELECT COMMITTEE.

No. 3065, dated 6th November, 1863.

ON THE RELATIVE PENETRATION INTO EARTH OF PROJECTILES FROM RIFLED AND SMOOTH-BORED GUNS, AND ON SEVERAL VARIETIES OF PERCUSSION FUZE.

Brigadier-General J. St George, C.B., R.A., *President.*
Captain L. G. Heath, C.B., R.N., *Vice-President.*
Colonel Hogge, C.B., R.A.
Colonel Younghusband, R.A.
Lieut.-Colonel R. S. Baynes, Unattached.
Lieut.-Colonel Gallwey, R.E.
Brevet-Colonel Lefroy, R.A., *Secretary.*
Captain Heyman, R.A., *Assistant Secretary.*
Lieutenant W. H. Noble, R.A., *Associate Member.*

[Communicated by direction of the Secretary of State for War].

1. The following detachment was detailed for this duty by Colonel Burke Cuppage, R.A., commanding the district, and arrived at Newhaven, August 7th, 1863:—

5 officers and 1 assistant-surgeon.	86 rank and file.
6 serjeants.	3 trumpeters.

2. The original object of the experiments on which the Committee have now the honour to submit a report, was to determine whether the Armstrong pillar fuze is sufficiently sensitive to explode shells on striking earthwork, and to try a more sensitive form of it. Since the period when this question was first raised (December 1861), several other forms of fuze have been proposed, and the Newhaven experiments embraced the trial of the following varieties:—

(1) The service pillar fuze for rifled shells only.

(2) A more sensitive pillar fuze.

(3) The field service C percussion fuze, enlarged to Moorsom gauge, and made to screw into the shell.

(4) Pettman's L. S. fuze for spherical shells.

(5) Pettman's S. S. fuze, adapted for rifled shells.

3. In addition to the foregoing inquiry as to the action of percussion fuzes in earth, experiments were made for the purpose of ascertaining the penetration of rifled and spherical projectiles, of various calibres, into earthwork.

4. The spot selected for these experiments was near the town of Newhaven, on the coast of Sussex, advantage being taken of a natural mound of earth called the Castle Hill, which overhangs the sea, and served as a target for testing penetration in natural earth. This experiment was combined with observations on the penetration of projectiles into artificial earth, for which purpose (in May 1863) a parapet, 25 feet thick on the superior slope, was thrown up at about 20 yds. from the base of the Castle Hill.

5. During the progress of the experiments, a second artificial parapet was erected to serve as a target for estimating the comparative breaching effects of live shells fired from rifled and smooth-bored guns at earthworks. The battery was established on a rising ground about 1060 yds. from the Castle Hill, at about 230 ft. above the sea. It consisted of the following pieces of ordnance.

Rifled.

12-pr. Armstrong gun of	$8\frac{1}{2}$ cwt.,	on travelling carriage.
20-pr. L.S. „ „	$16\frac{1}{2}$ „	„ „ „
40-pr. „ „	33 „	„ „ „
70-pr. side B. L. gun	61 „	on garrison carriage.
110-pr. Armstrong gun	81 „	on naval sliding carriage.

Smooth-bored.

10-in. gun,	86 cwt.,	on naval sliding carriage.
68-pr. „	95 „	„ „ „
8-in. „	52 „	on travelling carriage.
32-pr. „	50 „	„ „

The soil in the artificial parapets was a very compact loam, approaching in stiffness to clay, mixed here and there with white and red sand. The soil in the natural embankment on the Castle Hill varied from stiff clay to gravelly clay, with veins of very hard gravel and flinty conglomerate.

6. Fire was opened on the 11th of August, 1863, and the experiments ranged over a period of one month, eight days being occupied in firing, and the remainder in digging out shot, recording penetration, and repairing the parapets. The first experiment was to ascertain the penetration of projectiles from rifled and smooth-bored ordnance into natural and artificial earthwork. Solid shot and common shells, weighted with sand and plugged, were fired from the different natures of guns, with the exception of the 12-pr. Armstrong, which fired segment shells. Each gun fired till five hits were obtained with each nature of projectile; and the following Table gives the mean penetration of the several natures of projectiles into earthwork:—

Table I.

GIVING THE MEAN PENETRATIONS OF DIFFERENT NATURES OF PROJECTILES AT 1060 YARDS, CLASSED WITH REFERENCE TO THE SOIL.

Nature of gun.	Charge.	Projectile.			Soil.	Pene-tration.	Mean pene-tration.
		Nature.	Mean weight.	Mean dia-meter.			
	lbs. oz.		lbs.	in.		ft. in.	ft. in.
110-pr	12 0	Solid	111·0	7·04	Clay, artificial	21 2	
A*.	”	shot.	”	”	”	20 9	21 3
”	”	”	”	”	”	21 11	
”	”	”	”	”	Natural concrete† in natural butt	9 0	
”	”	”	”	”	” ” ”	9 5	9 2
”	”	”	”	”	” ” ”	9 0	
”	”	Blind	104·7	”	Clay, artificial	18 8	
”	”	shell.	”	”	”	18 1	18 3
”	”	”	”	”	”	17 11	
”	”	”	”	”	Natural concrete† in natural butt	7 3	7 9
”	”	”	”	”	” ” ”	8 3	
”	”	”	”	”	Red sandy loam in natural butt ...	12 10	12 11
”	”	”	”	”	” ” ”	13 0	
70-pr	9 0	Solid	70·1	6·44	Clay, artificial	17 0	
A.	”	shot.	”	”	”	13 2	
”	”	”	”	”	”	12 5	14 3
”	”	”	”	”	”	14 3	
”	”	”	”	”	”	14 8	
”	”	”	”	”	Natural concrete in natural butt ...	8 6	
”	”	”	”	”	” ” ”	4 0	6 4
”	”	”	”	”	” ” ”	6 6	
40-pr	5 0	Solid	41·2	4·80	Clay, artificial	13 9	
A.	”	shot.	”	”	”	15 5	
”	”	”	”	”	”	13 6	14 9
”	”	”	”	”	”	15 6	
”	”	”	”	”	”	16 4	
”	”	”	”	”	Hard gravel‡ in natural butt	7 8	
”	”	”	”	”	” ” ”	8 4	
”	”	”	”	”	” ” ”	7 3	7 8
”	”	”	”	”	” ” ”	7 6	
”	”	Blind	40·4	4·80	Clay, artificial	11 2	
”	”	shell.	”	”	”	9 0	
”	”	”	”	”	”	11 6	11 8
”	”	”	”	”	”	13 10	
”	”	”	”	”	”	12 11	
”	”	”	”	”	Hard gravel in natural butt	4 6	
”	”	”	”	”	” ” ”	6 6	
”	”	”	”	”	” ” ”	5 0	6 1
”	”	”	”	”	” ” ”	8 5	
20-pr	2 8	Solid	20·4	3·80	Clay, artificial	10 0	
A.	”	shot.	”	”	”	11 9	10 10
”	”	”	”	”	”	10 9	
”	”	”	”	”	Hard gravel in natural butt	4 5	
”	”	”	”	”	” ” ”	4 2	
”	”	”	”	”	” ” ”	5 0	4 7
”	”	”	”	”	” ” ”	4 8	
”	”	Blind	21·2	3·80	Clay, artificial	8 7	
”	”	shell.	”	”	”	8 9	
”	”	”	”	”	”	11 3	10 3
”	”	”	”	”	”	8 10	
”	”	”	”	”	”	13 3	
”	”	”	”	”	Gravelly clay in natural butt	6 0	
”	”	”	”	”	” ” ”	7 0	7 0
”	”	”	”	”	” ” ”	8 0	

* Armstrong.
† Composed of hard chalk flints, firmly bound together with stiff gravelly clay.
‡ Very nearly, but not quite, as hard as the natural concrete.

TABLE I.—*Continued.*

Nature of gun.	Charge.	Projectile. Nature.	Projectile. Mean weight.	Projectile. Mean diameter.	Soil.	Penetration.	Mean penetration.
	lbs. oz.		lbs.	in.		ft. in.	ft. in.
12-pr	1 8	Seg-	10·6	3·04	Clay, artificial	......	4 0
A.	„	ment	„	„	Gravelly clay in natural butt	3 0	
„	„	shell.	„	„	„ „ „	3 4	3 2
„	„	„	„	„	„ „ „	3 3	
10-in.	12 0	Blind	83·9	9·840	Clay, artificial	9 5	
gun.	„	shell.	„	„	„	12 0	
„	„	„	„	„	„	11 5	11 0
„	„	„	„	„	„	10 11	
„	„	„	„	„	„	11 3	
„	„	„	„	„	Natural concrete in natural butt	4 0	3 10
„	„	„	„	„	„ „ „	3 9	
8-in.	8 0	„	50·3	7·85	Clay, artificial	11 6	
gun.	„	„	„	„	„	10 5	
„	„	„	„	„	„	10 7	11 5
„	„	„	„	„	„	12 9	
„	„	„	„	„	„	12 0	
„	„	„	„	„	Hard gravel in natural butt	4 2	
„	„	„	„	„	„ „ „	3 0	3 6
„	„	„	„	„	„ „ „	3 6	
68-pr	16 0	Solid	65·9	7·91	Clay, artificial	21 6	
gun.	„	shot.	„	„	„	21 1	20 0
„	„	„	„	„	„	17 4	
„	„	„	„	„	Stiff clay in natural butt	11 0	
„	„	„	„	„	„ „	13 4	
„	„	„	„	„	„ „	12 1	12 5
„	„	„	„	„	„ „	13 4	
„	„	„	„	„	„ „	12 1	
„	„	„	„	„	„ „	13 0	
„	„	„	„	„	Hard gravel and natural concrete in natural butt	6 8	
„	„	„	„	„	„ „ „	5 6	6 0
„	„	„	„	„	„ „ „	6 2	
„	„	„	„	„	„ „ „	7 0	
„	„	„	„	„	„ „ „	4 8	
„	„	Blind	50·3	7·85	Clay, artificial	14 10	14 10
„	„	shell.	„	„	Gravelly clay in natural butt	8 0	7 6
„	„	„	„	„	„ „ „	7 0	
„	„	„	„	„	Hard gravel in natural butt	4 0	
„	„	„	„	„	„ „	4 0	
„	„	„	„	„	„ „	4 0	4 0
„	„	„	„	„	„ „	4 0	
„	„	„	„	„	„ „	4 0	
32-pr	8 0	Solid	31·2	6·170	Clay, artificial	14 0	
gun.	„	shot.	„	„	„	11 9	13 0
„	„	„	„	„	„	12 8	
„	„	„	„	„	„	13 6	
„	„	„	„	„	Gravelly clay in natural butt	4 6	4 9
„	„	„	„	„	„ „ „	5 0	
„	„	„	„	„	Hard gravel in natural butt	3 0	
„	„	„	„	„	„ „	3 0	2 8
„	„	„	„	„	„ „	2 0	
„	„	Blind	23·6	„	Clay, artificial	8 9	
„	„	shell.	„	„	„	8 10	9 5
„	„	„	„	„	„	9 6	
„	„	„	„	„	„	10 6	
„	„	„	„	„	Stiff clay in natural butt	5 6	5 8
„	„	„	„	„	„ „	5 10	
„	„	„	„	„	Hard gravel in natural butt	3 6	
„	„	„	„	„	„ „	2 6	
„	„	„	„	„	„ „	2 6	2 8
„	„	„	„	„	„ „	3 6	
„	„	„	„	„	„ „	2 3	

7. From this table it appears that, of the various projectiles fired, the 110-pr. Armstrong solid shot, with 12 lbs. charge, has the greatest mean penetration at 1060 yds., viz. 21 ft. 3 inches in the artificial earthwork, and 9 ft. 2 inches in the natural earth. The next is the 68-pr. smooth-bore gun with solid shot and 16 lbs. charge, viz. 20 ft. in the artificial earthwork, and 6 ft. in natural earth of the same quality as that struck by the 110-pr.

8. It appears that the rifle projectiles, after penetration, seldom continue to move with their point foremost, the axis being generally deflected by the resistance of the medium penetrated. This deflection in guns rifled with a right-handed twist is always to the right, and in several instances the rifle projectiles were found quite turned round, the noses pointing out towards the battery, and the curve which they had made could be distinctly traced in the earthwork.

9. In no instance did any projectile pass through the parapet, the interior of which was quite uninjured at the close of the firing with solid shot and blind shell, except at the crest. This shows that an earthen parapet, 25 ft. thick on the superior slope, is proof against solid projectiles fired from the heaviest guns used on this occasion at a range of 1000 yds. The superior accuracy of rifled guns was clearly manifested in this experiment, most of their shot striking either the point aimed at, or within a short distance of it. The practice with the smooth-bored guns was in some instances very erratic.

10. The next experiment was for the purpose of ascertaining whether the service pillar fuze would explode in earthwork. As this experiment subsequently became mixed up with observations on the effect of rifle and spherical shells fired at earthwork, with full, half, and reduced charges, the Committee decided to compare the action of percussion fuzes of the service with reference to the total number of rounds fired with each nature. The following Table has therefore been prepared, showing the number and nature of all fuzes used during the experiments at Newhaven, with the results obtained :—

Table II.

SHOWING RESULTS OF EXPERIMENTS TO TEST PERCUSSION FUZES.

Nature of fuze, and of earth fired at.	Nature of gun.	Charge.	Weight of loaded shell.	Striking velocity of shell at 1000 yards.	Blind.	Burst Properly.	Burst Prematurely.	Results.
		lbs.	lbs.	ft.				
Service pillar, marked R.L. 79. Shell fired against natural earth.	110 prA*	12	105·4	982*a*	...	8	9	This fuze is unfit for use with the 110-pr. Armstrong gun, as from some cause which is as yet unexplained, it is liable to explode the shell prematurely. In all other calibres it is a good fuze for use against earthworks when the striking velocity is not less than 900 ft.
	”	10	105·4	938*b*	4	5	1	
	”	9	105·4	875*b*	5	5	...	
	70-pr. A	9	69·5	997*b*	...	3	...	
	40-pr. A	5	40·5	995*a*	1	10	...	
	20-pr. A	2½	21·4	966*a*	1	5	...	
Do. do. fired against artificial earth	40-pr. A	5	40·5	995*a*	...	5	...	
Service pillar, marked R. L. 98 M. Fired against natural earth.	110-pr. A	6	105·4	709*b*	4	...	...	This seems a good fuze for use against earthworks when the striking velocity is not less than 900 ft. It has the great advantage of being free from liability to premature explosions.
	40-pr. A	2½	40·5	718*b*	...	3	...	
Do. do. fired against artificial earth	110-pr.A	12	105·4	982*a*	3	27	...	
	”	6	105·4	709*b*	3	2	...	
	70-pr. A	9	69·5	997*b*	...	3	...	
	”	8	69·5	944*b*	...	12	...	
	40-pr. A	5	40·5	995*a*	7	13	...	
	”	2½	40·5	718*b*	2	1	...	
	20-pr. A	2½	21·4	960*a*	5	10	...	
Service pillar, marked E. O. C. P. Fired against natural earth.	110-pr. A	12	105·4	982*a*	...	10	...	This fuze might be used against earthworks when the striking velocity is not less than 900 ft.; but it is not so good a fuze as the pillar fuze marked R.L. 98 M, being more liable to premature explosion. On the present occasion also, notwithstanding the greater sensitiveness of the phosphorus composition, there was a larger proportion blind.
	”	9	105·4	875*b*	...	5	...	
	”	6	105·4	709*b*	3	...	...	
	40-pr. A	2½	40·5	718*b*	1	2	...	
Do. do. fired against artificial earth	110-pr. A	12	105·4	982*a*	6	26	3	
	”	2¾	105·4	423*b*	2	...	...	
	40-pr. A	1¼	40 5	460*b*	1	...	...	
Sensitive pillar fuze, made by Sir W. Armstrong specially for this occasion. Fired against natural earth.	110-pr. A	12	105·4	982*a*	...	5	1	The action of this fuze is too uncertain for a service fuze. It is the only fuze which produced a premature explosion with so low a charge as one-sixteenth.
	”	6	105·4	709*b*	...	2	...	
Do. do. fired against artificial earth	110-pr. A	12	105·4	982*a*	2	6	2	
	”	6	105·4	709*b*	5	10	1	
	”	2¾	105·4	423*b*	2	...	...	
	40-pr. A	5	40·5	995*a*	...	30	...	
	”	2½	40·5	718*b*	1	4	...	
	”	1¼	40·5	460*b*	4	...	...	
Screw percussion fuze (being the service percussion fuze C fitted to screw into the shell). Fired against natural earth	110-pr. A	12	105·4	982*a*	4	2	...	This fuze is not so good for use against earthworks as the pillar fuze R.L. 98 M.
	40-pr. A	5	40·5	995*a*	3	5	...	
Do. do. fired against artificial earth	110-pr. A	12	105·4	982*a*	6	3	...	
	”	2¾	105·4	423*b*	2	...	...	
	40-pr. A	5	40·5	995*a*	1	8	...	
	”	1¼	40·5	460*b*	3	2	...	
Pettman S.S. fuze. Fired against artificial earth	70-pr. A	9	69·5	997*b*	4	8	...	This fuze is not sufficiently sensitive for use against earthworks.
	40-pr. A	1¼	40·5	460*b*	3	...	...	
Pettman L.S. fuze. Fired against natural earth.	68-pr. ...	16	49	912*b*	3	5	...	This fuze is not sufficiently sensitive for use against earthworks.
	8-in. gun	8	49	785*b*	7	...	...	
	32-pr. ...	8	23	800*b*	4	7	...	
Do. do. fired against artificial earth	68-pr. ...	16	49	912*b*	4	8	...	
	10in.gun	12	84	743*b*	4	2	...	

* Armstrong. *a*=Velocities observed at 1000 yds., and reduced to 1060 yds.
b=Velocities calculated for 1060 yds.

Table III.

SHOWING THE RESULTS OF EXPERIMENTS TO TEST THE PERCUSSION FUZES OF THE SERVICE, ARRANGED ACCORDING TO CALIBRE.

Nature of gun.	Charge.	Nature of fuze.	No. of rounds.	Blind.	Burst.		Total failed.	Remarks.
					Good.	Pre-mature.		
	lbs.							
110-pr. Armstrong	12	Service pillar, R.L. 79 P...	17	0	8	9	9	
" "	10	" " " ...	10	4	5	1	5	
" "	9	" " " ...	10	5	5	0	5	
" "	12	Service pillar, R.L. 98M...	30	3	27	0	3	
" "	6	" " " ...	9	7	2	0	7	
" "	12	Service pillar, E.O.C.P. ...	45	6	36	3	9	
" "	9	" " " ...	5	0	5	0	0	
" "	6	" " " ...	3	3	0	0	3	
" "	2	" " " ...	2	2	0	0	2	
" "	12	Sensitive pillar..............	16	2	11	3	5	
" "	6	" "	18	5	12	1	6	
" "	2	" "	2	2	0	0	2	
" "	12	Screw percussion...........	15	10	5	0	10	
" "	2	" "	2	2	0	0	2	
70-pr. Armstrong...	9	Service pillar, R.L. 79P ...	3	0	3	0	0	
" "	9	Service pillar, R.L. 98M...	3	0	3	0	0	
" "	8	" " " ...	12	0	12	0	0	
" "	9	Pettman, S.S.	12	4	8	0	4	
40-pr. Armstrong...	5	Service pillar, R.L. 79P....	11	1	10	0	1	
" "	5	Service pillar, R.L. 98M...	20	7	13	0	7	
" "	2	" " " ...	6	2	4	0	2	
" "	2	Service pillar, E.O.C.P. ...	3	1	2	0	1	
" "	1	" " " ...	1	1	0	0	1	
" "	5	Sensitive pillar	30	0	30	0	0	
" "	5	Screw percussion	17	4	13	0	4	
" "	1	" "	5	3	2	0	3	
" "	2	Sensitive pillar..............	5	1	4	0	1	
" "	1	" "	4	4	0	0	4	
" "	1	Pettman, S.S.	3	3	0	0	3	
20-pr. Armstrong...	2	Service pillar, R.L. 79P....	6	1	5	0	1	
" "	2	Service pillar, R.L. 98M...	15	5	10	0	5	
10-in. gun...........	12	Pettman's L.S...............	6	4	2	0	4	
8-in. "	8	" "	7	7	0	0	7	
68-pr. "	16	" "	20	7	13	0	7	
32-pr. "	8	" "	11	4	7	0	4	

11. From the foregoing Table it appears that the action of the percussion pillar fuzes of the service is not as satisfactory against earthwork as could be desired. The Committee have annexed to Table II. their remarks against each fuze in detail.

12. The large number of premature bursts with the 110-pr. gun induced the Committee to institute a special inquiry as to its cause. For this purpose the gun was fired with cartridges made up of different lengths, the space in the powder-chamber being left in some cases between the cartridge and the projectile, in others between the cartridge and the vent-piece, while in some it was filled up with a wooden disc placed at the base of the projectile. None of these precautions had the effect of removing the liability to this accident, as long as full charges were used; but a reduction of the charge to 9 lbs. appeared to remove it. The accident was confined to fuzes

made with the composition containing amorphous phosphorous, and occurred in the proportion of 10 to 37 fuzes of Royal Laboratory make, but in only 3 to 45 fuzes of Elswick make. Pillar fuzes made in the Royal Laboratory with the Moorsom composition answered perfectly. The Committee made a separate report on this subject on Minute 10,266. There were no premature bursts with any gun except the 110-pr.; but the Committee are of opinion that the number of failures from other causes are considerable, and they do not consider the pillar fuze in its present state sufficiently sensitive against earthworks, particularly with low velocities of impact, such as occur at long ranges with the service charge, and may occur with charges reduced to give a high descending angle at any range.

13. It also appears that Pettman's fuzes for spherical shells are not sufficiently sensitive against earthworks; the failures were many; in some cases the whole failed. The practice was very unsatisfactory as compared with that at Bexhill, in 1861, against brickwork, where only five out of seventy-three of this nature were imperfect.

14. The Committee took advantage of these experiments, with different natures of fuzes, to try the effect of a pitching fire from rifled guns, the object being to pitch shells with low charges over the crest of a work, and explode them on striking the terreplein. The results obtained with these low charges were irregular, and the effect upon the work inappreciable.

15. In prosecution of the test of fuzes, the Committee fired over 200 rounds of live shells from the different natures of guns, at an artificial earth parapet of the following dimensions:—

Length at base	75 feet.
Thickness	40 "
Thickness of superior slope	25 "
Crest of parapet above the ground in front	9½ "
Width of cutting behind	30 "

The practice commenced on the afternoon of the 3rd of September, with half charges, from the 40-pr. and 110-pr.; it was continued, with full charges, from the 110-pr., 70-pr., and 68-pr. smooth-bore.

At the conclusion of this day the following rounds of live shells had been fired at this parapet:—

Half Charges.

40-pr. Armstrong	8
110-pr. "	6

Full Charges.

110-pr. Armstrong	15
70-pr. "	12
68-pr. smooth bore	12
Total	53 live shells.

The parapet was examined, and photographed after the 437th, 443rd, and 461st general round.

16. The examination showed that the superior slope of the parapet was considerably damaged and altered in shape, and the interior crest on the proper left cut down 4 or 5 ft. deep, by 10 ft. wide. The terreplein was also covered with *débris* and splinters of shells. The experiment was renewed on the morning of the 4th of September, firing commencing at 9.50 a.m., and continuing until the afternoon, with some slight cessations, viz.:—

Commenced	9.50 A.M.	Commenced	12.57 P.M.
Ceased	11. "	Ceased	1.35 "
Commenced	11.30 "	Commenced	1.40 "
Ceased	12.40 P.M.	Ceased	2.13 "

The parapet was examined several times during this fire, and photographed after the general rounds 512, 571, and at the conclusion. After the 51st round, on the 4th September (Gen. No. 512), the face of the work was considerably damaged and cut up; several large shell craters appeared, particularly on the proper left, where the breach was enlarged; the rest of the interior slope was not much damaged, but the terreplein of the work was covered thickly with splinters of shells, stones, and lumps of hard clay, which in many instances had penetrated for some distance into the bank behind.

17. After the 110th round (Gen. No. 571), a photograph was taken of the interior. The damage done to the interior crest was not much increased. In front, the parapet had become an irregular heap of earth; the earth, however, was not so much displaced, the explosion of the shells throwing it up in a column, which fell down near the same spot from which it had been moved. The terreplein was covered with additional splinters and *débris*.

After the 143rd round (Gen. No. 604), a short examination showed that a clear breach was made on the proper left, the depth of which was about 4 ft. 9 in.

18. The total number of live shells fired at the parapet on the 4th September, was as follows:—

110-pr.	76	40-pr.	59
70-pr.	15	20-pr.	15
10-inch	6		

Full charges were used with each gun, except the 70-pr., which fired 12 rounds with 8 lbs. charge.

The grand total of live shells fired at this parapet in the two days will therefore be:—

110-pr.	97	20-pr.	15
70-pr.	27	10-inch	6
40-pr.	67	68-pr.	12

The examination at the conclusion of the practice showed the front of the parapet considerably disfigured; in fact, it was a mere shapeless mound of earth. The breach on the proper left was enlarged to about 33 ft. in width, by 5 ft. in depth, and the interior of the battery laid open.

19. These results were produced at the expense of 1975 lbs. of powder for cartridges, and 1150 lbs. in the bursting charges for shells. The amount of iron thrown was 15,091 lbs. If account be taken of those projectiles which actually struck the parapet and burst, the effect was produced by the following expenditure only:—Powder for cartridges, 1162 lbs.; powder for bursting charges, 714 lbs.; weight of iron, 9263 lbs.

20. The breach referred to in Paragraph 18 was almost entirely due to the fire of one 110-pr. Armstrong gun on the 4th, and by the expenditure of 69 rounds; and it was remarked that those projectiles which struck high on the superior slope did most execution, cutting away the earth at the point struck; those which lodged in the body of the work had not the same effect, as the earth was merely raised up, and in some instances into places from which it had been previously removed. The fire of the 40-pr., 20-pr., and smooth-bore guns, had comparatively very little effect. The craters formed were measured after the earth which had been dislodged by the shell had been cleared out. In this instance the shell acts as a pick, penetrates a certain distance, and then by exploding loosens a quantity of surrounding earth, some of which is thrown out of the crater, while some remains in it, held together by the sod and grass which covers the natural slope of the ground. The rifle shells in general attained about two-thirds of their proper penetration before exploding.

21. The great superiority of rifle over spherical shells was shown; thus the mass of earth displaced by the 70-pr. rifle shell is about fifteen times as much as that by the 68-pr. spherical; while the 40-pr. displaces five times as much earth as the 32-pr. The bursting charges are, respectively, 70-pr. rifle, 68-pr. smooth, 40-pr. rifle, 32-pr. smooth.

22. It was found extremely difficult to measure many of the craters of individual shells in the artificial earth. A section, however, has been prepared, showing the depth and width of a few different craters which were noted during the experiments, and a Table gives the other dimensions.

TABLE

SHOWING THE DIMENSIONS OF SHELL CRATERS IN ARTIFICIAL EARTH.

General No. of round.	Nature of gun.	Sectional measurements.		Diagonals in plan.		Line of least resistance.	Approximate cubic displacement.
		Horizontal.	Vertical.	A. B.	C. D.		
		ft.	ft.	ft.	ft.		
410	40-pr.	4·0	1·6	8·0	2·6	1·6	
413	40-pr.	2·6	2·3	6·6	4·6	2·3	
416	40-pr.	4·0	2·0	7·0	7·6	1·11	
421	110-pr.	6·9	3·0	9·0	8·0	2·9	
422	110-pr.	6·0	4·2	9·6	11·0	3·3	
429	110-pr.	7·0	4·9	13·6	5·0	3·9	
435	110-pr.	6·0	4·1	11·0	8·0	4·1	
456	70-pr.	3·0	3·3	8·0	8·3	3·3	

23. The Committee had many opportunities during this practice of witnessing the extreme accuracy of the Armstrong rifled guns; when once the range was obtained, it was easy to plant the shell in any part of the work that was desirable. For example, the experiments were concluded by firing a few rounds from the 110-pr. at the field splinter proof, which had hitherto sheltered the range party during the practice. This splinter proof was strongly built, and placed below the level of the natural ground. Although a small object, it was struck three times in six shots, and completely destroyed.

24. These experiments have solved many important points, and furnished some valuable hints as to the best mode of attack and defence in future operations against earthworks.

The Committee would draw attention to the following points:—

First. The best means of destroying an earthen parapet is by the direct fire of rifled guns with full charge, throwing shells of large capacity for powder. *One large gun is much to be preferred to several of a smaller nature.*

Second. In breaching an earthen parapet, the fire should be concentrated as much as possible, and the breach formed by cutting down the parapet, commencing at the top, the earth is by that means blown away. Shells planted low in the work merely throw up the earth into the breach already opened.

Third. Relatively speaking, smooth-bore guns are of little value for destroying large well constructed earthworks; and except for ricochet or enfilade fire, they ought to be discarded from any future siege train when a supply of rifled guns can be obtained.

Fourth. The guns forming a siege train for service against earthen parapets should fire as large a projectile as circumstances will permit, and, as before observed, *too great exertions cannot be made to bring a large gun to the front, if possible.* One 110-pr. would probably be equal to a battery of 40-prs.

Fifth. It has been clearly proved that 25 ft. on the superior slope is the minimum thickness that should be given to future parapets designed to resist heavy rifled ordnance; even this has been breached by one rifled gun firing 110-pr. live shells, with percussion fuzes, in from three to four hours, as shown above. If there had been embrasures, it would have been done in a shorter time.

Sixth. A working party, during the day, could not attempt the repair of an earthen parapet under a fire of rifle guns at 1000 yds. without great loss of life.

Seventh. The increased accuracy of the fire of rifled guns and the more destructive character of their shells make it evident that considerable modification must be made in the rules hitherto laid down as to works of attack, extending to details of construction of batteries, saps, and field magazines, the distance of the first approaches, and their subsequent development. These questions appertain chiefly to the duties of the corps of Royal Engineers, and have doubtless engaged the attention of the officers at the head of the instruction of that branch of the service. The Committee, therefore, will not enter upon them.

The Committee cannot conclude their report without expressing their obligations to the officers of the Royal Artillery and Royal Engineers who were employed in connection with this experiment. They also derived much assistance from the electric telegraph and from the photographic arrangements superintended by Captain Boileau, R. E. The County Constabulary, under Colonel Mackay, rendered on this, as on the two former occasions, most valuable services.

J. St. GEORGE, Brigadier General,
President.

Total of rounds fired in the preceding experiments.

First day	66	Fifth day	75
Second day	101	Sixth day	47
Third day	40	Seventh day	80
Fourth day	52	Eighth day	179

Grand Total...... 640

TABLE

GIVING THE WEIGHT OF ONE CUBIC FOOT OF DIFFERENT NATURES OF SOIL, TAKEN FROM THE PARAPETS AT NEWHAVEN.

Target.	Nature of soil.	Weight of one cubic foot.	Remarks.
		lbs.	
Artificial	Light yellow sand, unrammed	84	
„	do rammed	111·75	
„	Stiff yellow clay, moist and rammed	114·5	
	do dry	96	
Natural butt	Clay and marl	92·5	
„	Red sandy loam	124·75	

DESCRIPTION OF BOXER'S 2-INCH TIME FUZE

FOR

RIFLED ORDNANCE.

BY CAPTAIN VIVIAN DERING MAJENDIE, R.A.

CAPTAIN INSTRUCTOR, ROYAL LABORATORY.

A NEW fuze having recently been adopted for use with the 7-in. (110-pr.) Armstrong shells,[1] and the means of access to sections or specimens of this fuze, or other opportunities of becoming acquainted with its construction, being wanting to many Officers in the Regiment, I have thought that the following description might be acceptable, and perhaps, in some cases, useful.

As this fuze is merely a modification of Boxer's common fuze, with which those for whose use the following paper is contributed are no doubt perfectly familiar, I have, as it were, built my description upon the common fuze, not dwelling upon the details which are common to the two, but enumerating and explaining the points in which this fuze differs from the common.

This fuze resembles Boxer's common fuze in its general features and construction, but differs from it in several points of detail.

The points of difference may be most conveniently explained by arranging them under the following heads:—

(1) Points of difference in the head of the fuze.

(2) do do body do

(3) General dimensions.

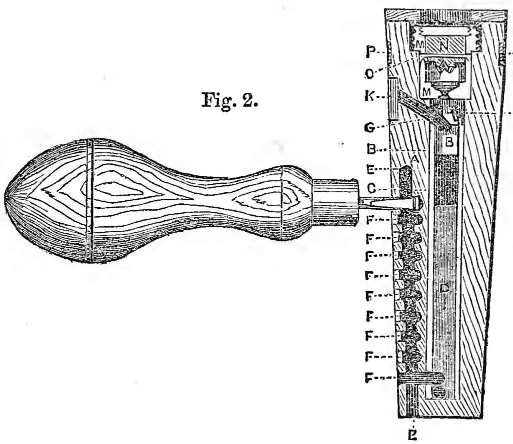
As regards (1) *The head of the fuze*:—The principal difference here consists in the method of ignition: Time fuzes for smooth-bore guns are ignited by the flash of the discharge, but owing to the absence of windage in Armstrong guns the fuzes intended to be used with them must be ignited by some other agency; accordingly a detonating arrangement is provided in the head of this fuze, by which it is fired. The arrangement is called a "detonator"

[1] Col. Boxer, the inventor of the fuze, proposed it for use with *all* Armstrong shells; and it is not impossible that fuzes of this construction may ultimately be employed with the lower natures.

(Fig. 1, MM), and consists of a small cylinder of gun metal,[1] with a projecting head, this head being screwed[2] for the purpose of fixing the detonator into the fuze.

Fig. 1.

Fig. 2.



A Body of fuze.
B A lining of papier-mache.
C Pressed gunpowder.
D Pressed fuze composition.
E Powder channel.
F Side-holes.
G Escape-holes.
K Protecting disc of copper and papier-mache.
M Detonator.
N Hammer of detonator.
O Suspending wire of hammer.
P Securing wire.

The "detonator" is hollow, and closed at both ends, with the exception of a small fire hole at the bottom. Immediately above this fire hole the bottom is recessed and roughed, for the reception of a small patch of detonating composition,[3] consisting of

Potash (Chlorate of)	6	parts by weight.
Antimony (Sulphide of)[4]	4	,, ,,
Mercury (Fulminate of)	4	,, ,,

Above this detonating composition is suspended, by means of a fine copper wire[5] (Fig. 1, O), a gun metal hammer (N), cylindrical in form, and fitting the interior of the detonator. This hammer has on its lower side a small partially-hollowed cylindrical projection, jagged into little teeth;[6] the teeth being thus presented immediately above the detonating composition.

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[1] The alloy is Copper 12 lbs., Tin 12 oz., Zinc 4 oz.

[2] With a right-handed screw, 14 threads to the inch.

[3] This composition is mixed and pressed into the recess in a dry state, and a drop of *thin* shellac varnish dropped into it, to render it more impervious to moisture.

[4] Crude antimony.

[5] No. 19 wire gauge.

[6] To make the ignition of the detonating composition more certain. A needle point would not answer the purpose as well, as it would be liable to fall into and choke the fire hole.

The detonator fits into the head of the fuze, which is shaped to receive it; the top of the detonator being flush with the top of the fuze, and the bottom a short distance above the composition.[7] (See Fig. 1.)

The presence of the detonator renders necessary some modifications in the construction of the head: in the first place, as the top of the fuze does not require (as in the case of the common fuze) to be opened before placing it in the gun it is not provided with a cap; but over the top is glued a collar of felt, which serves to reduce the jarring effect produced by fixing the fuzes into the shell.

In the second place, the top being closed by the detonator, an escape is provided for the flame of the burning composition at the side of the head immediately below the detonator, by three "escape" or fire holes (fig. 1, GG) being bored into the fuze with a downwards inclination; these holes are equidistant from one another, two of them being situated on that side of the fuze which is away from the side holes and powder channels, the third dividing the space between the rows of side holes.[8] The "escape" holes are countersunk, and are closed by means of a disc of fine sheet copper[9] (Fig. 1, K), over which is a millboard disc (Fig. 1, K), and finally a broad strip of fine paper[10] is pasted over the outside of the holes,[11] and painted black; by this arrangement not only is moisture effectually excluded, but the fuze is secured against accidental ignition.[12]

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7 Immediately above the three fire holes, of which mention is made in the text (see p. 172).

8 This distribution of the escape holes is thought to be conducive to the safety and efficiency of the fuze, by taking away the escape holes from the neighbourhood of the powder channels, and thus diminishing the liability of any communication between the two.

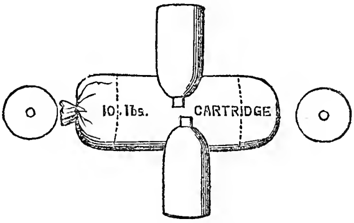
9 Copper ·012 in. thick.

10 White fine paper.

11 Immediately below the wire woolding (see text, p. 174).

12 That this arrangement does secure the fuze from accidental ignition is proved by the following experiment instituted by Col. Boxer, and described by him in a Memo. for the Ordnance Select Committee of the 18th February, 1864. The experiments were made on 16th February, 1864.

1st Trial. Four 40-pr. shells with fuzes fixed were placed as in the diagram, and the cartridge exploded. None of the fuzes were ignited.



2nd Trial. Same repeated, with four new fuzes: none ignited.

3rd Trial. do do none ignited.

4th Trial. Same repeated, with the same fuzes as were used in the third trial. None ignited.

5th Trial. Same repeated, with the same fuzes as were used in the second and third trials. None ignited.

None of the fuzes were blown out, or loosened in any way.

Since then the experiment has been frequently repeated; always with the same success.

In the third place, the head is strengthened[1] by being woolded near the top with a fine copper wire[2] (fig. 1, PP), secured by solder.

(2) *The body of the fuze*, differs from that of the common fuze principally in the composition bore being lined with a paper cylinder[3] (Fig. 1, B). This lining serves two purposes :—First, in the event of the wood shrinking, as it will sometimes do in dry hot climates, it prevents the formation of a space or groove between the wood and the composition, which would cause the fuze to explode[4] instead of burning regularly; and, secondly, it enables the side holes (Fig. 1, FFF) to be made deeper, thus diminishing the thickness of wood to be bored through[5] in preparing the fuze (see Figs. 1 and 2), and so facilitating and shortening the operation, as well as rendering it almost impossible for the fuze to be bored longer or shorter[6] than is intended.

In addition to being deeper, the side holes differ from those of a common fuze in being plugged with rifle powder only, the ground clay being dispensed with. The bottoms of the powder channels (Fig. 1, E) are not, as in the common fuze, closed with shellac putty, but, like those of the diaphragm fuze, are connected at the bottom with a piece of quick match.

Above the level of the top side hole the composition bore is driven with mealed (pit) powder, instead of fuze composition, to insure greater accuracy when the fuze is prepared for short ranges.[7] The fuze is not primed like a common fuze, being merely matched with two pieces of quickmatch (each 1 in. long) placed in two of the escape holes, and set down on to the mealed powder.

(3) *Dimensions:* This fuze differs from the common in being altogether about an inch longer, to give room for the detonator, and in being cut from a somewhat thicker part of the same cone.

In other respects the construction is identical with that of the common fuze.

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[1] The wood would be liable to split when the detonator is screwed in if not strengthened by some such arrangement as that adopted.

[2] The wire used is No. 21 wire gauge.

[3] "White wrapping" paper is used for this lining. It is shellaced on the outside before being placed into the fuze.

[4] On the principle of a tube.

[5] The mean thickness of wood left between the paper lining and the bottom of the side holes, is only about ·025 in.; or between the composition and the bottom of the side holes ·075 in., (the paper lining being ·05 in. thick).

[6] "Longer or shorter" according to the inclination downwards or upwards which is liable to be given to the hand borer (not to the hook borer) in preparing a common fuze, unless great care be taken; whereas in these fuzes the borer receives a positive direction from the length of the side holes (see figs. 1 and 2), and is, as it were, correctly guided into the composition by these holes. This improvement in the construction of the fuze makes the use of the hook-borer unnecessary, as the communication into the composition can be made with an ordinary brad-awl, with little or no chance of a wrong inclination being given.

[7] Pressed mealed powder burns twice the rate of fuze composition, and thus by substituting mealed powder for fuze composition twice the length is obtained, the chance of the brad-awl cracking the composition, as it would be liable to do if it entered near the top, being thus diminished, and the accuracy of the fuze at short ranges increased.

These fuzes are used with Armstrong's 7-in. common and segment shells; a brass adapter (Fig. 4) being employed to fit the shell for their reception. The preparation of this and the common fuze is the same[8] with the exception that this one does not require to be uncapped; and they are available for the same times of flight, viz. up to 10 seconds.

The action is as follows: the wire by which the detonating hammer is supported is broken by the shock of the discharge, and the detonating composition exploded by the hammer falling into it. The flash passes (through the small hole in the bottom of the detonator) to the match and composition, which become ignited, the action thenceforward continuing as in the common fuze.

This fuze is available as a percussion fuze when firing against earthworks or ships, without any preparation, it having been found in such cases that the fuze is driven into the shell on impact, and the shell exploded.[9]

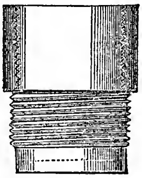
Adapter for Boxer's 2-inch Time Fuze for Rifled Ordnance.

The larger natures of Armstrong shells are bushed to receive the pillar fuze, but Boxer's time fuze being of wood requires a conical fuze-hole, and accordingly a gun-metal[10] adapter, or supplementary bush (Fig. 3), is provided for use with these fuzes.[11]

The lower part of this adapter is screwed externally to fit the bush, the interior is conical for the reception of the wooden time fuze, and slightly roughed or tapped to give the fuze a better hold. Into the bottom of the adapter is driven tightly a papier-maché wad (Figs. 4 and 5) to protect the bursting charge in the shell (before the fuze is placed in) from accidental explosion.

The wad is driven into the shell by the end of the fuze when the latter is fixed.

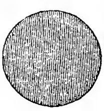
Fig. 3.



Adapter.

Fig. 4.

Fig. 5.



[8] So far the same that it consists in both cases in boring through the required side hole into the composition; but the preparation of the fuze for rifled ordnance is, as has been explained, simpler and more expeditious than that of the common fuze, owing to the reduced thickness of wood to be bored through, and to the fact that a brad-awl (fig. 2) is used instead of the hook borer.

[9] Experiments were made by the O. S. Committee, at Shoeburyness, on the 17th March, 1864, with a view to establish this point. The fuzes were fired from a 40-pr. Armstrong gun at an earthwork at 1022 yds. range, and from a 7 in. (110-pr.) Armstrong gun at an oak butt at 800 yds. and 1500 yds. range. The result places it beyond doubt that the fuze may be generally depended on to act as an efficient percussion fuze.

[10] The alloy used is—Copper 30 lbs., Tin 1 lb. 4 oz., Zinc 2 lbs. Lead 1 lb. 4 oz.

[11] The adapter used with the Armstrong brass (E pattern) time fuzes will not take these fuzes, "having two projections which prevent their passing through." (*Extracts from Reports of O. S. C.* Vol. I. p. 462); and being, moreover, cylindrical internally, instead of conical.

THE FOLLOWING EXPERIMENT WAS CARRIED ON AT SHOEBURYNESS, ON 15TH AUGUST, 1864, TO ASCERTAIN THE EFFECT OF STEEL SHELL FIRED FROM A 13·3″ ARMSTRONG M.L. WROUGHT-IRON SHUNT RIFLED GUN, ON AN IRON-PLATED VESSEL, AT 2000 YARDS RANGE.

[COMMUNICATED BY CAPTAIN A. HARRISON, R.A.]

For this experiment a "Warrior" target 12′ × 10′ (with wooden frame round it, making altogether a target of 17′ 6″ × 32′) was moored at 500 yds. range from the gun, and the charge was reduced to 51½ lbs., being equivalent to a striking velocity at 2000 yds. with a full charge of 70 lbs.

The initial velocity of the shell with 51½ lbs. charge is about 990 ft., and the striking velocity 940′.

Mean weight of shell, empty	585 lbs.
Burster	24 „
Diameter of shell	13″·24
Length { over all	23″·
Length { of steel	19·75
Mean recoil	6 ft. 1 in.

Elevation, 1°.

ROUND No. 1. Grazed edge of frame and passed through wood target at side of "Warrrior." Did not burst.

ROUND No. 2. Struck top of upper plate 3′ 7″ from right side; piece of plate 16″ × 12″ (measured at rear side of plate) broken out; hole in backing 16″ × 12″; skin driven out 12″ for a length of 5 ft.; third rib broken at top and bent out 18″; second rib bent out 3″; angle iron broken; shell burst in plate; three pieces of shell found.

ROUND No. 3. Struck about 10 yds. short and ricochetted on to centre of target, striking centre plate 4′ 2″ from left side; hole in plate 16″ × 13½″; centre plate started forward 6½″ at top and 4½″ at bottom on right side, and 3″ at top and 0·5″ at bottom on left side; 11 armour-plate bolts started in centre plate and one in bottom plate. Upper plate blown off and lying at foot of target in front; all the bolts (except three) of this plate broken at nut, the three being drawn bodily out of the plate; bottom of upper plate, where shell entered, indented 1½″ in length of 1 ft. At the back ragged hole 4′ × 2′ 3″ between third and fourth ribs from right side; two ribs broken and forced out, second rib from right bulged, angle iron cracked; skin cracked and opened for length of 3′ below hole. Seventeen armour-plate bolts, twenty-one rivets, and thirteen backing bolts broken. A great many splinters of timber, iron, bolt-heads, &c. on raft; shell on platform in rear of target, broken up into four pieces.

ROUND No. 4. Struck wood target to the left of "Warrior;" bursting charge fired, but shell did not burst.

ROUND No. 5. Struck 10″ left of "Warrior" target and 12″ above platform; shell did not burst.

THE FOLLOWING EXPERIMENT WAS CARRIED ON AT SHOEBURYNESS, ON 4TH AUGUST, 1864, TO TEST THE "SMALL PLATE" TARGET.

[COMMUNICATED BY CAPTAIN A. HARRISON, R.A.]

The target, 17′ 3″ × 10′, represents the ordinary construction of a wooden ship armour-plated, the armour plates being of small area, and secured by large "wood screws."

The target is faced with four rows of plates of the following dimensions:—

Two upper rows	5′ 9″ × 2′ 7″ × 4·75″.
Lower rows	5′ 9″ × 2′ 5″ × 5·9″.

The following are the scantlings: frame timbers, 11″; inner planking, 6″; outside planking, 10″.

The target has deck beams, waterway, and deck planking.

The wood screws are 1½″ diameter, and 19″ long, penetrating into the frame-timbers.

The total weight of the target proper is 28 tons, 3 cwt. 2 qrs. 13 lbs.

Range, 200 yds.

The guns used in this experiment were as follows:—

One service 68-pr. smooth-bore muzzle-loading gun.
One do 7″ Armstrong breech-loading rifled gun.
One 9·22″ Armstrong muzzle-loading rifled shunt gun (12 tons).
One 10·5″ Armstrong muzzle-loading rifled shunt gun.

The following shot and shell struck the target:—

From 10·5″ gun	Spherical steel shot, two; total weight, 332 lbs. Cylindrical steel shot, one; weight, 297 lbs. Cylindrical cast-iron shot, one; weight, 296 lbs.
" 9·22″ gun	Cylindrical steel solid shot, four; total weight, 868 lbs. Cylindrical (Palliser's) chilled cast-iron hollow shot, three; total weight, 776 lbs.
" 7″ breech-loading gun	Cylindrical steel solid shot, two; total weight, 221 lbs. Cylindrical cast-iron solid shot, one; weight, 111 lbs.
" 68-pr. gun	Spherical steel solid shot, two; total weight, 146 lbs. Spherical cast-iron solid shot, one; weight, 66 lbs.

Number of round.	Photographic No.	Nature of ordnance.	Projectile. Nature.	Weight in lbs.	Form and Diameter.	Length in inches.	Bursting charge of shell.	Charge in lbs.	Elevation.	Range in yds.	Deflection.	Effects. Depth of indent in inches.	Diameter of indent in inches.	Buckle.	Recoil.
					in.		lbs.		′		′			″	′
1	840	68-pr. smooth-bore gun	Cast-iron solid shot	66·	Spherical	...	...	16	20	200	...	...	...	...	...
2	841	7″ Armstrong breech-loading rifled gun	„	111·	Cylindrical	12·3	...	12	24	„	10 R	1·7	...	2·9	...
3	842	68-pr. smooth-bore gun	Steel solid shot	73·8	Spherical 7·92	...	...	16	20	„	...	5·7	8·5 × 8·7	...	...
4	843	7″ Armstrong breech-loading rifled gun	„	110·9	Cylindrical	11·3	...	12	26	„	10 R	...	...	...	...
5	844	9·22″ Armstrong 12-ton shunt rifled gun	„	220·	„	13·4	...	*30	45	„	5 R	Thro'	10·	...	7
6	845	9·22″ gun	Palliser's chilled cast-iron shot	258·12	„	20	...	44	25	„	4 R	„	10 × 11·5	...	‖10
7	846	10·5″ Armstrong muzzle-loading shunt rifled gun	Steel solid shot.	166·	Spherical 10·435	...	...	50	6	„	...	„	11· × 13·	...	10
8	847	68-pr. smooth-bore gun	„	73·	Spherical 7·92	...	...	16	20	„	...	3·9	...	4·	...
9	848	7″ Armstrong breech-loading rifled gun	„	110·8	Cylindrical	11·3	...	12	26	„	10	2·8	...	3·	...
10	849	9·22″ gun	„	220·	„	13·4	...	†30	40	„	5	Thro'	10·	...	7
11	850	10·5″ gun	„	166·	Spherical. 10·435	...	...	‡22½	33	„	...	„	10·5	...	4 3
12	851	„	Cast-iron solid shot.	296·	Cylindrical	15·5	...	35	30	„	...	...	...	...	‖11 3
13	852	9·22″ gun	Steel solid shot.	222·	„	13·4	...	30	30	„	4	Thro'	11· × 11·5	...	7
14	853	10·5″ gun	„	297·	„	14·07	...	*35	25	„	...	„	...	...	‖11 6
15	854	9·22″ gun	Steel shell.	206·	„	18·5	11	44	20	„	5	„	10 × 12	...	11 0
16	855	„	Palliser's §	259·	„	20·	...	†30	30	„	4	„	10 × 11	...	8 9
17	861	„	§	259·	„	20·	...	†30	25	„	4	„	...	...	8 11

REMARKS.

Struck left hand top corner of plate in second row from top, circumference of indent on a bolt, crack 9″ long through bolt-hole and across the face of indent; corner of plate, 14″ × 12″, driven into backing, 6″; crack 2″ wide at circumference of indent, and crack 6″ long from edge of plate at 2″ below circumference of indent; bolt at 5′ from indent (at opposite corner of plate) started 0·5″; plate separated 0·5″ from left hand one; two timber baulks cracked through at left end. Shot broke up. No damage at back.

Struck 5″ from bottom of same plate as last round on a bolt; plate driven in at bottom below indent 3·7″, started out 1·″ at left hand bottom corner and 0·9″ at right side; small crack on face of indent. At back, second knee from left started 0·25″.

Struck at junction of top and second row of plates at 7″ from left side, half the indent on each plate; plates separated, 0·8″; ripple, 0·9″; upper baulk of timber cracked for length of 2′ at 7″ from rear side of plate; bottom of indent cracked round. Knee (started last round) now 0·5″ from backing for 3′. Diameter of shot after firing, 7·285″ × 8·1″.

Struck 9″ from bottom of left hand upper plate; shot remained in, projecting 5·5″ from face of plate; corner of plate, 12″ × 8″, bent in 2·5″; circumference of indent 1·5″ from bolt-hole; plates separated 0·8″; left hand top bolt of plate slightly started; 2½″ of shot-hole on adjoining plate. At back, two knee bolts started 0·5″. Diameter of shot at head after firing, 7·146″; length, 10·16″.

Struck upper row 14″ from bottom, and 6″ from right side of plate, on a bolt; upper plate forced up 1·4″; bolt driven through; upper horizontal baulk of backing splintered, and partly blown away for a length of 8′; the shot penetrated waterway between two knees; backing between knees, driven out for a height of 12½″; shot struck Scott Russell's target (15 yds. at rear), made an indent on it 0·3″, broke a rib. Length of shot after firing, 12·2″; diameter at head, 9·76″.

Struck right hand small plate in second row 12″ from side and 8″ from top; plate opened out from left hand one 4″, was driven in at top 7″ and raised up from next row, 3″. At the back, one knee (in rear of where shot penetrated) was detached and driven 16′ to the rear, and inner planking destroyed for a height of 19″. Nearly all the shot appeared to have passed through and to have broken up in timber baulk at foot of Scott Russel's target.

Struck at junction of second and third row of plates on a bolt, 3″ of hole being on thick plate. At the back, the shot had penetrated between two knees, the timber between the knees was much shattered and driven out for a height of 2′; knee forced out 3·″ for 2′ from bottom; ground strewed with large splinters of timber. Shot broke up.

Struck on third row, 5·5″ from bottom, and 3′ from left of plate; indent cracked round at bottom; plate driven in 2·1″ at lower edge in length of 20″. At the back, one backing bolt driven out 1″. The shot after firing measured 7·39″ × 8·103″.

Struck right hand plate of third row 3′ 8″ from side and 1′ 2″ from bottom; edge of circumference of indent on a bolt; indent slightly cracked round at bottom. No damage at back of target. Shot after firing measured 7·924″ at head, and 9·526″ in length.

Struck on second row 18″ from bottom and 12″ from side of plate; hole closed up by timber; knee forced out from back of target 12″, and 7″ from deck planking. Shot struck Scott Russell's target (15 yds. at rear), and measured 9·81″ at head, and 12·237″ in length.

Struck 8″ above No. 846. Timber backing (already much damaged by No. 846 shot) driven out and much shattered; general damage considerably increased. Shot struck Scott Russell's target and measured 9·905″ at head, and 10·545″ in length. Only a narrow rim of metal between the two shot holes.

Struck at junction of second and third row of plates, two-thirds of indent on lower plate; depth of hole on 5·9″ plate, 11″, and edge of plate broken away for 16″ × 8″; right hand lower corner (measuring 20″ × 15″) of 4·75″ plate driven in 10″; edge of indent, 3″ from bolt, small cracks from bolt-hole; 5·9″ plate buckled out 1·4″ at right hand lower corner and driven in the same amount at left hand top corner, also out 1·4″ at left bottom corner, and in 0·8″ at right top corner. Shot broke up.

Struck third row 12″ from bottom and 7″ from side of plate, the top and bottom edge of circumference of hole on a bolt. At the back, lower part of knee carried away; backing much shattered and driven out in large splinters; shot cut through timber supporting beam and struck Scott Russell's target. The shot after firing measured 10·17″ at head, and 11·45″ in length.

Struck third row, left hand lower corner of plate; 14″ × 7″ of plate broken off, and plate driven into backing, 8·5″; shot penetrated at bottom of knee, backing very much shattered and driven out. Shot after firing measured 10·82″ at head, and 13·24″ in length. Plate laminated and opened at 1·5″ from front at top edge for a length of 2′ 6″.

Struck at the (vertical) junction of two plates in the lower row at 8″ from top edge of plates; plates separated 4·5″; plate in row above, immediately over shot hole, forced forward 2·5″; shell burst well in target, ignited timber; large hole at rear, daylight through; very numerous and large splinters blown out; timbers forced out bodily 2″ right and left.

Struck at junction of upper and second row of plates 16″ from side of target; upper plate forced up 3″; struck on knee which was detached by the blow and driven 8 yds. to the rear; inner planking, 4′ × 10″ driven out. Shot broke up.

Struck left lower corner of same plate, partly on thick plate of third row; piece of plate, 13″ × 8″, broken away; plate driven in 5″ at left lower corner and out at right upper corner; shot struck one of large supporting beams in rear and drove it back on Scott Russell's target; backing in rear of plate completely gone for 18″ in height. Whole ground in rear of target covered with large fragments of timber. Shot broke up.

THE *DERIVATION** OF ELONGATED PROJECTILES

FIRED FROM

RIFLED ORDNANCE.

BY MAJOR C. H. OWEN, R.A.

PROFESSOR OF ARTILLERY, ROYAL MILITARY ACADEMY.

ALTHOUGH accuracy of fire has been greatly increased by the introduction of rifled guns, the projectiles fired from them are as liable to deflection by wind as the balls thrown from smooth-bored pieces; but besides this deflection, it is found that the elongated shot fired from rifled guns are subject to a constant deflection to one side or the other, according to the direction of the rotation given to them by the gun and the form of the head of the shot; this constant deviation which has been termed by the French *derivation*, would occur in a perfectly still atmosphere.

Nearly all the different rifled guns, either ordnance or small arms, that have been made give their projectiles what is called a *right-handed* rotation, i.e. the upper part of the shot turns from left to right with reference to an observer behind the gun; and it has been found, that when, as is generally the case, the projectile has a rounded or pointed head†, it invariably deflects to the *right*.‡

On the contrary, projectiles having round or pointed heads fired from the few guns that have been rifled so as to give a *left-handed* rotation, (i.e. the upper part turning from right to left with reference to an observer behind the gun), deflect to the *left*. The amount of this deflection or *derivation* is influenced chiefly by the form of the head of the shot, the initial velocity of the shot on leaving the bore, the velocity of rotation given to the projectile, and the force and direction of the wind.

Table I. shows the deviations to the right of shot fired from a 40-pr. Armstrong gun which gives a right-handed rotation; in Table II. may be seen the left deflections of shot fired from a gun rifled according to a French system, and giving a left-handed rotation. Both the Armstrong and French projectiles are cylindro-conoidal in form.

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* It has been suggested that the term deviation would be better understood than derivation. The word deviation could not however be used without adding *constant* before it and *due to rotation*, &c. after it, or the peculiar deflection called *derivation* would be often confused with that due to wind or other causes. I may add that the term has been in general use for some years in England, America, and on the Continent.

† Either hemispherical, conoidal, conical, or ogival.

‡ It is to allow for the constant right deflection or *derivation* of the projectiles fired from the service rifled ordnance, that the tangent scales are now made to slope to the left.

Table I.

Practice at Shoeburyness on 15th March, 1861, with shot from a 40-pr. Armstrong rifled gun, giving *right-handed* rotation; weight of piece 31 cwt., charge 5 lbs. Five rounds fired at each elevation; no allowance for deflection in" laying."

Elevation.	Mean range.	Mean deflection.	
		Right.	Left.
°	yds.	yds.	—
2	1061	·06	—
3	1421	1·0	—
4	1769	3·6	—
5	2113	6·2	—
7	2687	16·4	—

The above are fair average deflections and have not been chosen as being favourable to the statement—that right-handed rotation gives right deflection to projectiles with pointed or round heads. It is found as may be seen from this table and from others further on, that with this gun the derivation is hardly sensible at 1000 yds., and also that at this range a wind blowing across the line of fire from right to left may not only counteract the derivation but even deflect the shot to the left; as however the range increases the right deflections become very apparent.

Table II.

Practice at Shoeburyness on 9th April, 1862, with shot weighing about 60 lbs., from a 32-pr. gun rifled on a French principle, and giving *left-handed* rotation; charge, 5·5 lbs. Fifteen rounds fired at each elevation; no allowance for deflection in "laying."

Elevation.	Mean range.	Mean deflection.	
		Right.	Left.
°	yds.	yds.	yds.
2	824	—	1·5
5	1672	—	6·1
10	2891	—	19·8

Of the 15 shot fired at 2°, two deflected to the right, one had no deflection, and the remaining eleven deflected to the left. All the shot fired at 5° and 10° deflected to the left, the deflection increasing with the angle of elevation.

Now, if cylindrical or flat-headed projectiles be fired instead of round pointed shot, the direction of the *derivation* is reversed; that is to say—a flat-headed shot fired with right-handed rotation deflects to the left, and one fired with left-handed rotation to the right. To prove that this is the case a number of cylindrical shot were made under the direction of the O. S. Committee and fired at Shoeburyness alternately with ordinary service cylindro-conoidal shot from the same gun, a breech-loading Armstrong 40-pr. Some of the cylindrical shot made for this experiment had their centres of gravity about the centre of the figure, in others the centre of gravity was nearer to the base, and in the rest nearer to the point of the projectile; the preponderance was given either by the iron of the shot or by lead. As however it was only required to establish the fact of the *left* deflection and not its amount, the position of the centre of gravity of shot fired at the moderate ranges found practicable was comparatively of little importance.

It soon became apparent from the practice, that to obtain comparative results, it was necessary to fire at angles of elevation giving moderate ranges, for at short ranges the derivation is not sensible, while at long ranges the velocity of rotation given by the gun was not high enough to prevent the cylindrical or flat-headed shot from turning over during flight. It may be as well to remark here, that flat-headed shot require a much higher velocity of rotation than projectiles with pointed or rounded heads, "for the current of air meeting the shot, instead of having merely, as with the latter forms, to pass round the pointed head, presses with the flat head upon a surface almost at right angles to the previous direction of the current, and consequently exerts a very much greater force proportionally, tending to upset the shot."*

In the following tables the ordinary cylindro-conoidal shot will be termed *service shot,* and the cylindrical or flat-headed experimental shot will be called *special shot,* the position of the centre of gravity of the latter being also given.

Very calm days were selected for the practice, so that the results might be affected as little as possible by wind.

Both service and special shot were fired at each day's practice from the same 40-pr. Armstrong gun mounted on a travelling carriage; weight of piece 32 cwt., calibre 4·75 in., spiral 1 turn in 37 calibres, and number of grooves 56.

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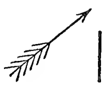
* "The motion of projectiles fired from Rifled Arms," p. 33. By Major C. H. Owen, R.A.

Table III.

Report of Practice. Shoeburyness, 22nd Aug. 1862.

Barometer,

Wind,—West, 3.

Direction of wind 

No. of round.	Elevation.	Projectile. Nature.	Projectile. Mean weight	Time of flight	Range.	Deflection. Left.	Deflection. Right.	Remarks.
	°		lbs.	sec.	yds.	yds.	yds.	
1	1		40·8		721	...	4	
2	"	Service shot	...		746	...	·8	
3	"		...		768	...	1·2	
4	"	Special shot	40·5		714	line.		
5	"		...		743	...	1·2	
6	2	Service shot	40·8		1069	...	1·4	
7	"		...		1054	...	1	
8	"	Special shot	40·5		934	...	·8	
9	"		...		989	·6		
10	5		40·8	Not observed.	2092	...	1·2	
11	"	Service shot	...		2072	...	1·6	
12	"		...		2101	...	2	
13	"		40·5		1611	4·4		
14	"		...		1810	10·2		
15	"	Special shot	...		1617	9		
16	"		...		1758	...	6	8′ deflection given so that axis of gun pointed along the range.
17	"		...		1728	8·2		
18	"		...		1662	5·6		
19	"	Service shot ...	40·8		2005	...	7·4	

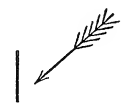
Table IV.

Report of Practice. Shoeburyness, 4th Sept., 1862.

Barometer, 29·8 in.

Wind,—East, 3 to 4 in gusts.

Direction of wind



No. of round.	Elevation.	Projectile. Nature.	Projectile. Mean weight	Time of flight.	Range.	Deflection. Left.	Deflection. Right.	Remarks.
	°		lbs.	sec.	yds.	yds.	yds.	
1	2	Service shot	41	not obs.	1025	...	1·	
2	,,		...	3·4	1099	...	1·2	
3	,,		...	3·4	1231	...	·8	
4	,,		...	3·4	1088	...	·8	
5	,,	Special shot. Centre of gravity towards base.	40·75	3·6	1102	1·4		
6	,,		...	3·6	1078	·8		
7	,,		...	3·6	1103	1·		
8	,,		...	3·7	1012	1·6		
9	,,	Special shot. Centre of gravity towards point.	...	3·4	1014	2·4		
10	,,		...	not obs.	1026	1·4		
11	,,		...	3·7	1068	3·2		
12	,,		...	3·7	1132	...	2·8	/ Elev. screw broke.
13	5	Service shot	41	6·7	2153	...	6·6	
14	,,		...	6·6	2211	...	7·2	
15	,,		...	6·6	2122	...	5·6	
16	,,		...	6·9	2177	...	8	
17	,,	Special shot. Centre of gravity towards base.	40·75	6·3	1710	6·2		
18	,,		...	6·3	1732	...	6·4	\
19	,,		...	6·6	1815	line		
20	,,		...	6·2	1691	5		
21	,,	Special shot. Centre of gravity towards point.	...	6·5	1739	·2		
22	,,		...	6·6	1774	...	1·4	/
23	,,		...	6·4	1775	...	3·2	/
24	,,		...	6·3	1658	10		
25	10	Service shot	41	11·8	3639	...	25	
26	,,		...	12·1	3649	...	26	
27	,,	Special shot. Centre of gravity towards base.	40·75	not obs.	2650	...	46	/
28	,,		...	11·8	2512	...	97	/
29	,,	Special shot. Centre of gravity towards point.	...	not obs.	2718	9	...	Sunk in sand.
30	,,		...	not obs.	2474	27·	...	

The gun was fitted with old pattern sights, and a constant deflection of 8′ right was given throughout the practice, so that the axis of the gun pointed along the range.

Table V.

Report of Practice. Shoeburyness, 9th April, 1864.

Barometer, 30·3 in.
Wind,—South-east, 2.
Direction of wind 

No. of round.	Elevation.	Projectile. Nature.	Projectile. Mean weight	Time of flight.	Range.	Deflection. Left.	Deflection. Right.	Remarks.
	°		lbs.	sec.	yds.	yds.	yds.	
1	2	Special shot. Centre of gravity towards point.	47·0	2·9	890	2	...	/
2	,,		...	2·9	899	2·4	...	<
3	,,		...	3·0	900	4	...	\
4	3		...	4·2	1234	2	...	These shot were unsteady.
5	,,		...	3·9	1149	2·6	...	
6	,,		...	4·0	1215	2	...	
7	4		...	5·0	1396	4	...	
8	,,		...	5·2	1456	4·4	...	
9	,,		...	5·0	1398	2	...	
10	,,	Service shot	41·5	5·4	1795	line		/
11	,,		...	5·3	1751	line		/
12	3		...	4·0	1432	·4	...	/
13	,,		...	not obs.	1387	line		/
14	2		...	3·0	1014	line		/
15	,,		...	3·3	1024	·4	...	/

The gun was fitted with new pattern sights, and no allowance given for deflection, the axis of the piece pointing therefore along the range.

Table VI.

Report of Practice. Shoeburyness, 18th April, 1864.

Barometer,
Wind,—South, 2.
Direction of wind 

No. of round.	Elevation.	Projectile. Nature.	Projectile. Mean weight	Time of flight.	Range.	Deflection. Left.	Deflection. Right.	Remarks.
	°		lbs.	sec.	yds.	yds.	yds.	
1	2	Service shot	41·5	3·1	1018	8	...	/
2	,,		...	2·9	1014	1·6	...	/
3	3		...	4·2	1407	1·2	...	/
4	,,		...	4·0	1364	...	4	/
5	4		...	5·3	1755	...	2·2	/
6	,,		...	4·2	1706	...	1.6	/
7	,,	Special shot. Centre of gravity towards base.	47·0	4·6	1362	8	...	\
8	,,		...	4·6	1336	10	...	\
9	,,		...	4·5	1369	7·4	...	\
10	3		...	3·6	1093	6	...	Broken graze.
11	,,		...	3·9	1145	5	...	/
12	,,		...	3·7	1094	12·6	...	\
13	2		...	2·8	830	4·6	...	\
14	,,		...	2·8	821	4·4	...	/
15	,,		...	2·8	855	1·2	...	/

The gun was fitted with new pattern sights, and no allowance given for deflection, the axis of the piece pointing therefore along the range.

Taking the practice of the 22nd August, 1862.—Table III. first. The special shot fired on this occasion were those having the centre of gravity situated about midway between the apex and base of the shot. The results of the practice were not so satisfactory as might have been obtained, in consequence of the gun used having an inclined sight to allow for the *derivation* to the right of the service shot, and no allowance having been made for this right deflection until the 16th round; still it can be seen from the Report, that when the angle of elevation was such as to ensure a sufficiently long time of flight, the deflections of the *special* (flat-headed) shot to the *left* were very decided. At 1° the time of flight was doubtless too short to allow of any apparent differences in the deflections, still the Report shows that the flat-headed projectiles did not deflect so much to the right as the conoidal pointed shot. At 2° the deflections of the former were also more to the left than those of the service shot. The wind blowing across the range from left to right might probably have caused all the shot fired to bear off slightly to the right. The 6 rounds from 10 to 15 fired at 5° proved however decisively that the flat-headed shot deflected to the left. Taking rounds 10 to 15 the mean deflections were,

	Mean deflections.
Service shot	1·6 yds. right.
Special shot	7·8 „ left.

The mean deflections of rounds 16 to 19, when the allowance for the right deflection of the gun with service shot was taken off by giving 8′ right deflection (the axis of the gun pointing therefore along the range) were,

	Mean deflections.
Service shot	7·4 yds. right.
Special shot	2·6 „ left.

In firing No. 16 round there was probably some mistake in "laying," or perhaps the shot may have turned over in flight, for rounds 18 and 19 showed as clearly as before (13, 14, and 15) that the flat-headed shot deflected to the *left*; if No. 16 round be omitted the mean deflection of 17 and 18 rounds will be 6·9 yds. left.

On the 4th September, 1862, an old pattern sight was used and 8′ right deflection given throughout the practice, so that the axis of the piece was not inclined to the line of the range, but pointed directly along it. The mean deflections obtained, the practice of the 4th September, 1862, Table IV., were as follow:—

	0° yds.	5° yds.	10° yds.
Special shot..	·95 right	6·8 right	25·5 right.
Special shot (centre of gravity towards base) ...	1·2 left	1·2 left	71 right.
Special shot* (centre of gravity towards point) ..	2·3 left	1·4 left	18 left.

From the Report it may be observed that at 2° the deflections of the special shot were invariably to the *left*; at 5° the mean deflection is also to

* 12th round omitted as elevating screw broke.

the *left*. That all were not to the *left* at 5° and 10° arose most probably from the unsteadiness of some shot and the turning over of others during flight; for the grazes of the shot which deflected to the right showed that the axis of the shot was considerably inclined to the line of the range. The unsteadiness during flight of the special shot at 5° and 10°, which might have been inferred from the inaccuracy of the practice, was noticed both at the battery and on the range.

Now as the special shot were unsteady when fired even at 5°, in consequence of the gun not giving a sufficiently high velocity of rotation for flat-headed projectiles, I suggested that the remaining special shot should be fired at 2°, 3°, and 4°; this was done on the 9th and 18th April, 1864, and very decisive results were obtained. The following were the mean deflections obtained on the 9th April, Table V.:—

	2°	3°	4°
	yds.	yds.	yds.
Service shot...	·2 left	·2 left	line.
Special shot (centre of gravity towards point)...	2·8 left	2·3 left	3·46 left.

The mean deflections on 18th April, Table VI., were,

	2°	3°	4°
	yds.	yds.	yds.
Service shot...	1·6 left	1·4 right	1·9 right.
Special shot (centre of gravity towards base) ...	3·4 left	7·8 left	8·46 left.

On both days the wind blew from right to left and will account for some of the service shot having a slight deflection to the left; every one who has seen much practice is aware that the right deflection of the service shot is hardly sensible at low angles of elevation, and that a little wind blowing from right to left is sufficient to counteract it.

I have purposely omitted to notice No. 1 round with service shot, Table VI., for the deflection 8 yds. left, is evidently a very wild one, there being no such eccentric graze (at 2°) recorded in any of the practice returns given in Tables III., IV., V. and VI., or in numerous other practice returns I have purposely consulted.

On the 9th April, Table V., it was noticed that at 2° the special shot were steady during flight; at 3° they were unsteady near the end of the range; and at 4° they were unsteady for some distance before grazing. As might have been supposed the left deflections of the special shot with preponderance behind were greater than those of the special shot with preponderance in front.

The results of the experiments shown in the preceding Tables are, I conceive, sufficient to establish the following facts:—

(1) That elongated projectiles with rounded or pointed heads deflect to the *right* at ordinary ranges when fired with *right-handed* rotation.

(2) That similar projectiles fired with *left-handed* rotation deflect to the *left*.

(3) That the *derivation* of cylindrical or flat-headed projectiles is in the opposite direction to that of projectiles with rounded or pointed heads fired

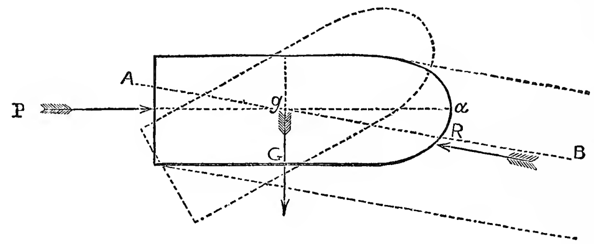
with similar rotation; for instance, if a cylindro-conoidal and a flat-headed shot be both fired with *right-handed* rotation, the *derivation* of the former will be to the right and the latter to the *left.*

(4) That the *derivation* of ordinary service shot fired from the 40-pr. Armstrong gun is hardly sensible at 1000 yds.; for it may be seen from Tables V. and VI. that a slight breeze from left to right was sufficient to counteract the tendency of the shot to bear off to the right. It also appears from the Tables that flat-headed shot require a very much higher velocity of rotation than cylindro-conoidal projectiles, and that the former lose their velocity very much sooner than the latter.*

Various explanations have been given to account for the *derivation* of shot fired from rifled guns, but that suggested by Professor Magnus, of Berlin, is in all probability the true one, confirmed as it appears to be by the results of actual practice. In order to ascertain practically the effect produced by the resistance of the air upon a rotating projectile, Magnus had a gyroscope constructed with a small elongated shot, instead of the ordinary disc, suspended in such a manner that it could turn freely in any direction. The limits of this paper do not allow of a discussion of the principles of rotation as shown clearly by such a gyroscope, but the effect of the air's resistance tending to produce the *derivation* of an elongated shot may be briefly stated as follows.†

In Fig. 1., the directions of the forces which act upon an ordinary cylindro-conoidal shot fired from a gun are shown.

Fig. 1.



P represents the force of projection.
G „ „ gravity.
R „ resultant of the air's resistance which must be parallel to the trajectory *AB* described by *g*, the centre of gravity of the shot.

The dotted lines parallel to *AB* represent the opposing current of air, and *R* must be midway between them.

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* False heads which will easily break up on impact have been attached to some experimental flat-headed shot for practice against iron plates, in order that the shot may retain a high velocity during flight.

† A translation of Magnus' pamphlet on the Deviation of Projectiles may be found in the "Occasional Papers" of the R.A. Institution, Vol. I. p. 443.

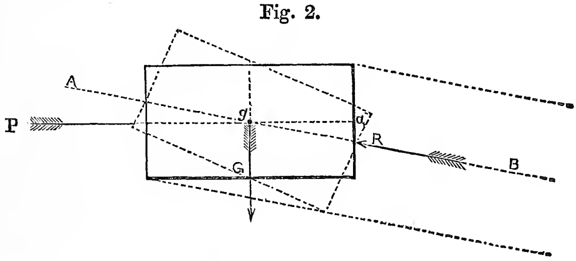
Now, although it would be very difficult to ascertain exactly the point on the shot at which the resultant *R* may be said to press, it is evident that in all cases of practical gunnery this point will be below *a*, and, unless the centre of gravity of the shot is very near the point, in front of *g*, the centre of gravity.* If the shot were fired without rotation it would turn over in flight, *R* causing the point to rise as indicated in Fig. 1. by the dotted shot;† but if the shot be rotating rapidly while moving forwards at a high velocity, the point of the shot will not rise (at least perceptibly), but will move laterally to the *right* when the rotation is *right-handed*, and to the *left* when it is *left-handed*; "consequently, the projectile assumes an oblique position to the direction of the air's resistance, and is thereby in its further progress depressed on the side towards which the apex is turned, while the air's resistance acts against it as against an inclined plane, and thus produces the deviation."‡

The direction of the graze of an elongated shot gives some indication of the turning of the point to the right. The grazes of the service shot fired on the 9th and 18th of April, as shown in the column of remarks in Tables V. and VI., were inclined to the right. In the artillery experiments made in Prussia at the suggestion of Professor Magnus, "it was also admitted by all, that, as much from the motion of the projectiles as from the furrows made in grazing the ground, in all the rounds fired, the point of the shot at the instant of touching the ground had a deviation to the right."§

The reason for the *derivation* of flat-headed projectiles fired with right-handed rotation being to the left instead of to the right will now be explained.

In Fig. 2, *P*, *G*, and *R* as before represent respectively the force of projection, that of gravity, and the resultant of the air's resistance.

Fig. 2.



If the shot (Fig. 2) were fired without rotation *R* would cause the head to turn *down*, as shown by the dotted shot, and not up as with the pointed shot; the flat-headed projectile would however turn over in flight, only in the opposite direction to that in which the pointed shot would turn. But if the flat-headed shot have a *right-handed* rotation, *R* would cause the point

* No shot have been used with the centre of gravity so far forward as to admit of the resultant acting behind the centre of gravity at ordinary elevations.

† The turning over of elongated shot fired without rotation, and the experiments with the gyroscope are explained in Section II., chapter ii. of the "Motion of Projectiles fired from Rifled Arms."

‡ Magnus on the Deviation of Projectiles, Berlin, 1860. Second Edition.

§ Magnus on Deviation of Projectiles, "Occasional Papers" of R.A. Institution, Vol. I., p. 443.

to turn to the *left* instead of to the right, and the *deviation* will therefore be in the same direction, viz. to the *left;* these principles are clearly shown by the gyroscope, and fully confirmed by the results of the practice before given.

The grazes of the greater number of the flat-headed shot fired on the 9th and 18th April were also inclined to the *left,* and that some were not so inclined no doubt arose from the unsteadiness of the shot during flight.

A popular theory frequently advanced to account for the *derivation* of projectiles from rifled guns is,—that a shot rotating rapidly and at the same time falling in the air will experience a greater pressure underneath than above, and will therefore roll as it were upon the denser air below. Were this the real cause a flat-headed shot having right-handed rotation would deviate to the right, like a shot of any other form, and the *derivation* would increase with the rapidity of the rotatory motion imparted to the projectile, which is not the case.

As a projectile having a pointed or rounded head deviates in one direction and a flat-headed shot in the opposite direction, it is probable that by making experiments with shot having heads of different shapes, a form might be discovered which would show no *derivation.** Derivation may be decreased by increasing the velocity of rotation of the shot.

It may be as well to point out in conclusion, that if an ordinary cylindro-conoidal shot maintained its velocity for a very long range, so that great resistance would continue to be exerted by the air upon the shot, the point of the latter, with right-handed rotation, would not only turn to the right, but would gradually droop, then turn to the left, and in fact describe a circle, and after a certain time the direction of the *derivation* of the shot would change. In practice, however, although the resistance during flight is doubtless sufficient not only to turn the point of a shot but also to cause it to droop, yet the resistance decreases so rapidly with the velocity, that at the end of any ordinary range the derivation is still in the direction at first given.

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* See "Motion of Projectiles," by Major Owen, R.A., p. 49.

A FEW HINTS UPON COLLECTING OBJECTS OF NATURAL HISTORY.

BY Mr H. WHITELY,

CURATOR OF THE MUSEUM, ROYAL ARTILLERY INSTITUTION.

[COMMUNICATED BY THE SECRETARY, R.A.I.]

Doubtless there are many members of the Institution who would gladly contribute to the collection of Natural History, did they but know what to collect, and how to preserve the specimens when collected. The following brief remarks are published with the view of assisting the student, and to facilitate the classification.

Commencing with mammals:—skulls of all the larger species would be of great interest, want of space making it undesirable that the skin of the whole animal should be sent, the smaller species—such as bats, rats, mice, moles, &c.,—may be either skinned or preserved entire in large bottles, or small wooden kegs; any kind of spirits* will do to preserve them in, and if of ordinary strength may be diluted with one-fifth of water, unless it is necessary to crowd the specimens; when such is the case, the water must be omitted.

It will add greatly to the perfect preservation of the specimens during transportation, if each one is wrapped up in cloth or paper. In packing, place all the larger specimens at the bottom, and if there are any very delicate ones, they must be separated by means of some immovable partition to prevent any damage being done to them in case the vessel should be inverted: great care must also be taken before the final closing of the vessel, that it is perfectly full.

All specimens should have an incision made in the abdomen to admit the spirits; if several of a kind are preserved, the intestines of some may be entirely removed to insure their perfect preservation.

The best plan of capturing the smaller animals, such as rats, mice, &c. is by means of the common rat and mouse traps, those caught alive in traps

* It is advisable to add a little tartar emetic, as cases have arrived at the Institution, from which the spirits had been abstracted, and consequently the specimens were completely destroyed.

will be found the best; the traps can be baited with fish, corn, fruit,—toasted cheese will always be found a most attractive bait;—by this means many animals will be taken that were previously unknown in the locality, for many of them being nocturnal in their habits may have escaped observation.

Fine sand smoothly laid in open spaces in woods, or in tracks leading to or from ponds or streams, will often indicate by the impressions left behind, that there are those in the neighbourhood that you would be pleased to become better acquainted with.

The larger mammals in most cases can be obtained by placing strychnine on any bait laid for them.

Skulls may be preserved by boiling, or cutting away the muscle and drying, or by putting in spirits; but in every case, care should be taken not to cut or mutilate the bone.

In the case of antelopes and deer, when not convenient to take the whole skull, sufficient should be taken to keep the horns attached.

When the skin of any of the larger mammals is to be preserved, the following mixture may be used; alum two parts, saltpetre one, to be pounded into a fine powder and well mixed; at the same time it must be stated that arsenic is the only true curative agent, all others only answer for a short time. Every portion of the skin must be covered while in a fresh state, the skin may then be allowed to dry partially, and when folded up, the hair side should be placed outwards.

Birds.

In making collections of birds the following notes should be taken.

Length from tip of bill to the end of tail, expanse of outstretched wings, length of wing from the carpal or first joint; if put down in this manner, 20, 36, 10 (the figures representing inches): the first will stand for the length; the second, the outstretched wings; the third, length of wing from first joint. The colour of the eyes, feet, bill, or any other naked part; the sex, which should always be given from dissection, the date and locality. If the specimen is numbered and a note book kept, the whole of these remarks should be recorded against the number in the book; when no book is kept, they should be written upon a label and attached to the bird.

For preserving the skins of birds there is nothing equal to arsenical soap, which may be made in the following manner:—

Camphor, 5 oz.; powdered arsenic, 2 lbs.; white soap, 2 lbs.; salt of tartar, 12 oz.; powdered chalk, 4 oz. Cut the soap into small slices, as thin as possible, put them into a pot over a gentle fire, with a very little water, stirring it often with a wooden spoon; when dissolved, add the salts of tartar and powdered chalk: take it off the fire, add the arsenic, and stir the whole gently; lastly, put in the camphor, which must first be pounded in a mortar with a little spirits of wine. When the whole is properly mixed together, it will have the consistence of paste. It may be preserved in tin or earthenware pots, well closed and cautiously labelled. When wanted for use, it must be diluted with a little cold water to the consistence of clear broth; the pot may be covered with a lid of pasteboard, having a hole for the passage of the brush by which the liquor is applied. This mixture must be applied to all parts of the inner surface of the skin.

Plaster of Paris, powdered chalk, or whiting will be found of much use in skinning specimens that are very fat or bloody, by being applied to the inside of the skin, as it quickly absorbs the grease and blood.

Specimens of birds from all parts of the world are much wanted for the collection of skins to be arranged in cabinets ; no matter how common or plain in plumage a bird may be it should be preserved, for although common in one locality it may be very rare in others.

Fish and Reptiles.

All the smaller ones are best preserved in spirits, following the directions under the head of mammals; the larger ones should be skinned, and if convenient, then placed in spirits; when that cannot be done, they should be well dried and packed in boxes, occasionally giving them a sprinkling with spirits of turpentine.

Insects.

In this branch the Institution collection is very deficient, donations from all parts of the world will be thankfully received. Beetles will give but little trouble in collecting or preserving, the best plan is to put them in wide mouth bottles with spirits, not crowding the bottles too much; they may be sought for in damp places, under stones, in the bark of trees, dung, in the bodies of dead animals, and in stagnant water.

Butterflies, bees, wasps, &c., if packed in layers of soft paper, or cotton, will travel quite safely: as the setting of these is attended with some trouble and cannot be always done at the time of capture, it is as well to know that they can be relaxed and properly set, upon their arrival in this country.

Shells, Coral, &c.

Any from Australia or New Zealand will be of value to the Institution collection; land shells from all quarters will be of much interest.

Birds' eggs if well authenticated would be highly prized, but if there should be any doubt on this point they are of little value.

THE FOLLOWING NOTES ON THIS SUBJECT HAVE BEEN KINDLY FURNISHED BY MR J. K. LORD, F.Z.S.

Birds.

An efficacious mode of preserving their skins is by means of a piece of common yellow soap and arsenic in powder.

Work up a lather first, just as for shaving, with a sash-tool, dip the brush covered with lather into the arsenic, and well rub it into the skin. The camphor is best sewn up in the skin in small pieces.

A solution of bi-chloride of mercury should always be kept for washing over bill, feet, and rump.

Insects.

In collecting insects, a wide-mouthed bottle fitted with a *bung* stopper tied over or rather covered with thin leather should always be carried; the leather, being tied at the top to form a knob, to aid in pulling out the stopper. Fastened to this bung by a bit of fine wire is a small sponge (the wire should reach within two inches of the bottom of the bottle), this sponge should be kept wet with chloroform, which may be carried in a small stoppered phial in the pocket. Every insect caught of whatever order should be at once popped into this bottle, and which will cause its instant death. This will be found a capital plan as violent struggling damages the fine colouring of a great many insects. Beetles can always be packed between layers of rag.

Butterflies, pressed flat and packed in triangular pieces of paper tightly gummed up, travel admirably.

Shells.

In collecting univalve marine shells the fish may be boiled out, but great care should always be taken to *carefully* preserve the operculum. After cleaning out the fish the shell should be filled with dry cotton wool (animal wool should in all cases be carefully avoided), and the operculum stuck to the wool at the mouth of the shell.

Small crabs may be easily preserved by soaking them well in cold *fresh water* for eight or ten hours; when thoroughly dried, wash them over with the solution of bi-chloride of mercury.

Large specimens should be cleaned out, and then rearticulated.

RESULTS OF EXPERIMENTS WITH PROJECTILES

AGAINST

IRON ARMOUR.

[Extracted from the Transactions and Reports of the Special Committee on Iron. 1861–1864.]

BY CAPTAIN A. HARRISON, R.A.

SERVICE cast-iron shot being comparatively useless for attacking either ships or forts which are protected with iron armour, it has become necessary to employ for this purpose projectiles of a harder and tougher nature, and numerous experiments have been made in order to determine the requisite material; it may, therefore, be of interest to give a short account of these experiments, showing the results which have been obtained.

In a memorandum by Mr Pole,* in reference to the action of shot upon plate armour, an explanation is given, which I shall here quote, regarding the power lost in using cast-iron shot:—

"The damage caused to a plate by a certain amount of work stored-up in an impinging shot, may be modified by three distinct qualities in the shot itself, namely, its *material*, its *weight*, and its *form*....... It was evident at an early period of our investigations, that, unless the shot could be supposed perfectly hard and coherent, (a condition unattainable in practice) a portion of the work it contained would, if the resisting power of the plate was great, be expended upon the shot itself—that is, in distorting its form, or in breaking it to pieces...... and it was also evident that the power thus applied must be so much wasted, or deducted from the effective action on the plate struck. The late trials of shot made of steel more carefully and efficiently tempered than heretofore, have afforded the opportunity of comparing its effects with those of simple cast and wrought-iron, and the difference has been very marked; for, in proportion as the material of the shot has offered greater resistance to fracture or distortion, the damage to the plate has been so considerably increased as to show that the power lost by the weaker materials has been greater than was before suspected.

"These results have led to some interesting experiments, with the view of ascertaining the *amount* of power lost. It was observed by the Committee that the shot, or fragments of shot, after striking the plate, were considerably *heated;* and Sir W. Armstrong, acting on this hint, has endeavoured, by the application of the dynamic theory of heat, to solve this problem. He fired shots of various

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* A Member of the Special Committee on Iron. Appendix C. Report 1862.

materials against iron plates, and, by measuring carefully the quantity of heat generated in them by the concussions, obtained an approximate estimate of the work lost. He found that, with hard-tempered steel shot, the power expended on the projectile was about one-tenth of that stored-up in it at the moment of striking; while with softer shot it was two-tenths, and with soft wrought-iron it amounted to more than one-half of the whole. Cast-iron has hitherto eluded observation, on account of the difficulty of collecting the fragments, and measuring the heat in them.

"These experiments are very rough, and the investigation of the subject is, yet, very incomplete; but still enough has been done to warrant the conclusion, that, in firing at plates of strong resisting power, considerable loss of effect takes place when cast or wrought-iron shot are used."

Mr Fairbairn, also a member of the Special Committee on Iron, arrived at the same conclusion, after making a series of experiments to ascertain the resistance of different kinds of shot to a force tending to crush them. The specimens experimented on were a portion of some shot of cast-iron, wrought-iron, and steel, which were manufactured at Enfield for the purpose of being fired from a wall piece against iron plates. The results obtained by Mr Fairbairn are thus described in his Report:—

"It has been correctly stated, that it requires a considerable amount of force to break up shot when delivered with great velocity against an unyielding object, such as the side of an iron-cased ship, and it may be thence concluded that the force expended in thus breaking up the shot must be deducted from that employed in doing work on the plate. This is confirmed by experiment, which shows that though the whole of the force contained in the ball, when discharged from a gun at a given velocity, must be delivered upon the target, the amount of work, or damage done to the plate, will depend on its weight and the tenacity of the material of which the shot is composed.

"If, for example, we take two balls of the same weight, one of cast-iron and the other of wrought-iron, and deliver each of them upon the target with the same velocity, it is obvious that both balls carry with them the same projectile force as if they were composed of identically the same material. The dynamic effect, or work done, however, is widely different in the two cases, the one being brittle and the other tough; the result is that the cast-iron is broken in pieces by the concussion of the blow, whilst the other either penetrates the plate, or what is more probable, flattens its surface into a greatly increased area, and inflicts greater punishment upon it. In this instance, the amount of work done is in favour of the wrought-iron shot; but this does not alter the condition in which the force was in the first instance delivered upon the target, but is entirely due to the superior tenacity of the wrought-iron shot to that of cast-iron, which yields to the blow, and is broken to pieces, in consequence of its inferior power of resistance. The same may be said of steel in a much higher degree."

The following table shows the summary of results of Mr Fairbairn's experiments:—

No. of experiment.	Description of shot.	Length in inches.	Diameter in inches.	Area in inches.	Weight laid on in lbs.	Compression per unit of length in inches.	Pressure per square inch in lbs.	Pressure per square inch in tons.	Work done during the experiment in foot pounds per square inch.	Means of ditto.	Remarks.
1	Cast-iron, flat ended	1·5	·875	·6013	73,428	·08	122,115	54·51	902·6	776·8	Crushed.
2	Do..............	1·5	·83	·541	68,052	·053	125,787	56·13	650·9		Crushed.
3	Cast-iron, round-ended	1·72	·85	·5674	35,540	·122	62,636	27·96	899·7	821·9	Crushed.
4	Do..............	1·72	·95	·7088	40,916	·139	57,725	25·77	744·1		Crushed.
5	Wrought-iron, flat-ended ...	1·5	·875	·6013	94,412	·193	157,013	70·09	2542·8	3441·4	Compressed.
6	Do.....	1·5	·83	·541	94,412	·37	174,513	77·9	4340·1*		Compressed.
7	Wrought-iron, round-ended	1·72	·85	·5674	75,220	·225	132,569	59·18	2996·1	2200·6	Compressed.
8	Do..............	1·72	·95	·7088	64,468	·168	90,953	40·6	1405·2*		Compressed.
9	Hardened steel, flat-ended ...	1·5	·83	·541	145,756	·026	269,419	120·27	1608·1	...	Compressed.
10	Hardened steel, round-ended	1·72	·85	·5674	114,980	·1162	202,643	90·46	2515·0	...	Fractured.
11	Leaden ball, flat-ended ...	1·5	·95	·7088	7,078	·393	9,985	4·45	270·9	...	Compressed.
12	Leaden ball, round ended	1·72	·95	·7088	7,078	·400	9,985	4·45	290·6	...	Compressed.

Mr Fairbairn remarks,—

"The mean resistance of the specimens of cast-iron is 800† foot pounds per square inch, that of the specimen of steel 2515, or rather more than three times as much."

Before giving an account of the experiments which have been made at Shoeburyness and Portsmouth bearing on the subject of this paper, it may be well to denote the properties which constitute the distinction in cast-iron, wrought-iron, and steel; for these three sorts of iron, although all coming under the common name of *iron* are (Dr Percy tells us) "virtually distinct metals, which, in external characters, differ far more from each other than many chemically distinct metals."

The following definitions are extracted, by permission of the author, from Dr Percy's work on Metallurgy:‡—

"When carbon is absent, or only present in very small quantity, we have *wrought-iron*, which is comparatively soft, malleable, ductile, weldable, easily forgeable, and very tenacious, but not fusible except at temperatures rarely attainable in furnaces, and not susceptible of tempering like steel; when present in certain proportions, the limits of which cannot be exactly prescribed, we have the various kinds of *steel*, which are highly elastic, malleable, ductile, forgeable, weldable, and

* These experiments on wrought-iron cannot be relied upon, as the socket of the plunger broke in both cases.

† A pressure of one pound exerted through a distance of one foot.

‡ Iron and Steel. By John Percy, M.D., F.R.S.

capable of receiving very different degrees of hardness by tempering, even so as to cut wrought-iron with facility, and fusible in furnaces; and lastly, when present in greater proportion than in steel, we have *cast-iron,* which is hard, comparatively brittle and readily fusible, but not forgeable or weldable. The differences between these three well-known sorts of iron essentially depend upon differences in the proportion of carbon, ...

With regard to the modes of effecting the combination of carbon with iron, Dr Percy states:

"The essential condition of this combination is, contact of iron at, or above, a red heat with carbon, or with certain gaseous compounds of carbon. When an oxide of iron is reduced in admixture with *excess* of carbon, at or above the melting point* of cast-iron, combination takes place rapidly and cast-iron is produced .... But combination is also effected, though much more slowly, when iron in the compact state of bar imbedded in charcoal powder is exposed to any temperature at or above redness.† In this way steel is very largely made in England, ...

Relative to the per centage of carbon which distinguishes steel from cast-iron, Dr Percy quotes the opinion of Karsten, the German, who states,

" .... in all iron containing more than from 0·2 to 0·25 of carbon the metal is designated steel ....and 2· of carbon appears to be the limit between steel and cast-iron."

In speaking of the conversion of cast-iron into malleable or wrought-iron by puddling, Dr Percy says:

"This process consists essentially in stirring about pig-iron molten on the bed of a reverberatory furnace, heated by flame, until it becomes converted into malleable iron, through the decarburizing action of the oxygen of the air."

Three main points have been proposed for consideration in the experiments which have been carried on, viz.:—

(1) To determine material.
(2) To determine form.
(3) To endeavour to obtain a shell which would act effectively against armour-clad vessels.

I propose to show the decision which has been arrived at under each of these heads.

Service Cast-iron Shot.

In October, 1858, an experiment was made at Portsmouth, to determine the *comparative* effect of 68-pr. and 32-pr. cast-iron shot, and also the effect of such shot at 20 yds. range, against iron plates.

The shot were fired at wrought-iron plates 4 in. thick, fastened to a ship's side; the following results were obtained:—

32-Pounder.

At 400 yds. Made an indent of 1·25″.
At 100 yds. Mean of six rounds, an indent of 2·16″.
At 20 yds. Penetrated the plate.

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* 2786° Fah. † 1830°.

68-Pounder.

At 100 yds. range. Penetrated the plate and from 17 to 22 in. of timber,

At 20 yds. Striking on a weak spot. Penetrated the side of the ship, pieces of shot and plate being found scattered on the deck. A second shot penetrated the plate and to a depth of about 10″ into the timber.

The Report on this experiment states, "It was found that there was no comparison between the effect of the two descriptions of shot, one 68 lb. shot doing as much damage to the plate, and more injury to the woodwork and frame of the ship, than five 32-pr. shot that had struck close together." The space in which these shot struck was 2′ 9″ × 2′ 8″, and the report goes on to state, that, whilst the framework of the side under where the 32-pr. shot struck was "scarcely injured," it was "much injured" under where the 68-pr. shot struck.

The result of this experiment clearly shows the necessity for an alteration in the present armament of our coast batteries, which consists, mainly, of 68-prs., 32-prs., and shell guns.

With regard to the thickness of iron plate required to break up cast-iron shot, Captain Chads arrived at the following conclusions, from numerous experiments made at Portsmouth in 1854, at a range of 450 yds.

(1) That both solid and hollow shot would, under ordinary circumstances, pass through $\frac{1}{4}$ and $\frac{3}{8}$ths inch iron without breaking.

(2) That under ordinary circumstances, solid shot will pass through $\frac{1}{2}$ in. iron without breaking; that hollow shot, under similar circumstances, will generally break up.

(3) That under ordinary circumstances all shot (cast-iron) solid or hollow, will break up in passing through $\frac{5}{8}$ths inch iron.

Captain Hewlett reported as follows on this subject, after carrying on experiments in 1862 with a 68-pr. S. B. gun.

(1) That the shot breaks up when it strikes the $\frac{5}{8}$th plate with high velocity, and generally with medium velocities, but not when fired with the lowest charges. Those fired with 5 lbs. charges passed through the plate whole.

(2) The shot that struck the $\frac{7}{16}$th plate did not on any occasion break up, whether fired with a high or medium charge.

(3) Plates intended to break up cast shot on impact, should never be less than $\frac{5}{6}$th″ in thickness; . . . .

(4) The lowest charges break up shell on the latter striking either the $\frac{5}{8}$th or $\frac{7}{16}$th plates.

The plan of using heavy shot at low velocities for attacking armour plates, had some advocates in this country a few years since. Sir W. Armstrong stated in his evidence before the Special Committee on Iron, that he thought "a heavy shot at a low velocity would be most effective;" the late Captain Lyons, R.A. was also of this opinion.

Shot of 200 lbs. weight were therefore manufactured for the 7″ Armstrong B. L. rifled gun, and were fired with a 10 lbs. charge at the original

"Warrior" target; they proved quite useless, for the record of the experiment states, "Indent too small to be measured; no damage apparent. The three shots hit close together." The initial velocity of these shot was about 765′.

The relative damaging power to iron plates of shot fired from a 68-pr. S. B. gun, and a 7″ Armstrong B. L. rifled gun, is a point which has been much discussed.

To determine this, shot of 68 lbs. weight were fired at a "Warrior" target at 200 yds. range, from a 7″ B. L. rifled gun, with 16 lbs. charge, and contrasted with a shot weighing 66 lbs. fired from a 68-pr. S. B. gun, with the same charge.

The velocity at 530′ of the shortened shot from the 7″ gun, was 1459′ against 1386′, the velocity of the 8″ shot; and the indent was 2·85″ for the 7″ gun, and 2· for the 8″ gun.

The Special Committee on Iron in their Report state,—

"Experiments made with shortened shot, fired from the 110-pr. Armstrong rifled gun, show that this gun is capable of being used with 68-pr. solid cylindro-conoidal shot, so as to be as effective at 200 yds. range against armour plates as the smooth-bore 68-pr."

This point is not of much importance, as neither gun is able effectively to attack armour clad vessels. I only allude to the experiment because it has been often asserted that the 68-pr. gives the greater blow, which, it will be seen, is not the case.

The heaviest cast-iron shot which have yet been fired in this country against iron plates are those used with the Horsfall 13″ gun. A shot of 279 lbs. weight was fired at a "Warrior" target, from this gun at Shoeburyness, with a charge of 74 lbs., at 200 yds. range. It completely penetrated, making a hole 28″ × 25″ in the armour plate, and 3 ft. square in the skin; the damage to fastenings, backing, &c., was very great, and portions of shot and plate were buried deeply in a timber bulkhead 3 ft. in rear of the target. The initial velocity of this shot was 1631 ft.

The report on this experiment states,

"It would have been very difficult to stop this breach."

Four rounds were fired at 800 yds. with shot having a mean weight of 284 lbs., the striking velocity with the same charge, viz. 74 lbs., was 1299 ft. The shot had been toughened by the addition of one-seventh of their weight of wrought-iron, and had been annealed.

The 1st and 3rd round missed the target, and the report on the experiment states,—

"Neither the 2nd nor the 4th rounds penetrated it; the shot of both rounds went through the armour plate, and buried themselves in the wooden backing, bulging the skin in, breaking the ribs, and shaking the target generally, but sent no splinters of plate or shot into the rear; in short, did not penetrate the side of the ship."

So that under the most favourable circumstances of attack,—viz. a steady platform, a stationary target, and time for careful laying of the gun,—a structure such as the "Warrior," although seriously knocked about by cast-iron shot of this weight, carrying a striking velocity of about 1300 ft. per second, is proof against their *penetration* at 800 yds. range.

An experiment was made at Shoeburyness in May 1861, in order to ascertain what protection could be obtained against cast-iron shot, from brickwork, faced with iron plates of various thicknesses, from 2″ to 3½″.*

The general results obtained were as follows :—

"That masonry covered with 2 inch iron plates will effectually resist a 12-pr. Armstrong shot at 600 yds. range.

"Covered with 2½″ plates, it will effectually resist a 25-pr. Armstrong shot, at 600 yds. range.

"Covered with 3″ plates, it will effectually resist a 40-pr. Armstrong shot, at 600 yds.

"But the 3½″ plates are not sufficient to resist the heavier natures of projectiles."

Granite faced with 4″ iron plates is seriously injured by 68-pr. cast-iron shot, fired with the service charge, at 100 yds. range. In an experiment at Shoeburyness it was found that blocks of granite 3 ft. thick, faced with an iron plate 4″ thick, were cracked through and split by the impact of a single shot fired under these conditions. The plates were of excellent quality and were only slightly indented.

Fig. 1.

Fig. 1† shows the form of cone which is invariably obtained from the impact of spherical or round-ended cylindrical cast-iron shot on iron plates.

The cast-iron shot of the service are generally made of soft grey foundry iron, which "from the ease with which it breaks up, is of very little comparative efficiency;"‡ and experiments have therefore been made with shot of an improved quality of iron, viz. Dr Price's improved pig iron, and some mixtures made in the Royal Laboratory.

Mr Fairbairn made some experiments on Dr Price's iron, with a view of ascertaining its tensile strength; and in summing up the results of these experiments he states,—

"The average tensile strength of cast-iron has been found to be about seven tons per square inch,"

whilst the mean of specimens cut from Dr Price's shot was 13·697 tons per square inch, or "nearly double the strength of ordinary cast-iron."

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* A detailed account of this experiment will be found in "Proceedings," R.A. Institution, Vol. III. p. 37. Remarks on Iron Defences, by Captain H. C. S. Dyer, R.A.

† This and all the other drawings are taken from photographs made after the experiments at Shoeburyness.

‡ Report, Special Committee on Iron, 1864.

Shot of these descriptions have been tested both at Portsmouth and Shoeburyness; Captain Key considers the order of merit to be as follows :—

(1) Dr Price's. (2) Laboratory. (3) Service.

And the Special Committee on Iron in their Report of 1863, thus refer to this subject :—

"Attempts have been made to improve the quality of cast-iron for this purpose. Col. Boxer, Dr Price, and Capt. Palliser have each produced metal much better than that ordinarily in use, and these improvements can, if required, be applied at a very slight additional cost."

The service cast-iron shot are, as is well known, cast in sand, but Major Palliser, late of the 18th Hussars, proposed that thick iron moulds should be used for the purpose. This method of casting has the effect of hardening the shot to a considerable extent, provided a proper description of pig iron is used.

Dr Percy thus alludes to chill-casting :—

"The mode of existence of carbon in iron is in great measure determined by the conditions of solidification after complete fusion, and the temperature at which fusion has been effected. Rapid solidification favours the retention of carbon in the combined state, and by this means it is possible to convert characteristic grey-iron into perfectly white iron. Thus by pouring liquid grey cast-iron into a cold metallic mould, so as to cause the most sudden cooling possible the exterior of the solid iron, where it comes in direct contact with the mould, will be found to be in the state of white-iron, while the interior will be in the state of grey-iron. This principle is extensively employed in practice, in the process known as *chill-casting*. It is adopted when it is desirable to render the surfaces extremely hard, white-iron being intensely hard as compared with grey-iron."

The first experiment which was made on the suggestion of this officer was with 12-pr. shot, in November 1863, and the opinion of the Committee on the result obtained on that occasion is thus recorded,—

"The chilled 12-pr. shot which were manufactured in the Royal Laboratory on the plan proposed by Captain Palliser, all broke up on impact, but they showed a marked improvement on the common cast-iron shot of the service, the indent of which on a 2½-in. plate is 0·75″, whilst an average of four shots of chilled cast-iron gives an indent of 2·, and in two instances the 2½″ plate was broken through by these shot."

The experiments since made with 7″ and 9·2″ cylindrical shot quite confirm the favourable results which were obtained from the 12-pr. shot; but two points still remain for determination regarding shot of this nature, viz. the description of pig iron best suited for chilling; and also how much of the success which has attended the use of Major Palliser's shot is due to the chilling process, and how much to the use of improved pig iron. With reference to the first point Major Palliser tells me that he has found in the case of Pontypool iron that No. 1, or the softest brand, only chills to a depth of about ⅛th of an inch; No. 2 to about ¼th, whilst a spherical 9″ shot of No. 6 was chilled to the centre. Some of the soft Scotch iron will not chill at all.

The Special Committee on Iron, in recording the marked success obtained with some of Major Palliser's shot which were fired at Shoeburyness last May, state :—

"It must, however, be remarked that Captain Palliser has used in some of his experiments a material to which, perhaps, some of the superiority may be attributed; and the Committee are unable to apportion the exact value which may be due in part to the material, and in part to the chilling process."

An experiment will shortly take place with a view of deciding this point; but under any circumstances it is quite evident that if shot can be manufactured uniformly, possessing the qualities of those of chilled cast-iron which were fired at the "Small Plate" target,*—viz. sufficient hardness for penetration without the toughness of steel shot—they will be infinitely superior to the latter for use against Iron-clads, for we shall then obtain the advantage of langridge which is lost by using steel shot. The saving of expense, by employing chilled cast-iron shot in place of steel, would also be very great.

As the tensile strength of cast-iron is considerably increased by frequent melting, it was considered desirable to ascertain whether metal thus treated could be advantageously used for shot. For this experiment 40-pr. Armstrong shot were cast from metal 4 times melted, 8 times melted, and 12 times melted, but each description proved inferior to the 40-pr. service shot.

The last experiment with cast-iron shot to which I shall refer, is one which was made in order to determine the amount of damage which could be inflicted on an iron-clad vessel by means of solid shot fired from a 13″ sea service mortar at a low angle of elevation, if, in case of emergency, owing to the absence of heavy guns, it should ever be found necessary to employ ordnance of this nature under such conditions.

The elevation of the mortar was 2°, and the shot, which had a mean weight of 279 lbs., were fired with a charge of 20 lbs. at Scott Russell's target ($8\frac{1}{8}''$ of iron) at 200 yds. range.

Three rounds were fired; the first shot struck the bull's eye, the second missed the target, and the third struck the target 6 *ft. above and* 3 *ft. right of the point aimed at;* the mean indent of the two shot which struck was 3·7″, and the plates were much damaged by the blow, but the Committee in their Report state,—

"The result showed that no reliance can be placed on the accuracy of a mortar fired under such circumstances."

The initial velocity of the shot was 788 ft. per second, and the terminal velocity 768 ft.

Table A shows the results obtained from cast-iron shot fired from various guns at iron armour.

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* Vide p. 177.

Wrought-iron Shot.

During experiments which were made at Portsmouth and Woolwich in 1857, 1858, against iron plates, wrought-iron shot were occasionally fired.

Shot of this nature never break up, but are always much "set-up" after impact. A report on a comparative trial of wrought-iron and cast-iron in 1857 states, "The effects of wrought-iron shot at 600 yds. range over cast-iron shot appears to be in the proportion of 3 to 1." In the trial of the "Meteor" floating battery (4″ plates on 25″ of timber), it appears that 68-pr. wrought-iron shot "did not penetrate her side at 400 yds. or cause any serious injury inboard;" and in summing up the results obtained from some experiments at Portsmouth in October, 1858, it is stated: "At 400 yds. the wrought-iron plates, 4 in. thick (on a ship's side) resist every description of projectile, even wrought-iron shot for a considerable time. At 200 yds., the effects of the projectiles have much increased, and the plates are sometimes penetrated with the heaviest wrought-iron shot and the frame of the ship much shaken."

In October, 1858, Mr Whitworth was very successful with a hardened wrought-iron shot which was fired from a 68-pr. cast-iron rifled gun. The shot weighed 68 lbs. and was fired with a charge of 12 lbs. at a 4″ plate attached to the side of the "Alfred" at a range of 450 yds. The shot passed through the plate and 6 or 7 inches of oak, and fell on the deck, about 2 ft. from the hole, making a hole in the armour plate 6″ diameter. It must however be noted that the record of the experiment speaks of the plate as being "badly welded" which defect would of course lessen its power of resistance.

In an experiment which was made to test iron embrasures at Shoeburyness in 1860, wrought-iron shot were fired from a 68-pr. S. B. gun and from an 80-pr., and a 40-pr., Armstrong gun.

The indentation of these shot on 4″ Thorneycroft bars at 600 yds. range was—

68-pr. W. I. shot......	$1\frac{1}{2}$″
,, Cast-iron shot ...	$1\frac{1}{8}$″
40-pr. W. I. and C. I.	$\frac{3}{4}$″

The Committee reported: "The dints on the iron nowhere exceed 1·5″ in depth; there is no material difference between those produced by the wrought-iron and cast-iron projectiles."

Some further trials of wrought-iron shot were subsequently made by the Special Committee on Iron, and the following extract is from their Report of 1863:

"Wrought-iron, though somewhat superior to cast-iron, is far inferior to steel and is not to be recommended as a material for projectiles to be used against iron plates."

Fig. 2.

Fig. 2 shows the form taken by spherical wrought-iron shot after impact. The shot in the sketch was fired from a 10·5″ rifled gun, and its major diameter after impact was 13″.

Fig. 3.

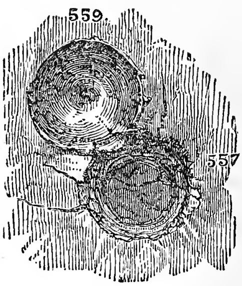

Fig. 3 shows the difference in the indent made by a cast-iron and a wrought-iron spherical shot—559 was made by a wrought-iron shot of 71 lbs. weight, the depth of indent was 3·1″ and its diameter 9·″; 557 was a cast-iron service 68-pr. shot, the indent being 2·5″ in depth and 8·5″ in diameter, both these shot were fired with the service charge, the velocities being 1413′ with the cast-iron and 1385′ with the wrought-iron shot.

In Table B will be found the results obtained from wrought-iron shot of various natures which have been fired against iron plates.

Steel Shot.

The first trial of steel shot in this country was in January, 1859. On the 6th of that month six flat-headed steel shot were fired from an Armstrong 32-pr. B. L. rifled gun with 6 lbs. charges at the "Trusty" floating battery, the ranges varying from 50 yds. to 480 yds.; two shot which struck at the junction of the plates penetrated 4⅛″ and 9⅛″ respectively; the remainder, after ricochet from water, merely caused indents, varying from 0·75″ to 1·25″. Further experiments were made in September, 1859, with puddled steel and homogeneous* iron flat-headed shot. They were fired from Sir W. Armstrong's 80-pr. rifled gun, at iron plates of various thicknesses up to 3 in., attached to a target of oak, representing the scantling of a 50 gun frigate; the result of this experiment is thus reported:—

"Puddled steel and cast-iron shot were fired at the 3″ plates, and as the target was now much shattered similar shot were fired at the 2½″ target. In each case the shot passed through both plate and scantling, the puddled steel shot entire, the cast-iron in fragments; the cast-iron damaging both plate and timber to a greater extent than the puddled steel."

In a further trial of the "Trusty," which took place at this time, shot of the same description were fired. From the report on this experiment it appears that at 400 yds. range a puddled steel shot drove in a large portion of plate "strewing the main-deck with fragments of plate and timber," the report goes on to state,—

"The only shot which on the first day, fairly penetrated both plate and timber was one of homogeneous iron, which struck near the centre of one of the upper plates, broke off a portion of plate 21″ × 11″ and forced its way through the scantling on the upper deck where it lay partially imbedded."

The shot weighed 78 lbs., and were fired with 12 lbs. charges. At 200 yds. range, a shot penetrated the plate and 10″ into the timber; a second shot, striking near the previous one, penetrated the side, and drove a portion of plate to the opposite side of the vessel, "on which it was buried

* "Homogeneous metal is evidently a variety of cast-steel, containing a small proportion of carbon, and is intermediate in that as well as other respects between malleable iron and cast-steel." —Percy's Metallurgy.

5″." The report states that, "The effect of these shot on the scantling in rear was in each case very great."

A shot was fired through a port-hole with a view of ascertaining the effect upon the plates on the opposite side of the vessel, the result was as follows: "A large portion of a plate 3′ × 2′9″ and weighing about 12 cwt. was broken off and fell overboard."

In October 1860, three rounds of flat-headed homogeneous iron shot were fired from Sir W. Armstrong's 80-pr. gun at Thorneycroft's embrasure, none struck the iron work, and it appears from the record of the experiment that, "Practice with these projectiles was discontinued at Sir Wm. Armstrong's request."

In January 1861, at Portsmouth, two flat-headed steel shot of 70 lbs. weight were fired with a charge of 12 lbs. from the Whitworth rifled 80-pr. at a 4½″ plate attached to the "Sirius." The range was 200 yds.—only one of the shot struck the plate, and indented it 3½ in.

No further experiment appears to have been made with steel shot until March, 1862, when a comparative trial of cast-iron, wrought-iron, and steel was made by firing, from a wall-piece, shot of 5½ oz. in weight against iron plates of various thicknesses, and the result having shown that the steel shot had the greatest power of penetration, a further trial with 12-pr. and 40-pr. shot of the same materials took place in June, 1862. The result of this experiment, however, led the Committee to report that

"The blow given by a wrought-iron or by a steel projectile to an iron plate is not so much more effective than that given by a cast-iron projectile as to render it desirable to substitute wrought-iron or steel shot for good cast-iron shot. The higher price of steel or wrought-iron over cast-iron, leads the Committee to believe that a greater effect can be performed at a less cost by the additional number of cast-iron shot that can be used for the same price." In this experiment the steel shot were too brittle, and broke up in nearly every instance.

In September 1862, a further trial of steel shot was made, when a flat-ended homogeneous metal shot weighing 12 lbs. 10 oz. was fired from a 12-pr. Whitworth rifled gun with a charge of 1 lb. 14 oz. against a 2½″ plate at 200 yds. range. The shot penetrated the plate and was only set up 0·5″. This was a great result to obtain as the indent of a 12-pr. *cast-iron* shot fired under similar circumstances is only about 1·2″.

On the 25th September a shot of the same material weighing 129 lbs. was fired from a Whitworth 120-pr. M. L. rifled gun with a charge of 23 lbs. against a "Warrior" target at 600 yds. range. The shot penetrated the armour and wood backing and fractured, but did not pass through, the skin. The plates of this target having proved of very inferior quality, the Special Committee on Iron recommended that the experiment should be repeated on a target faced with armour plates of a more suitable quality, and also that the Whitworth projectiles should be tried against a plate placed at an angle.

Owing to this recommendation experiments were carried on at Shoeburyness on the 13th and 14th of November, 1862, a description of which will be found at p. 41.* The Committee in their Report on these experiments, thus record their opinion:—

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* Recent Gunnery Experiments upon Iron Armour. By Captain Inglis, R.E.

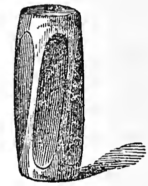
"Two solid shot of the same metal (i.e. homogeneous iron) and very slightly in excess in weight to the cast-iron ones, and fired with precisely the same charge, completely penetrated the plates, with scarcely any injury to themselves, clearly showing the value of this description of metal for penetrating iron plates, and that much of the work was expended in the destruction and dispersion of cast-iron shot."

Fig. 4 is from a photograph of a 12-pr. Whitworth shot which was fired on this occasion, taken after it had penetrated 3″ of iron. The Report states:—

"The three homogeneous metal projectiles......were so slightly changed in form as to present the same appearance as they did before use, and they could all have been fired again from the same gun."

This shot is now in the specimen room of the Ordnance Select Committee in the Arsenal.

Fig. 4.



Numerous experiments with steel shot were made during the year 1863.

In February of that year some steel shot were manufactured by Messrs Makin, of the Attercliffe Works, Sheffield, and were fired from a 40-pr. Armstrong rifled gun, and a 7″ Armstrong B. L. rifled gun, the latter at a "Warrior" target, and the former at $3\frac{1}{2}$″ unbacked plates, both at 200 yds. range; the 110-pr. shot remained in the target, and when subsequently removed were found to have penetrated about 7·5″, being "set up" about an inch; the 40-pr. shot penetrated the $3\frac{1}{2}$″ plates and broke up.

The report on this experiment states:

"The quality of the steel used in these two shot (110 lbs.) is a marked improvement on those formerly produced by Mr Makin; but they do not come up to Mr Whitworth's shot in toughness or temper."

And as regards the 40-pr. shot which all penetrated the $3\frac{1}{2}$″ plates, the Committee observe:—

"A good 3″ plate has always stopped a 40-pr. cast-iron shot, with more or less damage to the plate, according to its quality; so that, allowing for the inferior quality of the plates used on this occasion, yet as they were $3\frac{1}{2}$″ thick, it demonstrates the advantage there is in having shot of great hardness and tenacity."

The next comparative trial which was made of cast-iron and steel shot was in March 1863, when a steel shot $99\frac{1}{2}$ lbs. in weight was tested in comparison with a cast-iron shot of 66 lbs. weight; they were both fired from a 7″ Armstrong B. L. rifled gun at a "Warrior" target, 16 lbs. charge being used with the cast-iron shot, and 14 lbs. with the heavier steel shot, the terminal velocities being 1461′ and 1178′ respectively. The following is an extract from the report on this experiment:

"A comparison of No. 560 and No. 562 shows the superiority of steel over cast-iron shot in consequence of the great amount of loss arising from the breaking up of the latter; for although the *work** in No. 560 (a cast-iron shot) was 2,199,773 foot lbs.,† the damage to the plate was only an indent of 2·45″; whereas, in the case of No. 562 (a steel shot) although a less amount of *work* was stored-up in the shot,

---

* The quantity of *work* carried by a shot is $\frac{WV^2}{2g}$,

where W=weight of shot in lbs.,

V=its velocity in feet per second,

g being the force of gravity=$32\frac{1}{6}$.

† A pressure of one pound exerted through a distance of one foot.

viz. only 2,149,882 foot lbs., a much larger amount of damage was caused to the plate, viz. a penetration of 4½″.........."

The quality of the material of this shot (No 562) is thus recorded:

"The steel shot used in the 8th round was of great toughness and strength; it suffered but little from the blow, and nearly the whole *work* was expended on the plate, as was evident from the great damage done."

This shot was only "set up" 1·2″ in a length of 11·7″.

In November, 1863, experiments were made to test projectiles of cast-iron, wrought-iron, and various descriptions of steel. For this purpose one 12-pr. Armstrong B. L. rifled gun, and one Whitworth 12-pr. B. L. rifled gun, was used and the shot were fired at 2½″ unbacked plates, at 200 yds. range; the general result obtained was as follows:—

Whitworth shot.—Six flat-headed homogeneous metal shot were fired; all penetrated the plate; five were broken, and the sixth was shortened 0·6″.

Armstrong shot.—Twelve steel shot manufactured at Elswick were fired, viz. six round-headed and six flat-headed; ten of this number were fired at a 2½″ plate, and all penetrated without breaking up, the average shortening was 0·39″ flat-ended and 0·14″ round-ended. Two of the round-ended shot were fired at a 3¾″ unbacked plate; only one struck, and made an indent of 2·75″; the shot rebounded 17 yds. and was shortened 0·86″. The report adds:

"The metal of this shot must be of excellent quality to have resisted the blow without breaking up."

Bessemer's.*—Two steel shot of this nature were fired. They were not sufficiently hard for penetration.

Cast-steel.—Three cast steel shot, made at the Tow Law Iron Works, penetrated, and were only shortened about 1″. The report states:

"They proved to be next best in quality to the Armstrong shot. Considering that these shot were unforged castings, and consequently can be produced at far less cost than when steel is cast and then forged, the Committee consider that further experiments should be made with metal of this description."

In this experiment a Whitworth B. L. rifled gun was used, which being longer than the Armstrong service B. L. rifled gun gave an excess of velocity to the Whitworth shot, viz:—

Whitworth...........		1274′.
Armstrong	F. H.	1116·7
	R. H.	1150.

Under these circumstances it was thought desirable to ascertain whether the breaking up of the Whitworth shot was due to this high velocity, as had already proved to be the case with cast-iron shot.†

For this purpose a Whitworth muzzle-loading rifled gun was used, from which a velocity on impact of 1120′ was obtained. The report states:—

"The trial of a 12-pr. Whitworth homogeneous metal shot at a 2½″ unbacked plate, at 200 yds. range, with a velocity on impact of 1120′ per second, resulted in

* A description of Bessemer's process of making steel will be found in Vol. I. of "Occasional Papers," p. 323, in a paper written by Col. Eardley-Wilmot, R.A.

† Vide page 199.

the shot passing through the plate and not breaking up. All the other Whitworth steel shot (supplied at the same time) had broken up when fired at $2\frac{1}{2}''$ plates at 200 yds. range, with a velocity of 1274 ft. per second....."

Fig. 5 will convey some idea of the nature of hole made by steel projectiles, and also show the difference of effect between the steel and cast-iron shot.

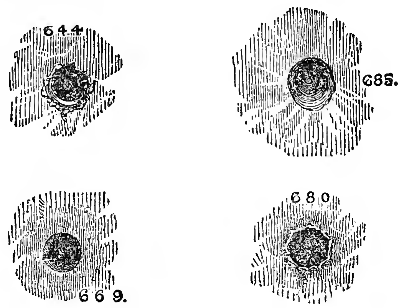


Fig. 5.

Nos. 644 and 685 were both 12-pr. Armstrong shot fired at a $2\frac{1}{2}''$ plate, with a charge of $1\frac{3}{4}$ lbs., but the former, which was steel, penetrated the plate, making a clean hole $3{\cdot}1'' \times 3,''$ whilst the latter, which was cast-iron, only made an indent of 1·2″. 669 was a flat-ended Armstrong 12-pr. shell, and 680 a Whitworth projectile of the same description, fired at a 2″ plate backed by 12″ of wood; 669 burst in the wood backing, and 680 passed through plate and backing whole, penetrated 5′ into an earth bank in rear, and did not burst.

In January and May 1864, experiments were made at Shoeburyness to test spherical steel solid shot, made of Bessemer's metal: they were fired from a 68-pr. S. B. gun, with service charges, at a "Warrior" target, at 200 yds. range. The result of the January experiment is thus recorded by the Committee:

"The shot were very tough, but were too soft for penetrating armour plates, for, although they did not break up on impact, they were considerably 'set up.' The superiority of steel over cast-iron for shot, to be used against armour plates, was very marked, for, whilst the penetration of the former was 4·8″, the latter, fired under precisely similar conditions, only made an indent of 1·75″."

This experiment also served to show that a 68-pr. smooth-bore gun, *even with steel shot,* is useless for attacking armour plated vessels at 200 yds. range, for the steel shot remained in the plate, thus serving as plugs to the holes they made.

The shot which were fired in May were of different degrees of temper, and the result of the experiment is thus recorded:—

"The plate fired at, which was of excellent quality, was tested at Shoeburyness on the 17th March 1863, and the indent made thereon by a cast-iron spherical shot fired from a 68-pr. S. B. gun at 200 yds. range, with a 16 lbs. charge, was 2″ deep, whereas with the Bessemer shot, fired under the same conditions, the smallest indent was 2·6″ deep, the greatest 3·8″ deep, and the mean indentation of six shot was 3·215″." The shot which made the deepest indent, viz. 3·8″ was very little distorted, the increase in diameter being only 0·24″.

Fig. 6.

Fig. 6, is from a photograph of one of the 68-pr. shot fired in January; it measured 8·25″ × 7·5″ after impact. A comparison of this sketch with Fig. 2 will show how much less distortion steel suffers than wrought-iron.

The result obtained from the Armstrong and Whitworth shot satisfied the Committee "That if expense is not considered, shot and shell capable of penetrating armour plates can be made of any required size." It was therefore needless to carry on further experiments with expensive shot, such as those used by Sir W. Armstrong and Mr Whitworth; but the Special Committee on Iron, after consulting with the Ordnance Select Committee, thought it very desirable that endeavours should be made to procure suitable shot of the cheaper kinds of steel, as they stated that they had "reason to believe that steel shot of the requisite quality will ere long be obtained at a reasonable cost."

It was in consequence of this recommendation that experiments were made in March, July, and August of the present year with 7″ steel shot.

These shot were fired from a 7″ B. L. rifled gun with 12 lbs. charges at 5½″ unbacked plates at 200 yds. range. The metal of which they were manufactured, with one exception (Krupp's), did not exceed £30 a ton, and was supplied by the undermentioned firms.

Messrs Attwood, Brown and Co., Bessemer, Butcher, Sanderson, the Bolton Co., the Ebbw Vale Co., the Mersey Co., Mr Deane, Mr Krupp.

The general result obtained from the experiments may be thus stated :—

Messrs Attwood's shot.—Three were fired; two remained in the plate, the rear side of the plate being broken out at the point of impact, and fracture extending over a space of 18″ × 17″; the nose of the shot visible; the third shot (this shot was conical-headed and the other two hemispherically headed) made an indent of 3·7″ and was shortened 1·5″.

Bessemer's shot.—Two were fired; one remained in the plate, the other made an indent of 2·5″, and was shortened 1·67″.

The Bolton Co.—Two of these shot were fired; indents 2·7″ and 2·1″; shot shortened 1·95″ and 2·04″.

Messrs Brown's shot.—Eleven were fired; five with 12 lbs. charges, three with 10 lbs. charges, one with 8 lbs., and two with 6 lbs.; four of those fired with the highest charge, passed whole through the plate, the mean "set up" being only 0·76″; with the 10 lbs. charge the greatest damage to the plate was an indent of 2·7″, two out of the three shot were broken up; with the 8 lbs. charge an indent 1·8″ deep was made, the shot rebounded 9′ from the plate, and was shortened 1″; an indent of 1·8″ was also made by the shot fired with the 6 lbs. charge, the shot rebounded 13′ and was shortened 0·6″.

Messrs Butcher.—Two of these shot were fired; indents 3·5″ and 3″; "set up" 1·2″ and 1·39″.

Ebbw Vale Co.—Three were fired, two with 12 lbs. charges, and one with 10 lbs; the greatest damage was an indent of 2·7″; the shot all broke up.

Mersey Co.—Two fired; indents 2·2″ and 2·1″; "set up" 2·″ and 1·73″.

Messrs Sanderson.—Two fired, one remained in plate, nose visible at rear side; 2nd indent 3·2″, "set up" 0·77″.

Krupp's shot were of three different qualities of metal; four of them were fired, but only one penetrated the plate, being "set up" 0·44"; one remained in; and one made an indent 3·3" deep and was "set up" 1·86".

Mr Deane's.—Four were fired; one remained in; two made indents 2·9", 4·8" respectively, and one, striking close to a previous round, 7·5"; "set up" (mean) 1·4".

The price of the metal supplied by the different firms varied considerably—from £60 in the case of Krupp's steel, to £15 in Mr Deane's. From the above statement it will be seen that, with the exception of one shot of Messrs Krupp's, Messrs Brown's were the only shot which penetrated the plate; but when it is remembered that the damage of a service 110-pr. cast-iron shot on a $5\frac{1}{2}$" plate is only an indent about one inch, whilst the smallest indent in this competitive trial was 2·1", it will at once be seen the enormous importance of obtaining proper material for the manufacture of shot to use against iron plated structures.

Solid steel shot of weights varying from 165 lbs. to 340 lbs. have been fired on several occasions at Shoeburyness; the general results obtained will be found in Table C., but I will here state the effect of such shot in a few instances.

Spherical Shot.

In the experiment on the "Lord Warden" target, a spherical steel solid shot weighing $168\frac{1}{4}$ lbs. was fired with a 50 lbs. charge, the shot having a terminal velocity of 1593'. It remained in the backing at a depth of 12" from the face of the target.

The report on the experiment alluding to this shot states,—

"The 10·5" rifled gun with a spherical steel shot weighing 168 lbs., and fired with a 50 lbs. charge, did less work on the target than the 9·22" rifled gun fired with an elongated steel shot of 221 lbs., and a charge of 44 lbs.......... "

The heaviest spherical steel shot which has yet been fired was in March of this year, when a shot weighing 344 lbs., was fired with a 90 lbs. charge from the 13·3" Armstrong M. L. rifled gun at a plate 11 inches thick, at a range of 200 yds. The plate was indented to a depth of 4·9" and broken in half; the shot was a good deal "set up" and cracked, and rebounded 14 ft. from the plate, it struck with a velocity of 1589' per second, and the *work* conveyed by it amounted to 13,501,132 foot lbs., being by far the greatest force which had ever been delivered against an iron plate at one blow.

Cylindrical shot.

A steel cylindrical shot weighing 301 lbs. was fired with a 45 lbs. charge at a $7\frac{1}{2}$" plate backed by 7" of timber and $2\frac{1}{2}$" of iron skin; it struck with a velocity of 1293' at 200 yds. range, and indented the plate to a depth of 6·2", the hole being 12·9" in diameter; the shot, which was originally 14" long, was set up 2". Figs. 7 and 8 show this shot before and after it was fired.

Fig. 7.

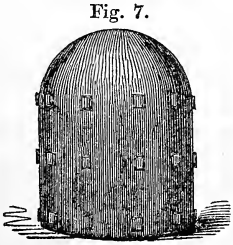
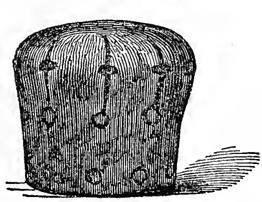


Fig. 8.



A shot of 330 lbs. weight which was fired with a 50 lbs. charge from Mr Lynall Thomas' 9″ gun at the same plate, made an indentation $7\frac{1}{2}$″ deep. The velocity was 1222′ and the shot broke in half.

A shot of 301 lbs. weight, fired with a 45 lbs. charge from a 10·5″ 12-ton gun, has penetrated both the "Chalmers" and "Lord Warden" targets; in one case being "set up" 1·9″, and in the other breaking into four pieces after striking a block of granite.

In the "Small Plate" target experiment a similar shot was fired with a reduced charge of 35 lbs. equivalent to a 45 lbs. charge at 1500 yds. range; it penetrated the target, and was only "set up" 0·83″—and it was also found that steel shot of 220 lbs. weight, fired from a 9·22″ Armstrong 12-ton rifled gun with a 44 lbs. charge, would penetrate this target at a range of 1500 yds.

Two steel shot of 603 lbs. weight have been fired at a $6\frac{1}{2}$″ plate on a "Warrior" target (as regards backing) at 200 yds. range.

The first shot which was fired with the full charge of 70 lbs., of course penetrated the target, making a hole 19″ × 16″ in the plate, and 4′ square in the skin; it was "set up" 2·2″. The second shot was fired with a reduced charge of 40 lbs., the striking velocity being equivalent to that produced by a charge of 70 lbs. at a range of 3300 yds.; it struck the top of the target, broke off a piece of plate weighing 1 cwt. 11 lbs., and drove it 27′ to the rear; the shot did not penetrate the skin; the "set up" was only 1″ in a length of $17\frac{1}{2}$″.

Form of Projectiles.

At the time of the appointment of the Special Committee on Iron, in January 1861, much difference of opinion existed as to the best form of shot for penetrating iron plates.

Sir W. Armstrong, in his evidence before the Committee, stated that he thought "a bolt of the smallest diameter" was best suited for the purpose; but he did not think that "there is much in the form of the head," and further, "that a given weight in the form of a cylinder will be more effective for penetration than in the form of a sphere."

Mr Lancaster on the other hand was satisfied that spherical shot produced the most effect; and Capt. Hewlett, R.N., thought that a flat-headed shot would act more like a punch, and that the penetration would therefore be greater than with a round-ended shot.

Mr Mallet was of a different opinion, he stated,—

"I do not think that any better effect is produced by flat-headed shot than even by spherical shot, provided the same amount of momentum could be imparted in the same time and upon an equal surface of plate by the latter;"

and further,—

"It appears to me that the best possible shot for penetration, will be a rifle shot, in order to get a sufficient velocity and range together,.........the front end of it should be an extremely obtuse curve."

Mr Fairbairn undertook some experiments, with a view of ascertaining the resistance of different kinds of shot to a force tending to crush them, and obtained the following results:—

Areas, ·6013 and ·541.

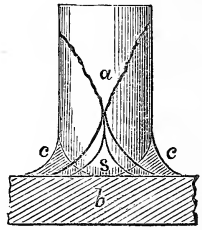
Number of Experiment.	Crushing weight in lbs.	Ultimate compression in inches.	Pressure per square inch in lbs.	Pressure per square inch in tons.	Remarks.
1	73,428	·120	122,115	54·51	
2	68,052	·092	125,787	56·13	Both ends flat.
Mean	...	...	123,951	55·32	
		Areas, ·5674 and ·7088.			
3	35,540	·22	62,636	27·96	
4	40,916	·24	57,725	25·77	One end rounded.
Mean	...	...	60,180	26·86	
		Areas, ·7088 and ·7088.			
5	38,260	·25	53,978	24·09	
6	37,580	·25	53,030	23·67	Both ends rounded.
Mean	37,920	·25	53,504	23·88	

Mr Fairbairn goes on to state,—

"In the foregoing experiments it will be observed, by reference to the two first Tables, that the resistance of cast-iron flat-ended shot to crushing is about 55 tons per square inch, whilst in the two following, we find that the round-ended specimens of the same material gave way, and were crushed with only 26½ tons, rather less than one-half the load required to crush the flat-ended ones. This may be accounted for as under:—

"Taking for example, the cylinder *a*, with a rounded end forcibly pressed against a steel plate *b*, it is crushed by (a fixed law observable in every description of crystalline substance) the part *s* forming itself into a cone, which, acting as a wedge, splits off the parts (*cc*) at the angle of least resistance, and these, sliding over its sides, are broken in pieces on the surface of the plate." (Fig. 9.)

Fig. 9.



These cones (*s*) have been obtained from cast-iron shot of all sizes, and in the collection of specimens in the model-room of the Ordnance Select Committee may be seen a cone of a 5½ oz. cast-iron bullet which has been fired from a wall-piece, and also a cone of precisely similar form of a 10″ spherical cast-iron shot which has been fired from a 12-ton gun.

Mr Fairbain found that the indentation made by a round-ended punch is nearly 3½ times as great as that made with a flat-ended punch, and deduced :—

"That the work done is twice as great in the case of the round-ended shot as compared with those of the flat-ended."

Numerous experiments have been made since 1861 in order to determine the form of head best suited for penetration.

Shot with flat heads, hemispherical heads, spike heads, stepped heads, &c., have been tried.

No advantage was found from stepping the head of the shot, either with one or two steps; with the former the step was broken off, and with the latter the first step was generally broken off, and the second was formed into a cone.

Mr Fairbairn made some experiments on statical pressure with stepped punches, and found that a plain flat-ended punch is more effective for perforating an iron plate than a $\frac{3}{4}''$ and a $1''$ punching surface, in the ratio of 1·6 to 1; and similarly, that a punch graduated from $\frac{3}{4}''$ to $1''$ and $1\frac{1}{2}''$ diameter is less effective for perforating a plate than a plain flat-ended punch, in the ratio of 1· to 1·16.

This agrees with the result obtained at Shoeburyness from the impact of stepped shot, as they were found to have less penetrative power than plain flat-ended shot; the flat-ended shot from a wall-piece penetrated a $\frac{3}{4}''$ plate at 25 yds. range, whilst the shot with one step only made a mean indent of 0·46″, and the shot with two steps an indent of 0·65″.

The following is an extract from the report on an experiment which was made in December 1862:—

"It seems to the Committee that the conical-ended shot did more injury to the plate, and suffered less, than any of the other forms submitted to them by Mr Makin. The cylinder with the front end slightly concave, was crushed out so much as to offer a much greater bearing surface on striking, and thus to hinder penetration on impact."

In an experiment made with experimental shot in March 1862, the report states:

"As regards the form of the shot, the remarkable effect of the shot in the 8th round, which had a conical end, as compared with those produced by flat-ends, leads the Committee to a preference of the former."

This shot, which weighed $99\frac{1}{2}$ lbs., and was fired from an Armstrong 7·″ B. L. rifled gun with 14 lbs. of powder, broke a hole through the armour plate of a "Warrior" target, and the record of the experiment states:—

"The shot 'set up' 1·2″, and the shoulder was broken off round the entire circumference, but it was otherwise uninjured."

Figs. 10 and 11 will give an idea of the greater distortion of the flat-ended shot, and Fig. 11 shows how slight was the alteration of form in

Fig. 10.

Fig. 11.

the case of the conical-ended shot. This experiment clearly indicated the proper form for penetration; the shoulder, which originally existed, and which only impeded penetration, was sheared off on impact, and the shot was thus reduced to a plain cylinder with a conical end.

In the experiment with 12-pr. experimental projectiles, which took place in November 1863, a comparison of flat-ended with round-ended shot was obtained. The mean "set up" of the shot was as follows, after they had performed an equal amount of work:—

	″
Round-ended	0·39.
Flat-ended	0·14.

And as the report says,—

"The round-ended thus showed the least alteration in form."

Fig. 12.

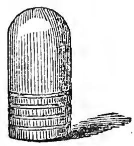
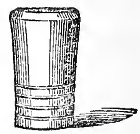


Fig. 13.



This will at once be apparent on looking at the accompanying drawings (Figs. 12 and 13), which are taken from photographs of 12-pr. solid shot which had penetrated a $2\frac{1}{2}''$ iron plate; Fig. 12 is hardly altered at all in form, whilst Fig. 13 is a good deal bulged out at the end.

An experiment was carried on to test the comparative effect of hollow-headed and solid shot. The shot were of steel and cast-iron, of a mean weight of 101 lbs., and were fired from a 7″ B. L. Armstrong rifled gun with a charge of 12 lbs., at a "Warrior" target at 200 yds. range.

The mean indentations were as follows :—

		″
Steel......	Solid shot.........	3·08
	Hollow-headed ...	2·12
Cast-iron	Solid shot.........	0·9
	Hollow-headed ...	0·6

Thus showing a great advantage in the solid shot.

A suggestion was made by Mr Mackay that a trial should be made of cylindrical shot fired from a smooth-bore gun, and for this purpose he forwarded to Shoeburyness some steel and cast-iron 8″ shot, 10·25″ long, and three of the latter description, of a mean weight of 117 lbs., were fired from a 68-pr. S. B. gun with a 10 lbs. charge at a "Warrior" target at 200 yards range. The shot were very high gauge, the windage being only 0·04″, and the velocity at 530′ was 1102 ft. per second. The armour plates were deeply indented and a good deal cracked by the blow, and the shot broke up.

The report states that the shot

"Did very considerable damage to the target, considering the low charge of powder used; they all struck the target with their points, and did not turn over" ... but that they "are not suited for general use........"

None of the steel shot were fired, as Mr Mackay objected to the charge being reduced in proportion to the increased weight of the shot, suggesting that on the contrary it ought to be increased, and as this suggestion was not feasible the experiment ended.

The general results obtained from the experiments made by the Committee led them to report—

"That conical-ended shot are superior in accuracy and range over flat-ended projectiles and, that except, perhaps, for oblique firing they are also superior for penetration."

The comparative value of rifled and spherical projectiles against iron plates is thus alluded to in a report on an experiment which took place at Portsmouth in August, 1860.

"The rifled projectile, striking a plate with the same momentum as a spherical one, will penetrate deeper than the latter, for although the force of the blow given by each projectile will be the same, there will be a greater amount of resistance due to the greater diameter of the spherical projectile, consequently its penetration is less than the elongated projectile, but the force of the blow is more spread and the smashing effect is greater."

The Special Committee on Iron in their final Report state that they

"Are satisfied that elongated shot (steel) have great advantages over those of a spherical form of the same weight, as admitting of being more uniformly tempered throughout."

SHELL.

In September 1859, cast-iron shell (thickened considerably at the head for penetration) filled with sand, were fired with a 10 lbs. charge from Sir W. Armstrong's 80-pr. rifled gun at iron plates attached to the scantling of a 50 gun frigate; they weighed 78 lbs., and at 400 yds. range passed readily through $1\frac{1}{2}''$ and $2''$ plates and the scantling; they were then fired at $3''$ plates, and out of four shells which were fired the Report says—

"Two were resisted (although they damaged considerably the plate and timber in rear) and two passed through the plate, but not through the scantling, fragments of the plate being driven into the timber to depths respectively of 12″ and 14″."

A service shell filled with sand, which was fired from a 68-pr. S. B. gun with 16 lbs. charge at a $2\frac{1}{2}''$ plate, indented it $1\frac{3}{4}''$, "but no portion of the plate was driven into the timber."

The Report further states,—

"In no instance, not even in the case of the $1\frac{1}{2}''$ plates, did the shell pass through the plate entire, but in a broken form, and the contents of the shell were projected (in cases where the plate was pierced) into the hole made by the exterior portion of the shell." "In the cases where the shell passed through the plate and timber, the destructive effect was very great, far exceeding what would have resulted had the plate been absent; innumerable pieces of plate and shells of all dimensions up to 10 and 15 lbs. weight, strewing the ground in rear of the target in all directions, the lateral spread being very great."

In all the subsequent experiments which were made at Shoeburyness it was found that cast-iron shell, whether filled with sand or live, were ineffective against iron plated structures, invariably breaking up, and merely causing a slight indentation or cracks to the plate struck.

In the case of the "Warrior" target for instance, the record of the experiment shows the following results, as obtained from shell fired from the 110-pr. B. L. rifled gun, and the 68-pr. S. B. gun, at 200 yds. range.

110-pr. 12 lbs. charge, shell filled with sand, weight 104 lbs. 1st round "made very slight indent." 2nd and 3rd rounds *struck close together* "made a small crack 5″ long." Three rounds of live shell were fired from this gun, the record states in each case "did no damage."

Shell filled with sand, weighing $49\frac{1}{2}$ lbs., and fired from a 68-pr. S. B. gun with 16 lbs. charges, only made an indent of 1·5″, and the live shell of the same weight indented the plate 1·8″, and cracked it in several places. The shells themselves were always broken up.

In consequence of these results no cast-iron shells have been used in any of the late iron plate experiments at Shoeburyness.

Against brickwork faced with iron the following results were obtained in May 1861:—

"The 110-pr. shell filled with sand penetrated all the plates except the $3\frac{1}{2}$." The first shell that struck this plate did apparently no damage at all; it broke up making a small indent on the plate; another, however, on striking near the same place, broke half the plate away and exposed the masonry."

"The live shell did very little damage when they struck the iron plate, not nearly as much as the blind shell, owing probably to its bursting before the whole of its force was expended on the plate; but when the shell struck where the masonry was exposed they caused great damage, and soon brought the wall and surrounding masonry to such a state that a few more shell would entirely have destroyed it."

Pettman's naval fuze was used with the 8″ shell, and the pillar fuze with the Armstrong shell.

Until the 16th September 1862, it was generally believed that iron plated ships of war were safe from the penetration of shells, and to Mr Whitworth undoubtedly belongs the credit of exposing the fallacy of this belief.

M. Xavier Raymond,—by no means a prejudiced witness in favour of English inventions,—in his book "Les Marines de la France et de l'Angleterre," in speaking of Mr Whitworth, says:—

"Nous n'avons rien à lui envier, rien que la priorité qui, par l'indolence, nous lui avons laissé prendre pour le tir des projectiles creux contre les plaques des cuirasses.........nous aurions mauvaise grâce à ne pas convenir, que nous devons regretter d'avoir laissé prendre à d'autres une priorité quelconque, même sur un détail si petit qu'il soit......... "

And further on in alluding to improvements which have been made in artillery by French officers, M. Raymond says:—

"Ce n'est pas sans un certain dépit, je le confesse, que j'ai vu M. Whitworth les devancer pour le tir des boulets creux contre les cuirasses......... "

So here we have satisfactory evidence that in this all important matter of steel shells, an Englishman has led the way; and although M. Xavier Raymond considers it merely,—

"Un détail si petit qui'il soit;"

this is not the opinion in this country, for the Special Committee on Iron in their last Report state,—

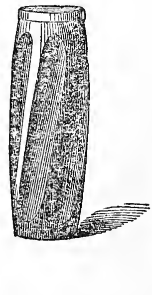
"It must, however, be borne in mind that by far the most damaging projectiles for use against armour-plated vessels are steel shells......... "

One peculiarity of these shells is that no fuze is used with them; the reason for the explosion of the bursting charge is thus given by Lieut. Noble, R.A., in his Report on Ballistic Experiments:—

"Upon the explosion of the charge in firing, the bursting charge is 'set up' in the interior of the shell, and becomes a hard compact cake; its volume is reduced by about one-third, and consequently there is an empty space left in the inside of the shell. Upon impact, this compressed powder is driven with enormous force, into this empty space, and receives a violent blow or shock against the iron; sufficient heat is developed by this blow and the friction against the inside to explode the charge."

An unexploded steel 300-pr. shell which was fired at Shoeburyness in December 1863, was found to contain 11 lbs. of powder (out of 15 lbs.) in a very compressed and hard condition, and which only occupied a depth of 8½ inches.

Fig. 14.



Mr Whitworth's steel shell and Sir W. Armstrong's differ considerably. The former are solid at the head, and open at the rear to receive the bursting charge, which is contained in a flannel bag, and the rear of the shell is closed by a steel cup which screws into the end of the shell. Fig. 14 shows a 12-pr. shell with the cup screwed in.

The Armstrong shell is open in front, and the bursting charge is "stemmed" in the shells by using a wooden setter and maul, a hollow cast-iron head being then screwed into the front of the shell. Fig. 15 shows an Armstrong 300-pr. steel shell with the cast-iron head unscrewed; these shells average about 303 lbs. in weight, and contain a bursting charge of 15 lbs. in the shell, and 3 lbs. in the cast-iron head. Fig. 16 is a sketch of the same shell after it had burst.

Fig. 15.

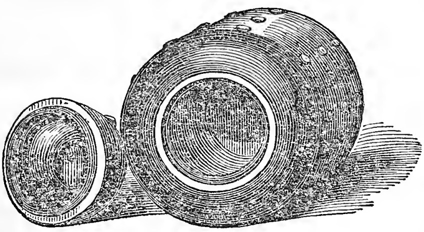
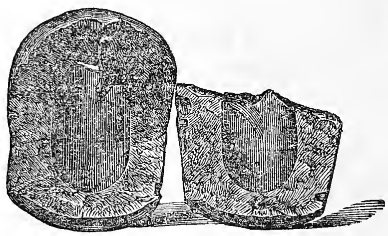


Fig. 16.



I think the Armstrong shell is superior to the Whitworth for this reason: when an Armstrong steel shell strikes an iron plated structure, the cast-iron head breaks up, and the whole force of the explosion takes effect in the ship's side; and even when, as is sometimes the case, the shell does not burst, the damage to the timber backing &c. is very great, owing to the explosion of the bursting charge.

With a Whitworth shell, however, owing to the front part being solid and the opening for the burster at the rear, if, as I have seen happen, the steel screw at the breech of the shell is blown out, before penetration is effected, the damage to the target is comparatively very slight.

The early experiments with steel shell, viz. those fired from Mr Whitworth's 12-pr., 70-pr., and 130-pr. guns have already been described in Captain Inglis's paper,* and it will therefore be sufficient here to state that, at 200 yds. range, a $2\frac{1}{2}''$ plate backed by $12''$ of wood, can be penetrated by a live steel 12-pr. shell fired with a charge of $1\frac{3}{4}$ lbs.; and a $4''$ plate backed by $9''$ of wood can be penetrated by a 70-pr. projectile of this nature, fired with a 12 lbs. charge. At 600 yds. range a steel shell from the 70-pr. fired with a 13 lbs. charge, penetrated $4\frac{1}{2}''$ of iron and $18''$ of wood, and shells of 150 lbs. weight, fired from the 130-pr. with a charge of 27 lbs., penetrated a "Warrior" target at 800 yds. range. The bursting charge of the 150 lbs. shells was 5 lbs.; they did not break into many splinters, and the report says,—

"That the splinters did not appear to have much force or lateral action, for that in one instance only was a piece driven with sufficient force to stick into a beam of timber."

And further that:—

"Shells such as those used on this occasion would have, comparatively, little damaging effect on the guns or crew of an armour plated ship, and the holes made in the armour plates could be easily plugged up."

Since the date of these experiments a very different result has been obtained from the large steel shells, fired from Sir W. Armstrong's $10{\cdot}5''$ and $13{\cdot}3''$ rifled guns, the damaging power of which, to iron plated structures, is exceedingly great.

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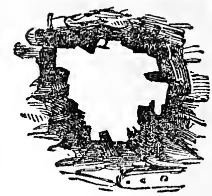
* Vide p. 37.

Fig. 17.



A steel shell weighing 612 lbs. fired from the 13″·3 R. gun with a 70 lbs. charge, and containing a bursting charge of 24 lbs., made a hole 30″ × 24″ in a "Warrior" target at 1000 yds. range; sixteen armour plate bolts were broken, and the shell burst into 12 pieces. Fig. 17 shows the nature of this hole in the skin of the target, and it will be seen how difficult it would be to repair the damage of one shell of this nature, more especially if the ship was struck at the water line.

The Report on this experiment speaks of the damage caused by this shell as—

"Greater than that of any other projectile which had been fired at Shoeburyness."

On the 15th of last August an experiment was made at Shoeburyness,* the result of which showed that a structure such as the "Warrior," could be pierced by one of these shells at 2000 yds. range. The hole made in the target was 16″ × 13½″ in front, and 4 ft. × 2′3″ in rear, and one armour plate was blown off the target; the destruction to the fastenings was, as in the previous case, very great; seventeen armour plate bolts, twenty-one rivets, and thirteen backing bolts having been broken. This shell only broke into four pieces.

In the experiment on the "Small Plate" target, it was found that a steel shell of 206 lbs. weight, containing a bursting charge of 11 lbs., and fired from a 9″·2 R. gun with a charge of 44 lbs., could penetrate a structure of this nature with ease at 200 yds. range, doing very great damage. The result is thus recorded,—

"Shell burst well in target, ignited timber; large hole in rear, daylight through; very numerous and large splinters blown out."

The great disadvantage of these shells is, that they break into such few pieces, and in some cases even do not break up at all, owing to the great toughness and tenacity which is given to them, to enable them to penetrate the iron plates; and consequently their action as shells cannot be compared to cast-iron. But it is quite possible that gun-cotton may become the means of remedying this great defect, by its employment in lieu of gunpowder for the bursting charge.

I have already alluded to the serious damage caused to the fastenings of iron clad structures by steel shell, and the report made on the experiments with Mr Whitworth's shells in November 1862, calls especial attention to this point as follows:—

"The opinion which we have already expressed regarding the objections to the present mode of fastening armour plates, received confirmation by the number of bolts broken after a very few rounds of firing; the injury in the present instance is the more remarkable considering the nature of the damage inflicted by the Whitworth projectiles, viz. the punching of a clean hole in the plate."

In a recent experiment at Shoeburyness, two Armstrong 70-pr. steel shell fired with charges of 14 lbs., broke *eighteen* bolts in a "Warrior" target; one round was fired at 50 yds. range, and the second at 200 yds.

Captain Hewlett, R.N., late in command of the "Excellent," and who, up to 1861, had had a larger experience of the results of practice against iron

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* Vide p. 176.

armour than any officer in the country, told the Special Committee on Iron, on the 1st February 1861, that no hollow projectile discharged from any of the ordnance then under trial, would penetrate a good rolled 4½″ iron plate at 200 yds. range; and when asked if he thought "at closer quarters than that, a hollow projectile could be made to penetrate a rolled iron plate," he answered, "not if 4″ or 4½″ thick."

It will, therefore, at once be seen what enormous strides have been made in the power of attack since that date; more especially when we remember that the quality of the armour plates now manufactured is immeasurably superior to what it was in 1861, whereby the power of resistance of a given weight of iron has been by so much increased.

The details I have given of the steel shell experiments show that a "Warrior" (one of the best arrangements of material for resistance to shot which has yet been tested) can be penetrated *with ease* at 2000 yds., and that an ordinary wooden frigate, protected with even 5¾″ of iron, can also be penetrated with ease at 200 yds.

There is, however, one thing which is essential to enable these results to be obtained, and unfortunately this one thing we are still in want of, viz. heavy *rifled* guns. Sir W. Armstrong in his evidence before the House of Commons' Committee on Ordnance in 1863, in replying to question 3167 stated,—

"I do not see how you can produce with steel round shot an effect comparable to the effect which can be obtained with cylindrical rifled shot. With respect to employing steel spherical shell, capable of penetrating iron plates, I consider it out of the question. It is only by means of the elongated form of the projectile that we can construct a steel shell capable of piercing an iron plate, and it is due to the principle of rifling that the elongated form can be adopted."

The Special Committee on Iron, after an experience of four years, have recorded their opinion,—

"That by far the most damaging projectiles for use against armour plated vessels are steel shells."

And from Sir W. Armstrong's evidence it appears that these shells must be of an elongated form, and therefore, until we possess a supply of rifled guns, we cannot make use of this "most damaging projectile."

I will only add that in speaking of *heavy* rifled guns, I do not refer to 600-prs. For all ordinary purposes, experiments tend to show that a gun of about 12 tons, capable of firing a shot of about 200 lbs. weight, with a charge of 45 lbs., is quite powerful enough to give a good account of any iron clad vessel which is ever likely to be brought against us.

A good supply of such guns for our coasts and ships, with a large provision of chilled cast-iron shot and steel shells, is what we now urgently require, and when we remember the large number of guns requisite for these purposes, and that we have at the present moment very few rifled guns larger than the 7″ Armstrong breech-loader, which is useless against iron-clads, it must be evident that the manufacture of heavy guns, which has now been taken in hand, is no small undertaking.

Nat		Velocity at impact.	Remarks.
Rifled Guns:			
Wall piece		1141	
6-pr. B. L. W. I.	}	...	Cake copper.[a]
12-pr. 〃	}	...	〃
25-pr. 〃			
40-pr. 〃			
7″ B. L. W. I. ..	}	...	Target 4½″ iron, 18″ of wood, ⅝th iron skin.
〃 ..		...	Shot broke up.
〃 ..		...	Shot broke up.
〃 ..		...	〃
9·22″ M. L. W. I		...	Shot broke up after penetration.
10·5″ M. L. W. I		1096	Target 6″ plate on a compound backing of wood and iron 10″ deep, and an iron skin 1½″ thick, in two ¾″ plates.
〃		1228	It is stated in the record of this experiment that "if the shield was exposed to continued firing from such a gun, it must soon be destroyed." Thickness of iron in shield 15″, in three thicknesses of 5″.
〃		...	Target 5¼″ iron and 27″ of wood.
Smooth-bore	t.		
68-pr. C. I. 95 cw	e spot.	...	The thickness of timber in the side of ship is about 24″. c Plates of A1 quality.
〃	ough.		
〃			
〃		1100	Mr Mackay's shot.
9·22″ W. I......			Shot broke up. Target 8⅛″ of iron, viz. 4⅜″ outer plate, three one inch plates, and ¾″ skin. Armour plates of bad quality.
〃		...	
〃		...	〃
〃	o a depth }	1448	Target 6″ of iron, in two plates (4½″ × 1½″) and 29″ of wood.
10·5″ W. I......	f 12″; hole }	...	Two shot of this nature and weight, fired with 40 *lbs.* charges, which struck close together, penetrated the target.
〃	of iron and plate 13″ }	...	Target, 5½″ plate, 9″ wood and ⅝ths skin.
〃	layer, and }		
〃			
〃	le in plate }	...	Target 5″ of iron, in two plates (3¾″ × 1¼″) a compound backing of wood and iron 10¾″, 6″ of timber and iron skin ⅝″.
〃			
13″ W. I. Hors	28″ × 25″, } ″; hole in }	Initial 1630 On impact 1299	Shot made in Royal Laboratory of an improved quality of metal.
〃			
13″ Sea Service		...	
One 120-pr. M. Three 7″ B. L. One 68-pr. S. B	e a hole }	...	Fired in salvo.

TABLE A.

SHOWING THE EFFECT OF CAST-IRON SHOT OF VARIOUS NATURES, ON IRON PLATES AND TARGETS.

Nature of gun.	Nature and weight of projectile.		Charge.	Range in yards.	Plate or target.	Result.	Velocity at impact.	Remarks.
	Nature.	Weight.						
RIFLED GUNS:—		oz.	drms.					
Wall piece	Cylindrical R.E. and F.E.	5½	10	25	Two ¼″ plates rivcted together.	Through.	1141	
	"	"	"	"	½″ plate.	M. I. 0·15″.		
6-pr. B. L. W. I.	Cylindrical, R. E. service.	lbs. 6	oz. 12	100 50 "	1″ plate. 1″·5 " 2″.[a] "	Through. I. 1·05″. Through.	...	Cake copper.[a]
12-pr. "	"	11½	lbs. 1½	100	1″·5 " 2″. " 3″.[a] "	Through. I. 1·24″. Through.	...	"
25-pr. "	"	24¾	3⅛	"	2″. " 2½″. "	Through. I. 1·69″.		
40-pr. "	"	40	5	"	3″. "	I. 1·47″.		
7″ B. L. W. I.	"	110	14	200	4½″ " "Warrior" target.	I. 2·68″. 1·6″.	...	Target 4½″ iron, 18″ of wood, ⅝th iron skin.
"	Major Palliser's chilled iron.	138	12	"	"	I. 4·2″.	...	Shot broke up.
"	Dr Price's pig iron.	110	12	"	5½″ plate.	I. 1·75″.	...	Shot broke up.
"	Royal Laboratory.	"	"	"	"	I. 2·4″.	...	"
9·22″ M. L. W. I.	Major Palliser's chilled iron.	259	30*	"	"Small plate" target.	Through.	...	Shot broke up after penetration.
10·5″ M. L. W. I.	Cylindrical R. E. service.	308	35	"	"Bellerophon" target.	I. 3·7″.	1096	Target 6″ plate on a compound backing of wood and iron 10″ deep, and an iron skin 1½″ thick, in two ¾″ plates.
"	"	"	45	"	"Capt. Inglis'" shield.	I. 2·″.	1228	It is stated in the record of this experiment that "if the shield was exposed to continued firing from such a gun, it must soon be destroyed." Thickness of iron in shield 15″, in three thicknesses of 5″.
"	"	296	35	"	"Small plate" target.	Hole 11″ deep.	...	Target 5¼″ iron and 27″ of wood.
SMOOTH-BORE GUNS:—								
68-pr. C. I. 95 cwt	Spherical	66¼	16	"	5½″ plate on side of wooden frigate.[c]	M. I. 1·8″. Single shot. 3·1″ Two shot / 5·25″ Three shot — On same spot.	...	The thickness of timber in the side of ship is about 24″. [c] Plates of A1 quality.
"	"	"	"	"	4½″ plate on side of wooden frigate.[c]	M. I. 2·25″. Two shot on same spot through.		
"	"	"	"	"	"Warrior" section.	M. I. 2″.		
"	Cylindrical R. E.	117	10	"	"	M. I. 3·9″.	1100	Mr Mackay's shot.
9·22″ W. I.	Spherical	100	25	"	5½″ plate on frigato.	I. 2·8″.		Shot broke up.
"	Dr Price's pig iron.	103	25	"	"Scott Russell's" target.†	I. 4″. D. 9·5″.	...	Target 8⅛″ of iron, viz. 4⅜″ outer plate, three one inch plates, and ¾″ skin. Armour plates of bad quality.
"	Royal Laboratory.	"	"	"	"	I. 3·85″. D. 10·″.	...	"
"	Major Palliser's chilled iron.	105	"	"	"Lord Warden" target.	Penetrated armour plate, and to a depth of 10″ into target.	1448	Target 6″ of iron, in two plates (4½″ × 1½″) and 29″ of wood.
10·5″ W. I.	Spherical	150	50	"	"Warrior" section.	Penetrated backing to a depth of 12″; hole in plate 11″ diameter.	...	Two shot of this nature and weight, fired with 40 *lbs.* charges, which struck close together, penetrated the target.
"	"	"	"	"	"Minotaur" target.	Hole through target, splinters of iron and wood driven through; hole in plate 13″ diameter.	...	Target, 5½″ plate, 9″ wood and ⅝ths skin.
"	"	"	"	"	"Capt. Inglis'" shield.	Broke plank in half in front layer, and cracked the inner layer.		
"	"	"	"	"	"Scott Russell's" target.	Through.		
"	"	"	"	"	"Chalmers'" target.	Penetrated to a depth of 11″, holo in plate 13″ × 12″.	...	Target 5″ of iron, in two plates (3¾″ × 1¼″) a compound backing of wood and iron 10¾″, 6″ of timber and iron skin ⅝″.
"	"	"	35	"	"	M. I. 4·5″		
13″ W. I. Horsfall gun	"	279½	74¼	"	"Scott Russell's" target.	Penetrated target; hole in plate 28″ × 25″, in skin 3 ft. square.	Initial 1630	
" "	"	284	"	800	"Warrior" section.	Penetrated to a depth of 12″; hole in plate 2′ × 1′ 11″.	On impact 1299	Shot made in Royal Laboratory of an improved quality of metal.
13″ Sea Service Mortar 2° elevation	"	278	20	200	"	M. I. 3·7″.	...	
One 120-pr. M. L. W. I. R. .... Three 7″ B. L. W. I. R. .... One 68-pr. S. B. C. I.	Service shot.	140 110 66¼	20 14 16	"	"Warrior" target.	Striking close together, broke a hole 18″ × 9″ in the plate.	...	Fired in salvo.

TABLE C.

SHOWING THE EFFECT OF STEEL PROJECTILES OF VARIOUS NATURES, ON IRON PLATES AND TARGETS.

Nature of gun.	Nature and weight of projectile. Nature.	Weight.	Charge.	Range in yards.	Plate or target.	Result.	Velocity at impact.	Remarks.
RIFLED GUNS (Solid shot):—								
Wall piece	Cylindrical F. E.	oz. 5½	drms. 10	25	¾″ plate. 1″ plate.	Through. M. I. 0·28.	1141	
12-pr. Armstrong B. L.	R.E. and F.E.	lbs. 12	lbs. 1¾	200	2½″ plate.	Through.	R.E. 1150 F.E. 1116	
12-pr. Whithworth B. L.	F. E.	″	″	″	″	″	1274	This gun is longer than the Armstrong 12-pr. B. L. gun.
40-pr. B. L. W. I.	Cylindrical, various forms of head.	39½	5	100	3½″ plate.	″	1271	A shot of this nature has penetrated a 2½″ plate at an angle of 45°, or a thickness of 3″ of iron, without breaking up.
70-pr. Armstrong M. L. W. I.	Cylindrical R.E.	70	14	200	"Warrior" section.	Penetrated plate, and about 17″ of wood.		
70-pr. Whitworth M. L. W. I.	Cylindrical F. E.	71	12	″	″	Penetrated plate and about 3″ of wood.		
7″ B. L. W. I. 81 cwt.	Cylindrical R. E.	110	12	″	5½″ plate.	Through.	at 120′ 1113 at impact.	
″	″	″	″	″	"Small plate" target.*	M. I. 2·9″.		
9·22″ M. L. W. I. 6½ ton	Spherical	114¼	25	″	"Lord Warden" target.†	Penetrated 4½″ plate and remained in timber; depth to shot 5″.	1444	
″ 12 ton	Cylindrical R. E.	221	44	1500	″	Through.	1292	Insido of target much damaged over space of 3′ 9″ × 2′ 3″, and splinters of wood and iron driven through to 20 yds.
″ ″	″	″	″	″	"Small plate" target.	″	...	Hole in plate 11·5″ × 11″.
130-pr. Whitworth M. L. W. I. 7½ ton	Cylindrical F. E.	149	25	200	"Capt. Inglis'" shield.‡	Shot broke up; portion remained in indent; no damage at back of shield.	1239	
″	″	130	27	800	"Warrior" section.	Through target; hole in plate 8″ × 8·3″.	1204	
10·5″ M. L. W. I. 12 ton	Spherical	166	50	200	"Clark's" target.§	″	1593	
″	″	″	″	″	"Lord Warden" target.	Penetrated outer plate, depth to shot 12″.		Target where struck weakened by previous firing.
″	″	″	″	1000	"Small plate" target.	Through.	...	
″	″	″	35	200	"Bellerophon" target.‖	Penetrated into timber to a depth of 7″.	1492	
″	Cylindrical R. E.	301	45	″	"Chalmers" target.¶	Through. Hole at back 2′ × 1′ 6″.	1254	
″	″	″	″	″	"Lord Warden" target.	Through; inner lining, fractured over 8′ × 4′.		
″	″	″	″	1500	"Small plate" target.	Through.		
13·3″ M. L. W. I. 22½ ton	Spherical	344	90	200	11″ plate.	I. 4·9.	1589	In addition to the indent the plate was broken in half.
″	Cylindrical R. E.	603	70	3300	6½″ plate on "Warrior" backing.	Penetrated armour plate and remained in backing, skin cracked.		
SMOOTH-BORE GUNS (Solid shot):—								
68-pr. C. I. 95 cwt.	Spherical	74	16	200	"Warrior."	Penetrated plate, shot remained in hole; depth in timber about 4½″.		
″	″	″	″	″	5½″ plate on "Warrior" backing.	M. I. 3·2″.		
″	″	71	″	″	"Lord Warden" target.	I. 3·6″.		
″	″	″	″	″	"Small plate" target.	I. 4·8″.		
9·22″ W. I. 6½ ton	″	114	30	″	6″ plate on wooden frigate.	Penetrated plate, and lodged in ship's side.		
″	″	″	25	″	″	M. I. 6″.		
″	″	″	″	″	5½″ plate on wooden frigate.	Through plate, exterior portion of shot 2·7″ from surface of plate.		
SHELL:—								
12-pr. {Armstrong / Whitworth} B. L. W. I.	{R. E. / F. E.}	12	1¾ burster 6 oz.	″	2″ plate, backed by 12″ wood.	Through.	...	Burst after penetrating plate.
70-pr. Armstrong M. L. W. I.	Cylindrical, with cast-iron head.	68½	14 burster 3½ lbs.	″	″	Penetrated the plate and to a depth of 6¼″ from the face of the target.	...	Damage to fastenings of target very great.
70-pr. Whitworth M. L. W. I.	Cylindrical F. E.	70½	12 burster 2 lbs. 8 oz.	″	″	Penetrated plate and to a depth of 7½″ from face of the target.		
130-pr. Whitworth M. L. W. I.	″	130	25 burster 3 lbs. 8 oz.	600	"Warrior" section.	Through target; clean hole in plate 8·5″ × 7·5″; in skin 13″.	1268	Shell burst into 14 pieces; pieces of shell, plate, and timber inside target.
″ ″	″	151	27 burster 5 lbs.	800	″	Through target; hole in plate 7·5″, and in skin 10″.	1175	Shell burst into about 20 pieces, and many fragments of iron &c. inside target.
″ ″	″	149½	27 burster 5 lbs. 8 oz.	200	"Bellerophon" target.	Through plate and penetrated backing to a depth of 6″.	1283	
9·22″ M. L. W. I. R. 6½ ton	Cylindrical with cast-iron head.	174½	20 burster 7½ lbs.	″	"Lord Warden" target.	Penetrated to a depth of 6·5″, and made a hole 12½″ diameter in the armour plate.	1120	Shell broke into 2 pieces. A shell of this nature which struck near a hole made by a previous shot, penetrated without bursting, although the burster ignited and did considerable damage to the backing.
″ 12 ton	″	206	44 burster 11 lbs.	″	"Small plate" target.	Penetrated, hole 12″ × 10″ in plate; great damage to backing; timber ignited.	...	
10·5″ M. L. W. I. R.	″	301	35 burster 13 lbs.	″	"Clark's" target.	Hole in skin 30″ × 27″, and 13″ × 12″ in plate, damage very great.	...	Shell broke into two pieces, and did not penetrate.
13·3″ M. L. W. I. R.	″	610	70 burster 24 lbs.	970	"Warrior" section.	Hole in plate 24″ × 21″, and in the skin 30″ × 24″.	1143	The shell burst into 12 pieces; the target very much shattered.
″	″	„	″	2000	″	Hole in plate, 16″ × 13½″, and at back 4′ × 2′ 3″.	940	One plate of the target blown off; great damage to fastenings; a large number of splinters of iron and wood blown through; shell burst into 4 pieces.

... In considering the results of different projectiles on this structure, it must therefore be

Result.	Velocity at impact.	Remarks.
Through. M. I. 0·28.	1141	
Through.	R.E. 1150 F.E. 1116	This gun is longer than the Armstrong 12-pr. B. L. gun. A shot of this nature has penetrated a 2½″ plate at an angle of 45°, or a thickness of 3″ of iron, without breaking up.
"	1274	
"	1271	
l plate, and about 17″ of wood.		
l plate and about 3″ of wood.		
Through.	at 120′ 1113 at impact.	
M. I. 2·9″.		
l 4½″ plate and remained in epth to shot 5″.	1444	
Through.	1292	Inside of target much damaged over space of 3′ 9″ × 2′ 3″, and splinters of wood and iron driven through to 20 yds.
"	...	Hole in plate 11·5″ × 11″.
ɜ up; portion remained in in- lamage at back of shield.	1239	
ırget; hole in plate 8″ × 8·3″.	1204	
"	1593	
l outer plate, depth to shot 12″.		Target where struck weakened by previous firing.
Through.	...	
l into timber to a depth of 7″.	1492	
Hole at back 2′ × 1′ 6″.	1254	
inner lining, fractured over		
Through. I. 4·9.	1589	In addition to the indent the plate was broken in half.
l armour plate and remained in kin cracked.		
l plate, shot remained in hole; mber about 4½″.		
M. I. 3·2″.		
I. 3·6″.		
I. 4·8″.		
l plate, and lodged in ship's side.		
M. I. 6″.		
ɔlate, exterior portion of shot surface of plate.		
Through.	...	Burst after penetrating plate.
l the plate and to a depth of 6¼″ ace of the target.	...	Damage to fastenings of target very great.
l plate and to a depth of 7½″ ɔf the target.		
target; clean hole in plate ; in skin 13″.	1268	Shell burst into 14 pieces; pieces of shell, plate, and timber inside target.
arget; hole in plate 7·5″, and ′.	1175	Shell burst into about 20 pieces, and many fragments of iron &c. inside target.
late and penetrated backing to 6″.	1283	
l to a depth of 6·5″, and made a diameter in the armour plate.	1120	
, hole 12″ × 10″ in plate; great backing; timber ignited.	...	Shell broke into 2 pieces. A shell of this nature which struck near a hole made by a previous shot, penetrated without bursting, although the burster ignited and did considerable damage to the backing.
kin 30″ × 27″, and 13″ × 12″ in age very great.	...	Shell broke into two pieces, and did not penetrate.
late 24″ × 21″, and in the skin	1143	The shell burst into 12 pieces; the target very much shattered.
ılate, 16″ × 13½″, and at back	940	One plate of the target blown off; great damage to fastenings; a large number of splinters of iron and wood blown through; shell burst into 4 pieces.

... results of different projectiles on this structure, it must therefore be

TABLE B.

SHOWING EFFECT PRODUCED, BY WROUGHT-IRON SHOT, ON IRON PLATES AND TARGETS.

Nature of gun.	Nature and weight of projectiles.		Charge.	Range.	Plate or target.	Result.	Velocity at impact.	Remarks.
	Nature.	Weight.						
		lbs.	lbs.	yds.				
SOLID SHOT:— 68-pr. S. B. C. I. 95 cwt.	Spherical	71	16	200	"Warrior." section.	I. 3·1″.	1397	
″ ……	″	″	″	″	4″ plate on wooden frigate. 5½″ plate on ditto.	I. 2·7″. I. 2″.		
″ ……	″	″	″	″	"Minotaur" target.	I. 2·4″		
10″·5 W. I. S. B. ………	″	162	50	″	″	…	…	The target tremendously shaken by this shot; armour plate very much buckled. The breach of the gun was blown out at this round, or no doubt the damage to the target would have been greater.
″ ………	″	″	″	″	"Scott Russell's" target.	Hole in armour plate 12¾″ and large hole in skin; large number of splinters of iron driven through target.	…	The shot after impact rebounded 5 yds. and measured 12·969″ × 8·2″.
″ ………	″	″	45	″	7½″ plate on 7″ of wood, and 2½″ of iron skin.	I. 3·7″.	1627	
9″.22 W. I. S. B. ………	″ case-hardened.	113	25	″	"Captain Inglis'" shield.	I· 2·4″.	1461	Major diameter of shot after impact, 12·2″. Target 15″ of iron.
″ ………	″	″	30	″	6″ plate on wooden frigate.	I. 4·5″.	…	Shot remained in plate much flattened.
9″ Lynall Thomas' gun…. W. I. M. L. R.	Cylindrical, conical-ended.	302	50	″	7½″ plate on 7″ of wood, and 6½″ plate on 8″ of wood with 2½″ of iron skin.	M. I. 5″.	…	Struck at the junction of the two plates.

ON THE DURATION OF WOODEN CARRIAGES IN A HOT CLIMATE.

By Lieut.-Col. H. CLERK, R.A., F.R.S.

The return to this country of a large portion of the carriages, platforms, &c. which were on the fortifications of Corfu, has afforded a favourable opportunity of estimating the probable duration of wooden carriages, a subject which has a peculiar interest at the present moment when the substitution of wrought-iron for wood in carriages and platforms is under consideration.

It has been generally supposed that 10 years is about the time that a carriage will last, when constantly exposed to the weather; but the result of the present investigation is, that 29½ years represents the average duration, and this in a climate where the sun has a powerful effect on wood. The newest and best of the carriages have been landed at Malta and only the worst returned to this country; if all had been included in the comparison the result would be still more favourable. Most of these carriages are of "English oak," and some made as far back as 1805 are still fit for service.

By "average duration" is understood, that period when, out of any number of carriages, the chances are, that the proportion of serviceable to unserviceable will be equal. Reference being had merely to the effects of age and climate, not to the wear and tear from constant use.

Tables I. and II. give the description of carriage, date of manufacture and present state. Table III. gives the dates, length of service and condition, arranged according to years. Table IV. is formed from Table III., by collecting the numbers into periods of 10 years. The proportion is obtained by dividing the number of serviceable and unserviceable in each period, by the total number issued in that period. As the date has been found on all carriages since 1805, those without date are supposed to have been made previously.

It will be seen on inspection of Table IV. that out of 338 carriages, &c. returned to this country from Corfu, there are 138 still fit for service, 200 that are unserviceable, but of these 16 have become so through wear and tear, consequently only 184 are worn out from age. Of the 138 serviceable, 25 were made upwards of 50 years ago. From this table it appears that the average duration is about 29½ years, and that 17 out of 1000 carriages will become unserviceable annually.

Table V. gives the probable number, out of 1000, of serviceable and unserviceable carriages for every 5 years up to 58·8 years, when the whole will be unserviceable, on the supposition that the decay goes on gradually from year to year by arithmetical progression, and that such is probably the case, may be assumed from the accordance between the numbers calculated and those observed, taken from Table IV.

Table I.

RETURN OF CARRIAGES, ETC. RECEIVED FROM CORFU WHICH ARE FOUND FIT FOR THE SERVICE, SHOWING THE DATE OF THEIR MAKE.

Nature and description.		Fit for the service.		Remarks.
		Number.	Date of make.	
Carriages	carronade, block trail, 32-pr.	2	1842	Oak (English).
	gun, common, standing 8-in., 65 cwt.	2	1859	Teak.
		2	1858	Teak.
	„ 32-pr., 63 cwt.	3	1853	Teak.
	„ „ 25 cwt.	3	1861	Oak (English).
		1	1863	Oak (English).
	„ 24-pr., 50 cwt.	5	no date	Oak (English).
	„ „	1	1806	Oak (English).
		1	1813	Oak (English).
		1	1816	Oak (English).
		1	1861	Oak (English).
	„ 24-pr., 20 cwt.	6	1861	Oak.
	„ 18-pr.	1	1805	Oak.
	gun, common, for platform 8-in., 65 cwt.	3	no date	Oak.
		1	1842	Oak.
		1	1845	Oak.
		4	1859	Teak.
		3	1858	2 teak, 1 oak.
		1	1860	Teak.
	„ 32-pr., 56 cwt.	1	1847	Teak.
		5	1858	Teak.
	„ 24-pr.	3	no date	Oak (English).
		4	1860	Teak.
	gun, dwarf, for platform, 56-pr., 98 cwt.	5	1848	Teak.
	„ 68-pr., 95 cwt.	1	1858	Teak.
		1	1861	Teak.
	„ 8-in., 65 cwt.	4	1861	Teak.
	„ 24-pr.	1	1852	Teak.
		8	1861	Teak.
	rear chock … 10-in. gun	5	1861	Oak (English).
	rear chock … 8-in. howit.	2	1860	Teak.
	travelling … 24-pr. siege	2	1860	Oak (English).
	travelling … 12-pr. „	1	no date	Oak (English).

TABLE I.—*Continued.*

Nature and description.	Fit for the service.		Remarks.
	Number.	Date of make.	
Carriages, travelling, 9-pr.	1	1807	Oak (English).
	1	1810	
	1	1814	
	3	1815	
Carriages, travelling, 6-pr.	2	no date	
	2	1858	
Carriages, travelling, 3-pr.	1	1836	Teak.
	1	1838	
	2	1839	Oak (English).
	4	1858	Teak.
Carriages, travelling, 24-pr. howitzer	2	1853	Oak (English).
Capstans, crab	1	no date	
	1	1855	
Carts, ammunition	1	no date	Oak and fir.
	1	1861	
Carts, forage	1	1855	Ash and fir.
Carts, sling, N. P.	1	1862	Oak (English).
Carts, „ O. P.	1	1856	
	2	1858	
Carts, trench	2	1854	Oak and elm, (English).
	1	1855	
Drugs, large or heavy	1	no date	Oak.
	1	1858	
	1	1861	
Gyns, Bell's	1	1825	
Platforms... common 8-in. to 24-pr.	2	no date	Fir.
	1	1850	
	2	1858	
	2	1861	
Platforms... dwarf 56 or 68-prs.	3	1848	Teak.
	5	1858	
Wagons, ... platform	1	no date	Oak (English).
Wagons, ... sling	1	1855	Oak.

Table II.

RETURN OF CARRIAGES, ETC. RECEIVED FROM CORFU WHICH ARE FOUND TO BE UNFIT FOR THE SERVICE, SHOWING THE CAUSE OF THE SAME.

Nature and description.	Unfit for service. Number.	Date of manufacture.	Cause of becoming unserviceable.
Beds, wood, mortar, $4\frac{3}{5}$ in.	2	no date	Wormeaten and decaying.
	2	1813	
	2	1814	
Carriages, carronade, block / trail 24-pr.	1	no date	
	1	1805	
	7	1807	
	1	1809	
Carriages, gun, common standing, 32-pr. 56 cwt.	2	1806	
Carriages, gun, common standing, 24-pr. 50 cwt.	39	no date	2 from fair wear and tear. 48 wormeaten and decaying.
	1	1805	
	3	1806	
	1	1808	
	2	1812	
	4	1815	
Carriages, gun, common standing, 18-pr.	8	no date	Wormeaten and decaying.
	1	1806	
	2	1815	
	1	1817	
Carriages, gun, common standing, 12-pr.	5	no date	
	7	1805	
	4	1806	
	7	1815	
Carriages, gun, common, platform, 8-in. 65-cwt.	2	no date	
	1	1823	
	1	1842	
	7	1845*	
	3	1846*	
	1	1859	
Carriages, gun, common, platform, 32-pr. 56 cwt.	1	1846*	
Carriages, gun, dwarf, for platform	1	1850	
Carriages, Rear chock, 10-in. gun	1	1861	
Carriages, Rear chock, 8-in. howitzer	1	1823	
Carriages, travelling 12-pr. gun	1	1805	
	2	1806	
	1	1810	
Carriages, travelling, 6-pr.	5	no date	Wormeaten and decaying.
	1	1808	
Carriages, travelling, 12-pr. howitzer	1	1810	
Carriages, travelling, $5\frac{1}{2}$-in. howitzer	1	1805	
	1	1806	
Carts, forage	1	no date	Fair wear and tear.
Carts, hand	2	do	
	1	1841	
	1	1842	
	1	1844	
Carts, trench	3	no date	
	2	1842	
Drugs, light	1	no date	
	1	1858	
Gyns, Bell's	1	no date	Wormeaten and decaying.
Gyns, triangle	3	no date	Fair wear and tear.
Platforms common 8-in. to 24-pr.	45	no date	Wormeaten and decaying.
Wagons, flanders	1	no date	
	1	1815	
Wagons, forge	1	no date	

* Converted carriages. Date of original manufacture unknown.

Table III.

RETURN SHOWING THE STATE OF THE CARRIAGES, ETC. RECEIVED BACK FROM CORFU IN THE YEAR 1864, TOGETHER WITH THEIR DATE OF MANUFACTURE AND LENGTH OF SERVICE.

Date of manufacture.	Years since made.	No.	Present state.		Remarks.	Date of manufacture.	Years since made.	No.	Present state.		Remarks.
			Fit for service.	Unserviceable.					Fit for service.	Unserviceable.	
No date	...	140	20	120	*a*	1834	30	...	...	...	
1805	59	12	1	11		1835	29	...	...	...	
1806	58	14	1	13		1836	28	1	1	0	
1807	57	8	1	7		1837	27	...	...	...	
1808	56	2	0	2		1838	26	1	1	0	
1809	55	1	0	1		1839	25	2	2	0	
1810	54	3	1	2		1840	24	...	...	...	
1811	53	...	...	...		1841	23	1	0	1	*b*
1812	52	2	0	2		1842	22	7	3	4	*c*
1813	51	3	1	2		1843	21	...	...	...	
1814	50	3	1	2		1844	20	1	0	1	*d*
1815	49	17	3	14		1845	19	8	1	7	*f*
1816	48	1	1	0		1846	18	4	0	4	*g*
1817	47	1	0	1		1847	17	1	1	0	
1818	46	...	...	...		1848	16	8	8	0	
1819	45	...	...	...		1849	15	...	...	...	
1820	44	...	...	...		1850	14	2	1	1	
1821	43	...	...	...		1851	13	...	...	...	
1822	42	...	...	...		1852	12	1	1	0	
1823	41	2	0	2		1853	11	5	5	0	
1824	40	...	...	...		1854	10	2	2	0	
1825	39	1	1	0		1855	9	4	4	0	
1826	38	...	...	...		1856	8	1	1	0	
1827	37	...	...	...		1857	7	...	...	...	
1828	36	...	...	...		1858	6	28	27	1	*e*
1829	35	...	...	...		1859	5	7	6	1	
1830	34	...	...	...		1860	4	9	9	0	
1831	33	...	...	...		1861	3	33	32	1	
1832	32	...	...	...		1862	2	1	1	0	
1833	31	...	...	...		1863	1	1	1	0	

a Ten of these carriages are unserviceable from fair wear and tear.
b This carriage is , , , , , , , ,
c Three of these carriages , , , , , , , ,
d This carriage is , , , , , , , ,
e Ditto , , , , , , , , , ,
f, *g* Converted carriages. The date of manufacture is unknown.

Table IV.

SHOWING THE PROPORTION OF RETURNED CARRIAGES, ETC. WHICH ARE FIT FOR FURTHER SERVICE, AND OF THOSE WHICH ARE UNSERVICEABLE.

Length of service.	No. issued.	State of carriage.		Proportion.		Remarks.
		Serviceable.	Unserviceable.	Serviceable.	Unserviceable.	
From 50 to 60 years	185	25	160	0·135	0·865	The mean proportion of serviceable carriages is 0·491, corresponding to a duration of 30 years, hence 0·5 will correspond to 29½ years.
" 40 " 50 " ...	24	5	19	0·208	0·792	
" 30 " 40 " ...	1	1*	...	...	...	
" 20 " 30 " ...	12	7	5	0·583	0·417	
" 10 " 20 " ...	30	17	13	0·566	0·434	
" — " 10 " ...	86	83	3	0·965	0·035	

* There being only one carriage issued during this period, no comparison can be fairly made.

Table V.

SHOWING THE PROBABLE NUMBER OUT OF 1000 CARRIAGES THAT WILL BE FOUND SERVICEABLE AND UNSERVICEABLE AFTER EACH PERIOD OF YEARS.

No. of years.	Serviceable.		Unserviceable.		No. of years.	Serviceable.		Unserviceable.	
	Calculated.	Observed.	Calculated.	Observed.		Calculated.	Observed.	Calculated.	Observed.
5	915	965	85	35	35	405	...	595	...
10	830	...	170	...	40	320	...	680	...
15	745	566	255	434	45	235	208	765	792
20	660	...	340	...	50	150	...	850	...
25	575	583	425	417	55	65	135	935	865
30	490	...	510	...	58·8	0	...	1000	...

NOTE.—A similar examination of wheels returned from Corfu, tends to shew that the average duration of a wheel composed of—ash felloes, oak spokes, elm nave, is fifteen years; and that out of 1000 wheels, the whole may be expected to be unserviceable after thirty years.

ERRATUM.

Page 186, line 6 from the bottom, *for* "Special shot," *read* "Service shot."

MEMORANDUM.

A SMALL number of copies of the contributions to "Regimental History" will be separately paged and struck off for the use of those members who wish to preserve them apart from other matter: these may be had at the cost of the paper and printing.

By order,

A. HARRISON, Capt. R.A.
Secretary, R.A.I.

18 . 1 . '65.

REMARKS

BY THE

ORDNANCE SELECT COMMITTEE,

ON A SERIES OF EXPERIMENTS WITH ROPE MANTELETS.*

[Communicated by direction of the Secretary of State for War].

The Committee have carried on a series of experiments with rope mantelets constructed by the Russians for the defence of Sebastopol, and with others made in the same manner as those prepared on board the British fleet for the attack of that fortress; they have also consulted the records of former experiments carried on at the Royal Engineer Field Establishment, Chatham.

From the result of the experience thus gained, they have had a rope mantelet constructed which is proof against the Enfield rifle bullet at 50 yds.

This mantelet consists of five layers of rope, 4½ inches in circumference, the two central layers lying parallel to each other, and the layers next to them lying across the former. The thickness of this mass of rope is very great, about 7 in., and it is very heavy, weighing 27½ lbs. per square foot. Supposing, therefore, that one were constructed so as to cover merely the *lower* half of the opening of an embrasure, it would weigh 165 lbs.

The Committee have prepared the accompanying table to show the thickness of mantelet required to resist the Enfield rifle bullet at different distances, from which it will be seen that one formed of two thicknesses of 7-in. rope, which weighs 21 lbs. per square foot, is proof at 200 yds. and this being lighter, may be found in some cases more useful than the one before mentioned; it may be remarked that if two of them were hung up together, they would be proof at 50 yds.

It does not appear to the Committee to be advisable to introduce any special description of mantelet into the service for general purposes.

When the use of mantelets is requisite, much will depend in their construction, on the particular nature of the service for which they are required, and the means of manufacture at disposal; but it seems desirable that the experience gained by these experiments should be made known to the two services.

* Reprinted from "Occasional Papers," R. A. Institution.

Description, Weight, &c. of Rope Mantelets, showing at what distance they afford protection from the Enfield Rifle Bullet.

Distinguishing Number.	Description, &c.			Dimensions, superficial feet.	Weight.		Remarks.
	Rope laid.		Construction.		Total.	Per foot superficial.	
	Layers.	Size.	Layers.				
	No.	in.			cwt. qrs. lb.	lbs.	
1	5	4½	2 vertical, 2 horizontal, 1 vertical	16	3 3 21	27½	Affords protection at 53 yds.
2	3	5	vertical	34	6 0 13	20	" " 100 yds.
3	2	6	………………	30	4 2 93	17	" " 200 yds. but not under. No. 3, not always at that distance; two of No. 4, hung together, afford protection at 50 yds.
4	2	7	………………	28	5 1 4	21	

Result of Experiments carried on between the 12*th and* 18*th November* 1856, *to ascertain the amount of protection afforded by some Russian Rope Mantelets against the Enfield Rifle Service Ammunition.*

Weight of ball, 530 grs.; charge, 2½ drs. F.G.

Description of Mantelet.

Distinguishing Number.	Description, &c.						Dimensions, superficial feet.	Weight.		Remarks.
	Rope laid.		Yarn loosely laid up, plaited three strand as gasket.		Construction.			Total.	Per superficial foot.	
	Layers.	Size.	Layers.	Size.	Layers.	Plat as gasket.				
	No.	in.	No.	in.				cwt. qrs. lbs.	lbs.	
1	3	4	—	—	vertical	—	29	4 1 26	17	
2	2	4½	—	—	...	—	21	2 2 20	14	
3	3	5	—	—	...	—	32	4 2 14	16	
4	3	5	—	—	...	—	34	6 0 13	20	
5	2	6	—	—	...	—	30	4 2 24	17	
6	2	7	—	—	...	—	28	5 1 4	21	
7	1	3	1	5	horizontal	vertical	15	2 1 2	16	(Plat on flat).
8	1	2½	1	5	...	...	16	2 1 10	16	" "
9	—	—	2	5	...	...	16	2 1 24	17	(Plat on edge).
10	—	—	6	4½	2	4*	14	3 0 20	25	* (2 inside and 2 outside).

Owing to obstructions the longest range which could be had was 300 yds. The mantelets were hung up, and a 2-inch deal target placed 3½ ft. behind them.

No. 1 Mantelet ...

At a range of 200 yards.

No. 1 shot, sent through mantelet, and 1 in. into target. } Struck between strands.
2 " sent through mantelet, and indented target. } Struck between strands.
3 " remained in mantelet, 2 in. deep, struck on brace.
4 " through mantelet, indented target, between strands.
5 " remained in mantelet, $2\frac{1}{2}$ in. deep, on strand.

At a range of 300 yards.

No. 1 shot, remained in mantelet, $1\frac{1}{2}$ in. deep, struck on strand.
2 " through mantelet, indented target $\frac{1}{4}$ in., between strands.
3 " through mantelet, into target $\frac{1}{4}$ in., between strands.
4 " remained in mantelet, $2\frac{1}{2}$ in. deep, on strand.

Not a sufficient protection up to or at 300 yds.

No. 2 Mantelet ...

At a range of 200 yards.

No. 1 shot, through mantelet, indented target, struck on strand.
2 " through mantelet and target do. do.

At a range of 300 yards.

No. 1 shot, remained in mantelet, 1 in. deep, on strand.
2 " do do do
3 " do do do
4 " do do do
5 " through mantelet into target, 1 in. between strands.

Not sufficient protection at 300 yds.

No. 3 Mantelet ...

At a range of 100 yards.

No. 1 shot, through mantelet, entered target 1 in., on strand.

At a range of 300 yards.

No. 1 shot, through mantelet, entered target sideways - } between strands.
2 " through mantelet into target, 1 in. - - } between strands.
3 " through mantelet, indented target only, on strand.

Not sufficient protection at 300 yds.

No. 4 Mantelet ...

At a range of 100 yards.

No. 1 shot, remained in mantelet, $2\frac{1}{2}$ in. deep, struck on strand.
2 " do do
3 " do do
4 " do do
5 " do 3 in. deep, between strand.
6 " do $1\frac{1}{2}$ in. deep, on strand.
7 " through mantelet, marked target, but did not enter between strand.
8 " remained in mantelet, $1\frac{1}{2}$ in. deep, on strand.
9 " do do
10 " do do
11 " do do
12 " do nearly through, between strand.
13 " do 2 in. deep. do
14 " do $1\frac{1}{2}$ in. deep, on strand.
15 " do $2\frac{1}{2}$ in. deep, between strand.

At a range of 50 yards.

No. 1 shot, through mantelet, 1 in. into target, between strand.
2 " do struck, but did not enter target.
3 " nearly through mantelet, head of bullet showing.

At a range of 20 yards.

No. 1 shot, through mantelet into target 1 in.
do struck, but did not enter target.
do into target 1 in.

Would appear to be a protection at 100 yds., but not under.

No. 5 Mantelet...

At a range of 100 yards.

No. 1	shot,	through mantelet into target 1 in., between strands.
2	"	remained in mantelet, 3 in. deep, struck on strands.
3	"	do do do
4	"	remained in mantelet, on strand.
5	"	do do
6	"	do do
7	"	through mantelet, struck but did not enter target between strands.
8	"	remained in mantelet, struck between strands.
9	"	through mantelet and target, between strands.
10	"	do into do do

At a range of 200 yards.

No. 1	shot,	remained in mantelet half-way through, between strands.
2	"	do do do
3	"	do do do
4	"	do do do
5	"	do do do
6	"	do do do
7	"	remained in mantelet, but nearly through, showing head of bullet at back, between strands.

A good protection at 200 yds., but not a thorough one; not sufficient protection at 100 yds.

No. 6 Mantelet...

At a range of 100 yards.

No. 1	shot,	remained in mantelet, on strand, ¾ in. deep.
2	"	do 2 in. deep on strand.
3	"	do 2½ in. do
4	"	do 1½ in. do
5	"	remained in mantelet, nearly through, between strand.
6	"	through mantelet, marked, but did not enter target, between strand.
7	"	remained in mantelet, ¼ in. deep on strand.
8	"	through mantelet, into target 1 in., between strand.
9	"	remained in mantelet, 1½ in. deep, do
10	"	do 1 in. deep, on strand.

At a range of 200 yards.

No. 1	shot,	remained in mantelet, between strand.
2	"	do 2¼ in. on strand.
3	"	do 4 in., between strand.
4	"	do ¾ in., on strand.
5	"	do do
6	"	do 2 in. deep, on strand.
7	"	do 1½ in., between strand.
8	"	do 1½ in. on strand.
9	"	do 1 in. deep, on strand.
10	"	do 2½ in. deep, between strand.

Would appear to afford protection at 200 yds., but not at 100 yds.

No. 7 Mantelet...

At a range of 100 yards.

No. 1	shot,	through mantelet into target 1 in. (between and on strands.)
2	"	do do (between and on strands.)
3	"	do and target (between and on strands.)
4	"	do do (between and on strands.)

At a range of 200 yards.

No. 1	shot,	through mantelet and target (between and on strands.)
2	"	do do (between and on strands.)

At a range of 300 yards.

No. 1 shot, through mantelet and target.

No protection at 300 yds.

No. 8 Mantelet ...

At a range of 200 yards.

No. 1 shot, through mantelet and target, placed No. 9 mantelet 3 ft. behind No. 8.
No. 1 shot, through 8 into 9, 1½ in
2 " do 1 in.
3 " through 8 and nearly through 9
} between and on strands.

At a range of 300 yards.

No. 1 shot, through mantelet into target, ¼ in.
2 " do do ½ in.

No protection at 300 yds.

No. 9 Mantelet ...

At a range of 200 yards.

No. 1 shot, through mantelet and target, between strands.
2 " through mantelet, struck target, but did not enter between strands.
3 " through mantelet and target, on strand.

At a range of 300 yards.

No. 1 shot, through mantelet into target 1 in.
2 " do and target between strands.
3 " through mantelet, struck target, but did not enter between strands.

No protection at 300 yds.

No. 10 Mantelet...

At a range of 300 yards.

No. 1 shot, through mantelet and target.
2 " do do
3 " do do

No protection at 300 yds.

From the above experiments it would appear that Nos. 4, 5, 6 mantelets are the only ones which afford protection at close quarters, neither of them under 100 yds. range, No. 4 being the best, and affording protection at 100 yds.; Nos. 5 and 6 affording protection at 200 yds., but not under; No, 56 not always at that distance; Nos. 1, 2, 3, 7, 8, 9, 10, no protection at 300 yds.

(Signed) Alex. T. Tulloh, Col. R.A., Supt. R.C.D.
G. Fraser, Capt. R.A., Capt. Insp. R.L.

Royal Carriage Department,
March 10, 1857.

Memorandum of Rope Mantelets made for Select Committee.

Distinguishing Number.	Description, &c.				Dimensions, superficial feet.	Weight.				Remarks.
	Rope laid.		Construction.			Total.			Per foot superficial.	
	Layers.	Size.	Layers.	—						
	No.	in.			ft.	cwt.	qrs.	lb.	lbs.	
1	4	4½	2	vertical	16	3	1	0	22¾	2 inside on vertical.
			2	horizontal						2 outside horizontal.
2	4	4½	4	vertical	16	3	0	12	21¾	—

(Signed) A. T. Tulloh, Col. R.A.
Supt. Rl. C. Dept.

Results of Experiments carried on 6th May 1857, to ascertain the protection afforded by four different Mantlets, against the Enfield Rifle Service Ammunition, and the 1842 pattern Rifle Service Ammunition, at different Ranges.

5 in. thick plats, vertical and horizontal, of ropes, 4½ in.; two of each size; 4 feet square; weight, 3 cwt. 1 qr.

The first mantelet tried was a rope one; description in the margin; at a range of 50 yds. with the Enfield rifle.

No. 1 shot, remained in mantelet 2½ in. deep, struck between ropes.
2 〃 do 2¾ in., struck on rope.
3 〃 do 4½ in., do
4 〃 went through mantelet, into wood target behind, of deal, and penetrated its own depth, struck between ropes.
5 〃 remained in mantelet 4½ in., struck on rope.
6 〃 do 4½ in., do
7 〃 do 2¾ in., between ropes.
8 〃 do 3 in., on rope.
9 〃 went through mantelet, indented target.
10 〃 do do struck between rope.

The 1842 pattern rifle was next used, against the same mantelet, at the same range.

No. 1 shot, remained in mantelet 3½ in., struck on rope.
2 〃 do 4½ in., struck between rope.
3 〃 do 4½ in., struck on rope.
4 〃 do 4½ in., do
5 〃 do 4¾ in., do

5 in. thick plats, vertical, rope 1½ in., 4 plats; size, 3 ft. 8 in. by 4 ft.; weight, 3 cwt. 12 lbs.

The next mantelet fired at was of rope; the Enfield rifle being used at a range of 50 yds.

No. 1 shot, went through mantelet, did not indent target at back, struck on rope.
2 〃 do do struck between ropes.
3 〃 went through mantelet and target, between ropes.

The 1842 pattern rifle was next used, against the same mantelet, at same range.

No. 1 shot, through mantelet, indented target, between ropes.

Steel plates $\frac{1}{61}$ in. thick, laid horizontal, so as to slightly overlap, backed by hide; size 2 ft. 6 in. by 2 ft. 2 in.; weight, 1 qr. 2 lbs., being about 5½ lbs. to the superficial foot.

The next mantelet tried was of steel, backed by hide; the Enfield rifle being used at a range of 200 yds.

No. 1 shot, indented, but did not penetrate or crack the plate.
2 〃 do do do

Moved up to 150 yds.

No. 1 shot, went though mantelet.
2 〃 did not penetrate, but indented deeply, and cracked the mantelet.
3 〃 went through mantelet.

Steel plates $\frac{3}{8}$ in. thick, laid horizontal, so as to slightly overlap; size, 2 ft. 6 in. by 2 ft. 8 in.; weight, 1 cwt. 21 lbs., being about 20 lbs. to the superficial foot.	The next mantelet tried was of steel, backed with hide, thicker than the last; the Enfield rifle being used at a range of 150 yds.

No. 1 shot made no impression on the mantelet.

Moved up to 50 yds. range.

No. 1 shot made no impression on the mantelet.

Moved up to 25 yds. range.

No. 1 shot made not the least impression on the mantelet.

Enfield Rifle.		*Musket rifled, pattern* 1842.	
Weight of bullet	530 grs.	Weight of bullet	848 grs.
Charge	$2\frac{1}{2}$ drs.	Charge	3 drs.

(Signed) G. Fraser, Captain, R.A.

ON THE OBJECTIONS WHICH HAVE BEEN URGED AGAINST THE DIAPHRAGM SHRAPNEL SHELLS; AND ON THE GENERAL MERITS OF THIS CONSTRUCTION.

BY CAPTAIN VIVIAN DERING MAJENDIE, R.A.

CAPTAIN INSTRUCTOR, ROYAL LABORATORY.

In my last paper on the Shrapnel class of shell,* I brought the subject down to the point at which there only remained to be considered the validity of the objections which have been urged against shells of the Diaphragm construction.

Upon careful consideration it appears to me that there are only two of these objections which are sufficiently grave, or sufficiently precise, to necessitate a careful examination. These two objections may be stated as follows :—

(1) That, from the relative positions of the bullets and powder, the shell is necessarily eccentric, and that great irregularity of flight does, and must, result from this eccentricity.

(2) That, the bullets are acted upon by the bursting charge in a way, and to an extent, highly injurious to the efficiency of the shell.

1. *With respect to the eccentricity of the shell and the consequent inaccuracy of flight which it is stated must and does result therefrom.* This objection appears first to have been raised by the Inspector General of Ordnance in Calcutta, in 1857 ;[2] but it can be shown, to quote Col. Boxer's words, to have "no foundation in Fact or in Theory,"[3] and that far from this

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[1] Vide p. 152.

[2] "The centre of gravity of the shell is not in the centre of figure, and experiments made with eccentric shot and shells in 1850, proved that such projectiles cannot be depended upon for accurate practice."—Report of Inspector General of Ordnance, in Calcutta, 21st December, 1857. See *Supplement to Synopsis of Ordnance Select Committee Reports*, p. 16.

See also Committee's Memo. on Diaphragm Shrapnel Shell, p. 3. Col. Boxer's *Remarks on Committee's Memo. on Diaphragm Shrapnel Shell*, p. 3.

The Inspector-General of Ordnance, at Calcutta, however, was not the only officer who held this opinion, nor, indeed, the only one who urged it, for in Col. Boxer's *Remarks upon Diaphragm Shrapnel Shell*, p. 17, the following passage occurs: "*It has been often stated*, and it is I believe, *the opinion of many* even at the present time that as the centre of gravity in the Diaphragm Shell does not coincide with the centre of figure............great irregularity in flight must result." See also *Supplement to Ordnance Select Committee Report on Shrapnel Shell*, p. 18. *Synopsis of Ordnance Select Committee Report on Shrapnel Shell*, p. 295. Also, *The Shrapnel Shell in England and Belgium*, pp. 48, 49; and *Revue de Technologie Militaire*, Vol. II., p. 390.

[3] *Remarks on Diaphragm Shrapnel Shell*, p. 17.

shell being necessarily inaccurate in its flight, it should theoretically "be even more regular than an ordinary shot of the same weight."[4]

First, then, as regards the Facts of the case: An immense number of references might be made to practice reports, and to the reports of the various Committees which have deliberated from time to time, to prove that the opinion as to the eccentricity of this projectile affecting injuriously its accuracy "has no foundation in fact;" the following, however, will perhaps be sufficient for this purpose.

On the 5th October, 1852, Col. Robe reports to the Director General, "The results as to *deviation*, range, and velocity have been most satisfactory. .... At 900 and 950 yds., 5 shell out of 6 went through the target, and the 6th was 5 yds. to the left of the centre line .... At 1600 yds. 5 shells were fired and grazed at 3, 4, 5, 6, and 7 yds. to the left of the line."[5] At the foot of the same report Col, Robe writes "The *direction* of these shells were remarkably good."[6]

Again, the Committee report 18th April, 1853. "The results" as to *direction*, range and velocity were very satisfactory.[7]

On the 15th August 1853, Col. Lake, R.A. reports: "I beg to state that these shells appear to answer most effectually, *and the direction was very exact*."[8] Again on the 22nd August 1853, with reference to further experiments, Colonel Lake reported: "I beg to observe *that the direction is very good, &c.*"[9] On the 23rd September 1853, the same officer reports: "The experimental practice with Captain Boxer's Diaphragm shells being completed, I have the honour to inform you that they appear to me to be very effective.... *The direction was good*."[10] On the 1st October 1853, the Committee report, "With the Diaphragm Shrapnel shell.... *the direction is good*."[11]

Such are a few of the many positive testimonies which might be quoted to prove the accuracy of the practice which was made with these shells;[12] to which may be added, that the whole tenour of the reports of the Committee,[13] and the teaching of some fifty pages of practice reports[14] go

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[4] Col. Boxer's *Remarks upon Committee's Memo. on Diaphragm Shrapnel Shell*, p. 4.

"In fact the flight of these projectiles should be theoretically more accurate than ordinary round shot of the same weight, and I am quite satisfied that in practice it will be found quite as accurate." *Remarks on Diaphragm Shrapnel Shell*, p. 23.

[5] *Synopsis of Ordnance Select Committee's Report on Shrapnel Shell*, p. 276.

[6] Col. Boxer's *Remarks on Committee's Memo. on Diaphragm Shrapnel Shell*, p. 4.

[7] *Synopsis of Ordnance Select Committee's Reports on Shrapnel Shell*, p. 281.

[8] *Ibid.* p. 281. [9] *Ibid* p. 283. [10] *Ibid* p. 285. [11] *Ibid* p. 288.

[12] I might perhaps also quote a passage from a report of the late Sir George Barker, R.A. in positive proof of what I am seeking to establish; the passage is as follows: "The objection referred to by Col. Abbott, that the centre of gravity is not in the centre of the figure, has been found *by experiment* not to affect the flight of the projectile to a perceptible degree."—*Supplement to Ordnance Select Committee Reports on Shells*, p. 23. I do not, however, quote this passage in my text, for the reason that I cannot discover to what particular experiment Colonel Barker referred, and I think that I may very well afford to dispense with a piece of evidence which is not as precise as I wish all the evidence which I make use of to be. At the same time I give the passage in a note that it may not be supposed that I have overlooked it, and because it shows what this distinguished artillery officer thought upon the subject.

[13] See *Synopsis* &c., also Committee's *Memo. on Diaphragm Shrapnel Shell*, pp. 3, 4, &c.

[14] *Ibid.* p. 9 to 58.

to prove that the practice with these shells as regards accuracy of flight was at least up to the average of practice with spherical projectiles of the same weights.

As regards the negative evidence available for the same object, the following appears to me sufficiently conclusive: I can discover only two unfavourable opinions *professing to be based upon practice or experiment*[1] respecting the accuracy of flight of these projectiles.

The two unfavourable reports are as follows :—

(*a*) A report made in 1857, which says: "The weight of the bullets being all on one side of the shell causes an irregular motion, and consequently great inaccuracy in the flight of the projectile."[2] And (*b*) a report made by another officer in 1858, to the same effect: "With the same charge and elevation, and only a few ounces different in the weight of the shells, the range of one would exceed that of the other by 200 or 300 yds., while also, owing to their eccentricity, the lateral deviation was very great."[3]

These, then, are the two, and, as far as I can discover, the only two, instances in which officers *speaking from practice and experience, and not merely on theoretical grounds*,[4] have reported unfavourable of the accuracy of flight of the Diaphragm shell; and the case against the projectile in this respect rests therefore, solely upon these two reports.[5]

This not a very strong case, and when we take into consideration the mass of evidence pointing to a different conclusion, hardly strong enough to make it necessary to do more than prove that supposing great inaccuracy of flight *did* occur with these projectiles, the effect could not possibly have proceeded from the cause so confidently assigned. I prefer, however, before I proceed to the theoretical aspect of the question, and with a view to rendering my vindication of the Diaphragm shell more complete, to endeavour to account for the only two exceptions to the generally favourable testimony borne to the accuracy of flight of these projectiles, by officers who have actually experimented with them. The following explanation suggests itself:—

In speaking of the accuracy of these shells it is necessary carefully to distinguish between Accuracy of Fire, and Accuracy of Flight. By Accuracy of Fire is meant the accuracy, with respect to the object fired at, at which the shells burst; and this will depend upon a variety of conditions, chief among which may be named an accurate estimate of the range, correctness of line and elevation, accuracy of direction of the projectile, and correct adjustment and action of the fuze; by Accuracy of Flight is meant only accuracy of direction up to the bursting point; Accuracy of Flight is, in fact, only one of many elements necessary to secure Accuracy of Fire. Now it is evidently

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[1] The opinion of the Inspector General of Ordnance, at Calcutta, was entirely theoretical, for the Select Committee says: "It does not appear from the correspondence that any experiments were made at Dum Dum to prove the correctness of the opinions entertained by the Inspector-General of Ordnance."—*Committee's Memo. on Diaphragm Shrapnel Shell*, p. 4.

[2] *Synopsis*, &c., p. 295.

[3] *Supplement to Report of Ordnance Select Committee on Shrapnel Shell*, p. 18.

[4] I have already pointed out (*see* note 1) that the opinion expressed by the Inspector of Ordnance at Calcutta, was a purely theoretical one.

[5] See P.S. appended to this paper, respecting Reports made in 1863 from 30 Artillery stations, *in* NONE *of which the shells are stated to be inaccurate in flight.*

quite possible that the Accuracy of Fire at some particular practice may be very inferior, while the Accuracy of Flight is all that can be desired; for Accuracy of Flight being, as has just been pointed out, only one of the elements of Accuracy of Fire, the failure may arise from any other of those elements which I have enumerated.

In this way much confusion and difference of opinion may exist as to the proper application of the term "accurate" and "inaccurate" to any particular practice with this class of shells; while even with the best intentions, and the clearest and most correct views upon the subject, the distinction is not an easy one to make *practically* with shells which generally burst, it must be remembered, before they graze.

The proper way to determine the Accuracy of Flight of Diaphragm shells is to fire a number of them blind; but neither of the two officers from whose reports I have quoted, make any mention of having done this.[6]

I observe, also, on examining the Practice Reports upon which the second of the two unfavourable reports is based, and other Practice Reports given in the *Committee's Memo. on Diaphragm Shrapnel Shells,* p. 9 to 58, that where the shells failed to burst, the accuracy of flight seems to have been very good; generally the shells which so failed went through the target, in the majority of the other cases they were "in the line," and when not in the line the deflection right or left is generally inconsiderable. I think this is very strong proof that inaccuracy of Flight and inaccuracy of Fire were not always carefully distinguished from one another, and that the former term was often misapplied.

I may now pass on to the Theory of the question, and prove that even if the testimony to inaccuracy of flight been universal, and the fact been placed beyond all possibility of doubt, the defect could not properly be assigned to the cause from which the officers who reported upon the subject believed it to proceed,—prove, in short, *that any observable inaccuracy of flight on the part of these projectiles could not be in any way connected with their eccentricity.*

In the case of all spherical projectiles fired from smooth-bored guns there is a certain rotation generated in the bore,—arising, when the projectile is concentric, principally from the windage;[7] and where the projectile is eccentric, and the line joining the centres of gravity and figure is not in, or parallel to, the axis of the bore, from the powder acting upon a larger surface on one side of the centre of gravity than on the other, and so producing a rotation about the centre of gravity.[8] Now the direction of the rotation which arises

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[6] It is worthy of observation that there is no record of any such experiments having been made; and this may fairly be accepted as a sort of negative proof that those who practised and experimented with the shells were generally well satisfied with regard to their Accuracy of Flight; otherwise it is reasonable to suppose, that so grave a defect would have been tested by an experiment specially calculated to expose it.

[7] "There is a considerable degree of friction between the bore and the projectile.........where there is windage, the direction of the force being opposite to that of the gunpowder, and upon the surface of the ball. It will therefore tend to give rotation to the shot."—*Treatise on Artillery,* Section 1, Part I. p. 158.

"Friction.........is the only immediate cause of deflection in a projectile whose centres of figure and gravity are coincident."—*Ibid,* p. 166.

[8] *Motion of projectiles,* p. 125, par. 19.

"Suppose the ball to be perfectly round, but its centre of gravity not to coincide with the centre from these causes affects very appreciably the flight of the projectiles;[1] and as in the case of eccentric projectiles the direction of this rotation will vary according to the relative positions of the line joining the centre of figure and gravity, and the axis of the piece,[2] so also will the flight of the projectile vary from the same cause, and depend upon the angle which the line joining the centres of figure and gravity happens to make with the axis of the piece.

But when an eccentric projectile is so placed in the bore that this line does *not* make an angle with the axis of the piece, but lies parallel to, or in, it, then no rotation will be generated, and no deflection from the natural line of flight be produced, *except from those causes which produce rotation and deflection in a concentric projectile*, i.e., from windage,[3] and an eccentric projectile thus situated may therefore be considered as a concentric projectile, being

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of figure. In this the impelling force passes through the centre of the ball, or nearly so, and acts in a direction parallel to the axis of the piece; but if the centre of gravity of the ball be out of the line of direction of the force of the powder, the shot will be urged to turn round its centre of gravity." *Treatise on Artillery*, p. 158.

[1] "A ball leaving the bore of a gun rotating on any axis, except one parallel to that of the bore, will deviate accordingly to the direction of the rotation."—*Motion of Projectiles*, p. 26.

"If the anterior part of the shot turn from below to above there will be a force tending to raise the centre of gravity, and the range will be increased; if from above to below it will be diminished. Should the rotation be from left to right the shot will be thrown to the right."—*Treatise on Artillery*, Section 1, Part I., p. 166.

"To our countryman Robins is due the credit of first pointing out the great change which the rotation of a shot would produce in the path of its flight."—*Ibid.* p. 159.

See Robin's experiments and remarks upon this subject embodied in *Ibid.* p. 159–165.

[2] "The direction of rotation will depend upon the position of the centre of figure with regard to that of gravity."—*Treatise on Artillery*, Section 1, Part I., p. 159.

"If a spherical eccentric projectile be placed in the gun; so that the line joining its centres of gravity and figure form an angle with the axis of the bore.........the line representing the sum of all the forces resulting from the explosion of the charge, will not pass through the centre of gravity, as it passes through, or nearly so, the centre of figure; and the result will consequently be........ a motion of rotation round an axis at right angles to the axis of the bore."—*Remarks on Diaphragm Shrapnel Shell*, p. 18.

"The shot.........is found to deviate according to the position of the centre of gravity when the ball is placed in the bore of the gun."—*Motion of Projectiles*, p. 26.

[3] "The experiments in 1850 with shot purposely made eccentric and placed in the bore, with the centre of gravity in various positions.........proved.........that if the centre of gravity was placed in the centre of the piece, the eccentric lump being towards the charge, the range and deflection were about the same as those with concentric shells."—Committee's *Memo. on Diaphragm Shrapnel Shell*, p. 4.

"If the direction of the force be through the centre of gravity it causes a progressive motion only ....If the body besides its progressive motion had a motion of rotation likewise, this last will not be changed by the action of a new force, whose direction passes through the centre of gravity." *Treatise on Artillery*, Section 1, Part I., p. 157.

In other words, if the force act through the centre of gravity, as it does in the case of a Spherical concentric projectile, and in the case of an eccentric projectile the line joining the centres of gravity and figure of which lies in, or parallel to, the axis of the piece, a progressive motion only, and no rotation, will be communicated to the projectile,—although such a projectile may have a motion of rotation *from other causes*, such as windage. Therefore, whether the projectile be concentric or eccentric, *so that it be situated with its centre of gravity in the axis of the piece, and with the line joining its two centres in, or parallel to, that axis*, it matters not,—the same motion will be the result, and the eccentric projectile under these circumstances becomes *virtually*, and for all practical purposes, a concentric one.

under these circumstances subject in respect to its rotation and deflection to the same laws and influences, and to no others. Now, the Diaphragm shell is from its construction, and from the fact of its having a wood bottom attached, a projectile of this nature,—that is to say, although eccentric, it is always necessarily placed in the bore with the line joining its centre of gravity and figure parallel to the axis of the piece and thus no rotation is generated in it which would not be generated in a concentric projectile,[4] *and therefore no deflection or inaccuracy of flight, results from its eccentricity.*

But more than this, it may be shown, as already stated, that "these shells should, theoretically, be even *more* regular in their flight than an ordinary shot of the same weight."[5] This is not difficult to prove; for, it will be apparent to any one who has followed the above remarks carefully, that "if eccentric projectiles be always placed in the gun in similar positions as regards the lines joining their centres of gravity and figure, *whatever that position may be*, their path will be more regular than that of ordinary round shot placed accidentally in the bore,"[6] because in the one case the direction of rotation is known and determined, in the other,—the case of ordinary round shot,—it is uncertain and variable, owing to the fact of nearly all ordinary round shot being more or less eccentric,[7] and the position of their centres of gravity and figure undetermined; it follows, therefore, that the practice with ordinary round shot will be less accurate than the practice with Diaphragm shell, the line joining the centres of gravity and figure of which always occupies, as has been explained, a known and uniform position in the bore. And how much more must the advantage incline to the side of that projectile of which the eccentricity is, so to speak, neutralized, by its always occupying a position in the bore which prevents any deflection due to eccentricity being produced. In other words, the comparison lies between projectiles more or less eccentric, and which occupy accidental positions in the bore, on the one hand,—and projectiles which are virtually concentric, on the other; there can hardly be much difficulty in determining which of the two should theoretically be most accurate in flight.

2. The second objection which has been urged against the Diaphragm shell is, *That the bullets are acted upon by the bursting charge, in a way, and to an extent highly injurious to the efficiency of the shell.*[8]

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[4] "Although the Diaphragm Shrapnel shell, when prepared for service, is from the relative positions of the bullets and powder, what is termed eccentric, still no rotation will be generated in the bore from this arrangement, as the wood bottom which is firmly riveted to the shell, always ensures the straight line which joins its centre of gravity and centre of figure, being in a position parallel, or very nearly to that of the axis of the bore, or the line representing the direction of the propelling force."—*Remarks on Diaphragm Shrapnel Shells*, pp. 22, 23.

[5] Col. Boxer's *Remarks on Committee's Memo. on Diaphragm Shrapnel Shell*, p. 4.

[6] *Remarks on Diaphragm Shrapnel Shells*, p. 22, Col. Boxer adds: "The results of the experiments which were made in 1850 and in 1851, at Shoeburyness, notwithstanding the imperfect mode adopted to secure the proper position of the eccentric shot, confirms this view."—*Ibid*, p. 22.

[7] From the difficulty, almost amounting to an impossibility, of casting a perfectly concentric sphere of iron, or any other metal.

[8] See *Ordnance Select Committee Report on Shrapnel Shell*, p. 192—297.

The answer to this objection is fourfold:—

1st. That a special arrangement was made by Col. Boxer to preserve the balls from the direct action of the bursting charge,—this arrangement consisting on the four grooves in the inside of the shell, and in the thickening of the metal round the line of junction of the diaphragm described in my last paper;[1] and unless it can be proved that this arrangement has failed, it is fair to conclude that it has answered the end required of it.

2nd. In examining unfavourable reports respecting the failure of the shell in respect to this arrangement, particular attention must be paid to the date of such reports; and whether they were made before or after 1858, for, as has been explained, the details of the arrangement by which the balls are preserved from the direct action of the bursting charge, and upon which the proper opening and action of the shell depends, were not perfected until 1858.[2] Consequently, no unfavourable reports upon this subject which bear date previous to 1858, or which are urged against shells manufactured before that date, can be received in evidence against shells of the 1858 pattern; *and the only unfavourable reports upon this subject which I have been able to discover bear date* 1857,[3] *and are therefore of no account in dealing with shells of the present pattern.*

3rd. There is positive evidence that even with shells which were manufactured before the adoption of the 1858 pattern, this defect was by no means universal; indeed, it seems certain from the following extracts that with *shells which were correctly manufactured*[4] the defects complained of were not generally apparent: Letter from Col. Robe, 5th October, 1852: "The results as to direction, range, and velocity have been most satisfactory. The shells *break into very large fragments,* which range to great distances; *they appear to break in the direction marked by the construction.*"[5] On the 22nd August, 1853, Col. Lake writes, "I beg to observe that the direction was very good, *also the force of the balls, and spread.*"[6] In a report from Col. Boxer to the Director-General of Artillery, 27th Sept., 1853, he says: "The spread of the balls has been *symmetrical with regard to the trajectory.*"[7] Surely, therefore, it may fairly be conceded that the *principle* of construction was not at fault, but that the defects arose in part from the details of construction being *at that date* slightly imperfect, and in part from bad workmanship.

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1 On the subject of this arrangement I would refer the reader to p. 157, and to the drawing there given, taken from the photograph of a burst shell.

2 See pp. 155, 158.

3 The Reports given in *Ordnance Select Committee Report on Shrapnel Shell*, p. 223 to 297. These reports, with one exception, almost entirely have referenee to these two defects—want of velocity on the part of the balls, and the splitting of the shell into two hemispheres round the junction of the diaphragm with the shell. See P.S. respecting Reports made in 1863.

4 See p. 155, note 17.

5 *Synopsis of Ordnance Select Committee Reports on Shrapnel Shell*, p. 276.

6 *Ibid*, p. 283. 7 *Ibid*, p. 216.

4thly. There can be no doubt that the defect was entirely remedied by the improvements introduced into the 1858 pattern shells, and that with shells correctly manufactured on this improved design no further failures in respect to the proper action of the balls took place. The fact seems to be established, (1) by the negative evidence borne by the absence of any unfavourable Reports against the shells on this score subsequent to 1857;[1] and, (2) by the positive and very strong evidence afforded by the following table of practice carried on in 1858, with Diaphragm shells of the improved construction. The table is epitomised from a table given at length at page 46, of *Remarks on Diaphragm Shrapnel Shell*. The targets were arranged in eight rows, each row 15 yards behind the one in front, except the two last intervals which were 30 yards, so as approximately to represent a battalion in column at half intervals. The frontage of each row was 80 feet, the height 8 feet. The whole of the targets were made of 1-inch boards, except the first row which was *originally* of 1-inch boards, but for which 2-inch boards were afterwards substituted. It should be noticed that these shells were fired in one important respect under unfavourable circumstances for the most suitable elevation and length of fuze were not previously determined."[2] *It will be observed that out of* 9600 *no less than* 9346 *bullets took effect, and of these* 6299 *went through the targets.*[3]

TABLE

SHOWING THE PENETRATION OF BULLETS, THE RESULT OF 180 ROUNDS WITH DIAPHRAGM SHRAPNEL SHELLS, FROM 12, 9, AND 6-pr. GUNS, 60 ROUNDS PER GUN AT THE FOLLOWING RANGES, VIZ.:—

Range.	No. of rounds per gun.			Total No. of rounds.
	12-pr.	9-pr.	6-pr.	
yds.				
1200	10	10	10	30
1100	20	20	20	60
900	20	20	20	60
650	10	10	10	30
Total	60	60	60	180

[1] See P.S. respecting Reports made in 1863.

[2] Col. Boxer's *Remarks on Diaphragm Shrapnel Shell*, p. 42.

[3] I shall be happy to afford any officers who may desire it occular proof that the shells do really burst in the directions indicated by the grooves, and that this arrangement answers the end required of it, if they will call at my office in the Royal Laboratory, where they may see a number of burst shells; or, should they call on a day when shells are being burst for proof (a per centage of all Diaphragm manufactured are tested in this way) they may themselves see them burst in the bursting cell belonging to the Department.

I would also again refer the reader who is interested in the subject to the drawing taken from a *photograph* of a burst shell, which is given in my last paper, see p. 157.

TABLE—*continued.*

			Total distance from No. 1 to No. 8, 135 yds.									Total.
			2-in. boards.	One inch boards.								
			1	1	2	3	4	5	6	7	8	
Bullets	Through		845	530	1079	704	699	743	894	464	341	6299*
	Penetration:—											
	Lodged	·2 inch	3	...	...	...	...	...	...	...	1	4
		·3 "	8	21	49	42	17	21	28	15	9	210
		·4 "	7	9	17	23	8	13	15	8	6	106
		·5 "	21	10	21	18	19	22	20	9	11	151
		·6 "	46	23	59	42	41	17	58	21	21	328
		·7 "	37	12	24	19	23	24	23	21	20	203
		·8 "	28	5	15	9	18	8	12	3	2	100
		·9 "	24	2	5	8	2	...	1	1	...	43
		1·0 "	47	...	...	...	...	...	...	...	...	47
		1·1 "	26	...	...	...	...	...	...	...	...	26
		1·2 "	62	...	...	...	...	...	...	...	...	62
		1·3 "	42	...	...	...	...	...	...	...	...	42
		1·4 "	31	...	...	...	...	...	...	...	...	31
		1·5 "	34	...	...	...	...	...	...	...	...	34
		1·6 "	47	...	...	...	...	...	...	...	...	47
		1·7 "	14	...	...	...	...	...	...	...	...	14
		1·8 "	14	...	...	...	...	...	...	..	...	14
		1·9 "	3	...	...	...	...	...	...	...	...	3
	Struck	·0 inch	5	20	55	17	33	16	39	51	40	276
		·05 "	13	45	84	53	46	60	51	29	37	418
		·1 "	20	29	94	49	46	52	60	50	55	455
		·15 "	1	...	...	...	...	8	4	3	2	18
		·2 "	28	24	69	45	28	38	39	23	39	333
		·25 "	1	...	1	...	...	...	2	1	1	6
		·3 "	15	5	12	6	7	12	9	4	6	76
Total	Through		854	530	1079	704	699	743	894	464	341	6299*
	Lodged		494	82	190	161	128	105	157	78	70	1465
	Struck		83	123	315	170	160	186	204	161	180	1582
	Took effect		1431	735	1584	1035	987	1034	1255	703	591	9346*

Number of bullets in the 180 shells, 9600.

I have now dealt with the only two objections which appear to me to demand a special and careful investigation, and I trust it will be considered that my remarks have vindicated the character of the Diaphragm Shrapnel shell in these respects.† A number of minor objections were urged against these shells on their first introduction, the fallacy of most of which has been exposed by time and practice and experience, and they therefore are not

* There is a mistake in these figures in the original table, which I have corrected.

† The following passage from a letter addressed by the Secretary of State for War to Col. Boxer, shows what was the opinion entertained by the authorities respecting the objections which were urged against the shell, after these objections had been fully discussed: "Major General Peel has observed with great satisfaction *that the various objections urged against this construction have proved to be groundless,* that its efficiency against targets has been amply established, and that its success in obviating premature explosions is fully recognized by the Committee."—War Office letter 19th January, 1859, 75/12/226.

likely now to find many, if any, supporters. Among objections of this class may be noticed the following:—that a complete separation of the powder and bullets could not be effected by the Diaphragm arrangement; that the shells will not continue for any length of time in store in a serviceable condition; that the effect caused by the jolting action in travelling in limber boxes, will render the shells inefficient; that owing to the skill and care requisite to cast the shell correctly being so great, the expense of manufacture will be very considerable, and that there will be little guarantee that the projectiles supplied are of the proper quality.[1] Other objections, such as, that the shell is generally of too complex a character, have been raised, but these are of so vague and intangible a character,—and where not vague and intangible, so often afford unmistakable indication of having been put forward by those who are unacquainted with the details and objects of the Diaphragm construction; that it is unnecessary to attempt to reply to them categorically.[2]

Of course the Diaphragm shell will always be open to those objections which some hold to be common to all shells of the Shrapnel class. I have already in a former paper,[3] dwelt at considerable length upon "The Practical Value of shells of the Shrapnel Class," and have explained the grounds upon which my own high opinion of these projectiles is founded; in the present paper I have merely attempted to answer the objections which have been urged against the particular form of Shrapnel shell known as the Diaphragm. The general conclusion I would draw is—and I believe that those who are at the

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1 *Remarks on Diaphragm Shrapnel Shells*, pp. 27, 28.

2 As an example of the class of objection to which I refer, I give the following passage from a Report of some American Officers:—

"Some objections present themselves in examining this arrangement, viz. the complicated construction of the shell, the great reduction of its capacity for balls, the peculiar boring instrument required for piercing the fuze, and the time required for performing this operation and adjusting the fuze in the shell in the field."—*Report of American Commission to Europe*, p. 140.

By two foreign authors—General Bormann and Colonel Delobel—the Diaphragm system has been subjected to vigorous criticism; but I believe that an attentive perusal of the objections urged by them (see *The Shrapnel Shell in England and Belgium*, p. 47 to 57, *et seq.*; and *Revue de Technologie Militaire*, Vol. II., p. 329 to 405) will satisfy any one well acquainted with the construction of the projectile that neither to General Bormann nor to Colonel Delobel were the details of this construction thoroughly familiar. It is, of course, impossible for me to quote their objections at length,—I have given references to the works in which they may be found; but one objection appears to me so good an illustration of the way in which the indictment against the Diaphragm is sometimes made up, that I extract it entire: The objection is urged by Colonel Delobel, and quoted approvingly by General Bormann, who, indeed, adduces it in his Appendix, p. 126, on his own account: "The series of operations necessary at the very moment of the fire for the preparation of the Shrapnel, the regulation of the fuze and the driving it into the ampoulette, will require too much time; without taking into account that, if all this may be done properly and without error on the practice ground, it would not be the same on the field of battle for the complete boring of the regulating-hole up to the column of fusing composition, the introduction of the fuze into the ampoulette, SO THAT THE ROW OF CYPHERS CORRESPOND TO THE GROOVE AND ITS HOLE OR VENT (*lumière*), *and especially the driving home of the fuze into the ampoulette*, are things very difficult to do rapidly and well during the excitement of battle and amidst a thick smoke, and which will certainly occasion a great number of failures in igniting and premature burstings."—*The Shrapnel Shell in England and Belgium*, pp. 55, 56.

To the practical and well-instructed artilleryman this objection will suggest its own comments.

3 See p. 4.

trouble of investigating the subject carefully will agree with me—that General Shrapnel's object in introducing this class of shell, viz. to provide the service with an effective long range case shot, is attained in a most remarkable manner by Colonel Boxer's Diaphragm arrangement, and that while by this construction the defects of the original Shrapnel have been removed, no fresh ones have been originated; and while the principle has been preserved in more than its original integrity,[1] the advantages have been multiplied and developed.[2]

P.S. Since the foregoing paper was written I have had an opportunity of examining the Reports furnished in 1863 by 30 commanding officers of Royal Artillery at different stations, at home and abroad;[3] and through the kindness of General Lefroy I have obtained permission to make use of the Ordnance Select Committee's Abstract of these Reports. From this Abstract, which is given (p. 245), it will be seen that out of the 30 Reports, one only is condemnatory,[4] three are unsatisfactory,[5] three are only *moderately* favourable,[6] *and twenty-three are highly satisfactory.*

In none of the above Reports are the shells stated to be inaccurate in flight; and in three only is it affirmed that the flight of the bullets is affected by the bursting charge, or that the shells have failed to open properly,[7] and in these three cases this effect is spoken of as exceptional.

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[1] I refer to the principle of preserving the bursting charge from the direct action of the bullets, and allowing their effect to depend entirely upon their communicated velocity. I say that in the Diaphragm this principle has been preserved "in more than its original integrity," because I believe the bullets to be less affected by the action of the bursting charge in the Diaphragm, than they were in the original Shrapnel shell.

[2] Owing to the fact that full service charges may be used with the Diaphragm shell, they are available at longer ranges, than the original Shrapnel, while their velocity will be greater at short ranges. Therefore whoever admits the advantages of Shrapnel fire, must admit that these advantages have been "multiplied and developed" by the Diaphragm construction.

Moreover, the Diaphragm shell may be more safely carried filled.

[3] In all 35 reports were furnished, but at 5 stations there had been no practice with the Diaphragm shell, and the reports from these stations accordingly embodied no opinion.

[4] Devonport.

[5] Colombo, Bermuda, and Leith Fort; in the last of these cases (Leith Fort), the opinion expressed in the Report is formed from "a few rounds fired by militia artillery regiments, when undergoing their annual course of training."

[6] St Helena, Jamaica, and Shoeburyness (Col. Taylor's). Perhaps it may be thought that the Report from the Mauritius should be included among the "moderately favourable," but as it pronounces the Diaphragm pattern to be "a great improvement upon either the old or improved Shrapnel," I have thought that it might fairly be included among the "satisfactory" Reports.

[7] Colombo, ("Several shells fell in a lump, like a round shot"); Jamaica, ("Lateral spread very uncertain"); and Shoeburyness, Colonel Taylor's Report, ("Generally effective, although SOMETIMES not ALTOGETHER satisfactory as regards breaking up of the shell").

In one other case, Mauritius, it is stated that *beyond* 1200 *yds.* "the bullets *appear* to strike the water in one solid mass."

Ordnance Select Committee's Abstract of Reports received in 1863 *from the several Stations abroad and at home, upon the practice made with Diaphragm Shrapnel Shell.**

FOREIGN STATIONS.

Stations.	Results of practice.	Premature bursts.	Spread on targets.	Remarks.
Barbadoes.	No practice.	—	—	—
Bermuda.	Inferior to improved Shrapnel.	—	Effect inferior to improved Shrapnel.	The only advantage of the diaphragm, is in facility of loading.
Cape of Good Hope.	Most satisfactory in all respects.	—	—	
Colombo.	Several shell fell in a lump, like round shot.	—	—	Practice from 8-in. and 32-pr. guns.
Corfu.	Most satisfactory.	—	—	Practice from 8-in., 32-pr., 24-pr., 9-pr. and 6-pr. guns.
Gibraltar.	Satisfactory, *from heavy guns.*	—	Penetration good at 1200 yds., and effect much more destructive than common shell.	—
Halifax.	No practice. (See Remarks).	—	—	Previous local records shew that results have been satisfactory.
Hong Kong.	Satisfactory.	—	—	From range reports in March, 1863, and former experience.
Jamaica.	Good as to the onward velocity of the balls.	4 out of 43.	Lateral spread very uncertain.	Practice from 8-in. and 32-pr. guns.
Kingston.	Satisfactory.	Very rare—1 out of 100.	—	Instances of blind shells more frequent than with common shell.
do (*2nd report included in Montreal*).	Satisfactory.	2 out of 113.	—	5 out of 113 blind.
Malta.	Satisfactory.	Per centage small.	Effect good, judging from spread on water	Blind shells—per centage small.
Mauritius.	Great improvement	Per centage small.	Effect certain at 1200 yds., but beyond that distance the bullets appear to strike the water in one solid mass.	Practice from 8-in., 68-pr., 32-pr. and 9-pr. guns, and 8-in. and 24-pr. howitzers. Blind shells frequent.
Montreal.	Most satisfactory.	—	—	
Quebec.	Very satisfactory.	Nil out of 62.	Effect on target not ascertainable.	5 blind out of 62.
St Helena.	32-pr. favourable. 24-pr. unfavourable.	—	—	—
St John's, NB.	No practice.	—	—	—
Toronto.	Highly satisfactory.	Nil out of 50.	—	—

* See Extracts from Reports and Proceedings of Ordnance Select Committee, Vol, I. p. 386.

HOME STATIONS.

Station.	Results of practice.	Premature bursts.	Spread on targets.	Remarks.
Alderney.	Very satisfactory, and superior to all former Shrapnel.	Very rare.	Very satisfactory.	Practice confined to firing at a mark on the water, when shells are often blind, either from fuze or elevation.
Aldershot.	No opinion.	—	—	—
Ballincollig.	No opinion.			
Colchester.	Very satisfactory.	—	—	No Royal Artillery practice, experience of Norfolk Militia.
Devonport.	Feeble and harmless, as a shell.	—	Effects nil.	An unfavourable opinion of the diaphragm construction is expressed, as far inferior to the old Shrapnel.
Dover.	Extremely satisfactory, *from heavy guns*.	—	Floating targets unsuitable for judging effect.	—
Dublin.	No practice.	—	—	—
Guernsey.	Most satisfactory.	—	—	Experience based on former local practice reports, and personal experience elsewhere.
Jersey.	Most satisfactory.	—	—	—
Leith Fort.	Unsatisfactory as regards the splinters striking the target.	—	—	—
Manchester.	Very satisfactory.	—	—	Local practice very limited
Pembroke Dock.	Highly satisfactory.	Very rare—1 out of 75.	—	—
Portsmouth	Very satisfactory.	—	Spread on water, good	—
Sheerness.	As perfect as diaphragm shells can be.	—	—	Experience considerable.
Woolwich.	No results noted.	Reduced to a minimum.	—	From 13th Brigade only.
Shoeburyness, School of Gunnery.				
1. Colonel TAYLOR'S Report.	Generally effective, although sometimes not altogether satisfactory as regards breaking up of the shell.	—	Very good from 24-pr. and 32-pr.; not much lateral spread with 9-pr.	Practice confined to firing at a mark on water.
2. Colonel GARDNER'S Report.				

Colonel Gardner classifies the usual complaints under four heads.

(1) *Blind shells.* They are chiefly due to want of skill, in boring or fixing the fuze, or its extinction on graze. The former is remedied by instruction, the latter incidental to all shells.

(2) *Uncertain burst and dispersion of bullets.* He does not allow that this complaint is well founded.

(3) *Premature explosion.* It is very rare, and has been traced in some recent instances to the fuze having been split by the rammer.

(4) *Inaccuracy of flight.* He affirms that they are much more accurate than common shells, and scarcely, if at all, inferior to round shot.

Colonel Gardner gives six examples of actual practice.

		Range.	Rounds.	Target.	Hits.
25 / 5 / 60....	32-pr. 50 cwt.	1200	15	9 ft. × 18 ft.	1087
	8-in. 52 cwt.	,,	15		
19 / 3 / 61....	24-pr. howitzer.	800	16	6 ft. × 6 ft. 10 in. column. 15 yards. apart.	464
	9-pr. ,,	,,	16		
20 / 3 / 61....	24-pr. howitzer.	1000	22	6 ft. × 72 ft.	806
	9-pr. ,,	,,	22		
20 / 4 / 63....	24-pr. howitzer.	800	27	10 ft. × 60 ft.	1372
	24-pr. ,,	,,	27		
24 / 4 / 63....	24-pr. howitzer.	700	20	6 ft. × 12 ft.	196*
	24-pr. ,,	,,	20	6 ft. × 12 ft.	98
28 / 5 63....	68-pr. 95 cwt.	900	10	6 ft. × 12 ft.	517
	32-pr.	,,	10	6 ft. × 12 ft.	708

During this practice, which was as rapid as possible, the guns were dismounted and mounted, limbered up and unlimbered, wheels were shifted, and the detachments changed round, each operation four or five times.

* And two shells through.

CONTRIBUTIONS TO REGIMENTAL HISTORY.

[No. I.]

BY BRIGADIER-GENERAL LEFROY, R.A., F.R.S.

The present paper is the first of a series in which it is proposed to print in a more or less extended form the text of various manuscript journals and other similar documents illustrating the services of the Royal Artillery, which have been collected by the Regimental Institution or are deposited in the Regimental Library. These papers are not History, but are *pièces justificatives,* the documentary foundation for a Regimental History, and often preserve traits and details of much interest, while they record in an unpretending manner the good and gallant service of many an old soldier who has gone to his grave with no higher honor than that of having done his duty. It is believed that many more of such papers exist than have as yet come to light. We owe the preservation of a portion of the brigade orders of Major-General Phillips, R.A., in the first American war, to his friend and Brigade-Major Blomefield, afterwards Sir Thomas Blomefield, to whose son, the present baronet, the Regimental Institution is greatly indebted for their presentation among a number of professional papers collected by that distinguished officer. They include his own journals of the expedition to Denmark in 1807, in which he commanded the Artillery, and which will appear in the present series in due course.

Phillips' brigade orders have been selected for the first paper of this series because they are of moderate length, they relate to a period of regimental history which is but little beyond living memory, whose traditions of service doubtless influenced the older soldiers of our own day, and whose material may be said to be still in use; and also because he was himself an officer of great distinction, filling a position but too rarely occupied by the artilleryman.

It was towards the end of May 1776, with the opening navigation, that several regiments arrived in Canada from England and Ireland, together with a body of Brunswickers, making up the forces in the province to about 13,000 men. The general rendezvous was at Three Rivers. Phillips who had the local rank of Major-General was not at that post when the American insurgents, or provincials as they were termed, made a daring attempt from Sorel on the 8th June, to surprise the king's troops, but was on the march from Quebec: the six light 6-prs. which General Frazer had landed contributed however mainly to their defeat. The army united at Three Rivers a day or two afterwards and pushed on to Sorel, which was reached on the 14th June. Here a strong column was landed under Burgoyne on the south side with orders to follow the course of the Sorel to St John's. The rest of the army proceeded to Montreal, and finding that the rebels had abandoned the city and island, was immediately landed at La Prairie to join Burgoyne's column at St John's. Lieut.-General Burgoyne did not reach that place until the evening of the 18th June, when he found the town in flames and everything destroyed that could not be carried off. Here the campaign of 1776 virtually came to an end, for the Americans were masters of Lake Champlain, and the difficulties of transporting vessels thither precluded General Carleton from pursuing his advantages that season. He was able however to seize Isle-au-noix as an advanced post, and to devote himself without disturbance to the construction of gun boats and other vessels at that station and at St John's. Blomefield resumed his duties as aide-de-camp to Lord Townshend on the cessation of active hostilities but rejoined Phillips, who had been made Major-General in the army in August, with the earliest navigation. The extracts for 1777 commence on the 1st July, the day on which General Burgoyne's column reached Ticonderoga, and the day preceding a successful operation by which Major-General Phillips obtained possession of the very advantageous post of Mount Hope, which besides commanding the American lines, cut off their communications with Lake George. The field artillery attached to the army had been largely increased since the last campaign, and was then considered to be the finest and best appointed that had ever been allotted to a *corps d'armée* of such limited size (about 8000 men, including 500 Indians). Phillips commanded a division in the engagement which shortly followed, at Whitehall (then called Skeenesborough), and here his aide-de-camp was killed. Of the prodigious exertions by which the artillery was got over the savage intervening country at the rate of about a mile a day we learn nothing from these orders, but we know that the royal forces took possession of Fort Edward on the 29th July, and we find some indications of them in the order of 7th August from that post. The army was occupied from the 30th July to the 15th August in getting up supplies, when a force of about 500 men with two light guns was despatched to the Hoosack river to surprise Bennington, the rest pushed on to join Burgoyne at Saratoga. The expedition was a failure, the guns had to be abandoned, and the insurgents received an encouragement from this success attended as it was by the capture of such trophies, which had the most unfortunate moral influence for the royal cause.

The extracts terminate before Burgoyne's advance from Saratoga in September, but the order of the 14th of that month may be regarded as giving the artillery arrangements in force at the battle of Stillwater on the 19th, where Phillips and the artillery were much distinguished.

The enemy under Arnold had at first made every disposition to turn the right wing of the army, but "being unexpectedly checked by the strong position of General Frazer, they immediately counter-marched, and the same peculiarity of country which had occasioned their mistake, now operating as effectually to prevent the discovery and consequently the taking any advantage of their subsequent movement; they directed their principal effort to the left of the same wing." Here the brunt of the action was sustained for four hours by the 20th, 21st, and 62nd regiments, but Phillips who commanded the left wing, hearing the firing, made his way with Major Williams and a part of the artillery through a very difficult part of the forest, and leading up the 20th regiment at a critical moment* saved the day.

* The terms employed in the official record of Phillips' services are, that "his presence of mind had nearly saved the army," and this is the expression of the writer of the Annual Register for

"Though every part of the artillery" we are told "performed almost wonders in this action the brave Captain Jones (who was unfortunately though gloriously, killed) with his brigade, were particularly distinguished."*

It is not the purpose of this introduction to trace the American campaign of 1777, but only to supply what is requisite to make the circumstances under which the following orders were issued intelligible. The brevity of the extracts is to be regretted, but it can be readily imagined that at such a time the brigade-major had something else to do than make notes. Captain Blomefield himself was severely wounded with a musket ball through the front part of his head, at Stillwater, and was left for some time on the field of battle, but his life was providentially spared, and in the spring of 1779 he returned to England. With this event the record closes, but it is hoped that the publication of an imperfect account may have the effect of inducing parties in whose possession there may be further particulars to communicate them for future use.

Extracts from the Brigade Orders of Major-General Phillips, R.A., in Canada, 1776–7.

NOTE.—*The italics are all in the original.*

1776.

June 3rd, 1776. Lieut Twiss is to proceed to *Three Rivers* and give his directions for constructing of boats; the description of one of these boats is a common flat bottom, called a "king's boat," or "royal boat," calculated to carry from 30 to 40 men with stores and provisions, with this only difference, that the bow of each boat is to be made square resembling an English punt, for the convenience of disembarking the troops by means of a kind of *broad gang-board* with loop-holes made in it for musketry, and which may serve as a mantelet when advancing towards an enemy, and must be made strong accordingly.

1777, whence the above extract is taken. It is a somewhat unusual phrase for hinting that the army was nearly lost; but as was recently pointed out by a writer in the United Service Magazine of September, 1864, it is one that misleads. The victory was a barren one but it remained with the royal troops. When the same writer proceeds to say that Phillips never served under Clinton and died a prisoner of war in Virginia he is at variance with the contemporary accounts. The official record of his services distinctly states that he was attached to the army under Lieut.-Gen. Sir H. Clinton at New York in 1781, and the Annual Register for that year states that a convoy arrived at New York in March 1781, with Major-Gen. Phillips and 2000 men on board, adding, "The long durance which that distinguished officer with his fellows of the Convention Army had undergone, having been happily terminated by a new cartel, which had been some months before concluded, he was now appointed to take the chief command in Virginia." He died on that command on the 13th May following.

* The public papers having been much occupied recently with discussions on longevity, it may be interesting to state that the widow of this gallant officer survived him 69 years, and died in 1846, in her 103rd year. She enjoyed for that long period the provision of the Royal Artillery Marriage Society, and the testimony as to her age is unquestionable.

June 6th. *The General having directed Major-General Phillips to take the Department of Artillery and Corps of Engineers under his Command.* He is assured the utmost harmony and good disposition will subsist between the two corps, so very necessary for His Majesty's service.

Major Williams being commanding officer of the detachment of artillery under Major-General Phillips, will have the ordering all details and ordinary duties, and he will receive his orders from and report to Major-General Phillips on all occasions. Major Gordon will make such arrangements in the Corps of Engineers as he shall see proper, and will be so good to order an officer to receive orders from the major of brigade every day.

The major-general informs the officers that in common detail duties he means to adhere to a roster, but in particular cases not, as he shall always employ such officers as he shall think most proper from experience in the service, and he makes no doubt but the young and newly appointed officers will use every means to make themselves intelligent in the service, and by activity and a strict attention to their duty, render themselves useful and good officers; and does assure them, he shall study to give them every possible mark of regard and favour accordingly. The major-general relies on the captains for the strictest attention to their subalterns and men, that they will discourage all ideas of difficulties, and prepare them for a fatiguing campaign, which the major-general is assured will be entered upon with zeal and pursued with all manner of activity, subordination, and strict discipline.

June 7th. Second Lieut. Collier will act as secretary to Major-General Phillips during this campaign, all orders signified by him from the major-general are therefore to be obeyed.

June 8th. Major Gordon on compleating two armed boats and having given such orders relating to the rest, as also with regard to the large boat, so that the compleating of the whole may go on under the direction of the engineer who is left at Quebec, will set out as soon after as he pleases for the army. He will direct engineer Wade to take such plans, and make such inspection of the works at Quebec as may be necessary to form a report for the General of the present situation of the place, so that arrangements may be taken to put it into that state of defence as may be thought proper.

Captain Jones will remain at Quebec, taking upon him the command of the Garrison Artillery.

German additional gunners at Quebec are to receive 6d. per day, and non-commissioned officers 7d. per day.

As all orders in detail go through Major Williams, he is to have an officer constantly attached to him, who will receive brigade orders, and the detachment will obey any order delivered in Major Williams' name by this officer during the campaign: Major Williams will appoint whom he pleases to this duty.

Lake St Peter's.

June 14th. Two brigades to be formed immediately and ready for landing under Major Williams; each brigade to consist of *four* 6-prs.; the first, Captain Carter and his company; the second, Captain Walker, and his company; the rest of the officers and men are to be divided, as to render the two brigades equal, an ammunition cart with each gun with its proper proportion of ammunition and stores.

The brigades to be divided, and officers attached to each directly, so that when guns are ordered to be separated from either of the brigades it may be instantly done, with the proper number of officers and men: to do this, each brigade must be divided and subdivided.

A proportion of entrenching tools to be taken with each brigade, as it may be necessary to form batteries when on shore.

The greatest precision is to be observed by the officers in giving their orders, the greatest coolness and subordination by the men in obeying them, and as the use of artillery in action will depend on a clear arrangement and management of the guns, and a strict attention of the men to their officers, in order to which the most profound silence is absolutely necessary: Major General Phillips, *therefore orders the officers to punish on the spot during the time of action any disobedience of their orders.*

The officers in the field being separated, are to command according to seniority, but are not to detach themselves from the brigade to which they are posted by Major Williams according to his order.

Particular instructions in the field when landed, relative to the nature of ammunition to be employed at particular times, will fall under the orders of Major Williams, the captain commanding brigades, and the eldest officers as they may happen to be detached.

Major-General Phillips relyes on Major Williams and the detachments continuing that zeal and good conduct for which the corps of Artillery have hitherto been so fortunately distinguished.

The utmost care to be taken that the artillery do not uselessly fire away their ammunition; nor even fire at all, but when some object appears to make it necessary. The great consequence of this order will be evident from considering how difficult it will be to supply regularly the ammunition on shore. This order is particularly addressed to the young officers who are to take care not to fire their guns too quick, and not without being well sponged and carefully pointed; whenever it may be necessary to call for the assistance of the infantry in deep roads or marshy grounds, or in steep ascents or descents, application must be immediately made to the Brigadier-general, if with the brigade, or otherwise, to the commanding officer of the nearest regiment if the situation is so critical as to prevent an application to the commanding officer of the troops on the spot.

Articles which are to be ordered to *Chamblie* by the first conveyance: a field officers' tent and marquee, for Major Gordon; six officers do. compleat; the engineers' instruments, and a box of stationary.

July 6th. Major-General Phillips has appointed Second Lieut. William Houghton to be firemaster to the detachment of the Royal Artillery in Canada, and he is to be obeyed as such. The serjeants and corporals are for the future to use carbines instead of halberts when on duty.

July 11th. In the quick firing motions, the man who rams home is on falling back, to give the word "fire" as usual; but is on no account to turn his head, but keep his eyes fixed on the muzzle of the gun so that he may be certain when the gun is fired before he steps forward to sponge.

The gunner that fires, although he hears the word "fire" from the man who rams, is yet not to put the portfire to the vent but by order of the officer or non-commissioned officer who is at the gun.

In quick firing practice, the gun is to be sponged between every firing except now and then; by order of the commanding officer a few rounds may be fired without sponging, to practise the men for a time of action when this may become necessary.

The officers will order sponging again by a word of command.

Aug. 11th. Major Williams will order a practice with a medium 12-pr., a light 6-pr., a light 3-pr., an 8-in. howitzer, and two mortars at the battery, to begin to-morrow and continue all the week, morning and evening.

As it is possible this will be the only practice before the companies separate, it is to be carried on with great attention, and to be practice for service and not experiment; and it is intended to make the officers and men perfect in the use and ready managing the artillery in the field. In the course of the week an experiment will be made to fire royal shells from 24-pr. guns. The mortars are to be fired at small ranges, and each day a fixed quantity of powder, by which, from the different ranges may be formed, a mean range of each day's practice.

The latter part of the week will be firing of grape shot.

NOTE.—We find above one of the earliest public allusions to that horizontal shell firing which is now developed to such destructive proportions. August 11th, 1776.—"In the course of the week an experiment will be made to fire royal shells from 24-pr. guns." The first suggestion for the employment of shells in this way is commonly attributed on the authority of Drinkwater to Captain Mercier of the 39th regiment, in the defence of Gibraltar in 1782; it is satisfactory to claim priority for an artilleryman; but a much earlier date than either of those may in fact be assigned to the proposal. In 1709 M. de Grignan wrote from Marseille to the French Minister of War "that a young Italian named Piret had proposed to throw a hollow projectile from a cannon horizontally with a fuze which should ignite by the fire of the piece, and that this hollow projectile submitted to trial by M. d'Albert, Lieutenant of Artillery, had succeeded well the second attempt."—(Paixhans). There is an interesting proof that this subject was brought to the notice of Lord Nelson. "In looking over a bundle of old papers that once belonged to Lord Nelson," writes Mr John Wilson Croker to Sir George Murray, "I found the enclosed plan for firing shells from cannon, I believe the idea has been since carried much further, and that the plan is of no value now-a-days, but nevertheless, I think it may as well be placed in your archives at the Ordnance office. It was found in a bundle of papers of dates prior to 1801." The paper in question was forwarded by Sir George Murray to the office of the Ordnance Select Committee, 1 May, 1845, and is there preserved. It contains the particulars of experiments made at the Military School of Auxonne, in 1784—1786, with 8-in. shells fired from a bronze cannon with various charges, at angles of about 40°; if our great naval hero ever seriously thought of augmenting the power of his broadsides, it can scarcely have failed to occur to him, that what could be fired from cannon at 40° could be fired at lower angles, nevertheless the world waited twenty years longer before the idea forced its way to attention, and became the basis of new tactics in artillery.

Chambly.

Aug. 13th. The following disposition will take place for the artillery for the campaign:—

Captain Carter's brigade	12-prs. medium	4
	6-prs. light	4
	howitzers 8-in.	4
	howitzers 5-in.	4
Captain Mitchelson's brigade attached to the left wing of the army.	6-prs. light	4
Captain Borthwick's brigade attached to the right wing of the army	6-prs. light	4
	3-prs. light	4
Captain Walker's brigade detached with Brig.-Gen. Fraser's corps	6-prs. light	4
	3-prs. light	4
	howitzers $5\frac{1}{2}$-in.	2

The heavy artillery for the service will be communicated in particular to Major Williams.

Captain Walker with his company complete to march to-morrow sen'night to join Brigadier-General Fraser's corps; 1st Lieut. Dunbar is to be added to Captain Walker's company for the campaign.

Captain Mitchelson's brigade to be composed of two subalterns, and a detachment of two non-commissioned officers and eight men from Williams', Carters' and Captain Borthwick's companies, Lieut. Dysart and the youngest Lieut. of Captain Carter's company for this brigade.

Captain Borthwick will have his own company, with Lieut. Barnes added to it, for the campaign for his brigade.

Captain Carter's brigade to consist of his own company and Major Williams'.

Major Williams command the whole wheresoever he happens to be, but he will be particularly attached to the artillery of the park.

Whenever detachments are made it will be by brigades, divisions, or subdivisions of brigades as the service may require, but the officers and men are to be attached as they are now brigaded till further orders.

Whenever the service of heavy artillery requires detachments of officers and men, they will be taken by divisions and subdivisions of brigades, and it is to be observed that none of these detached duties will be done by *roster*, but the officers and men taken in the manner before mentioned, as the only method by which the service can be carried on with propriety and precision.

Captains commanding brigades will take care that their subalterns and non-commissioned officers are perfectly acquainted with every part which concerns them.

Captain Walker will exercise his company every day with the 3-prs. which have shafts, in the mounting, dismounting and carrying of them, and in every other particular for which they are intended.

Proportion of Ammunition.

	Round.	Case.	Shells.
12-pr. medium	120	80	
6-pr. light	120	80	
3-pr. light	220	80	
Howitzers 8-in.	—	40	60
Howitzers $5\frac{1}{2}$-in.	—	50	100

A proportion equal to this to form a reserve which will be carried in the *Radeaus* with the heavy artillery.*

A proportion also equal to this to be lodged at St John's as a depôt.

Major Williams will take care that the proportion of laboratory and other stores, and every particular necessary to compose the proportion of ammunition &c., &c., &c., for the brigades for the reserve, and for the depôt is prepared as soon as possible.

Two conductors of stores to be attached to Captain Carter's brigade, and two to Captain Walker's brigade, one conductor to Captain Borthwick's, and one to Captain Mitchelson's brigade.

One ammunition cart to be for each of the light guns and royal howitzer.

The medium 12-pr. and 8-in. howitzer, one ammunition wagon each.

A number of entrenching tools equal to two wagons' load to be sent with Captain Walker's brigade, the remainder with the park of artillery.

Particular orders will be given relating to the powder, musket shot, musket cartridges, paper, &c., &c., &c.

The Commissary will take care that all materials in his department are taken upon the lakes.

1777.

July 1st, 1777. *Major-General Phillips is sorry he is under the necessity of repeating what he thought would have been sufficiently impressed upon the officers' minds: that fatigues and difficulties would certainly attend this campaign, but that he expected and made no doubt they would go through both with cheerfulness, with credit to themselves, and with due obedience and zeal for the King's service.*

The Major-General desires the utmost alertness and dispatch in all the different movements of the army, and particularly upon coming to fresh ground; and in a campaign such as this, that officers act, from their own lights, and not tediously wait for fresh intelligence and new orders in matters which should go on from day to day; and it is to be observed that all orders and regulations are to be considered as standing orders unless contradicted; he hopes no officer during the present critical situation of the army be ever out of camp, unless upon duty; and that they will every morning, as soon as it is light, reconnoitre and become perfectly acquainted with the ground all round their own camp, and also as it bears towards any other of the army.

The Major-General does not wish to have it supposed that he is dissatisfied with the corps he has the honor particularly to command, but they cannot but be sensible that some things have happened not quite to his satisfaction; he does assure them that when they give him cause to interest himself for their credit and honor, he will do it with indefatigable zeal and the most cordial frendship.

All orders to be most carefully read to the men every day, and the particulars explained to them by an officer.

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* "Radeau," a timber raft. The term was probably applied to some large flat-bottomed vessels.

Fort George.

Aug. 4th. Captain Carter is appointed commissary of horses to the Royal Artillery, Lieuts. Dunbar and Rimington are to act as assistant commissaries till further orders; Lieut. Dunbar to have charge of the brigades attached to the wings of the army, and to the advanced corps and German reserve. Lieut. Rimington to have charge of the brigades of the park, and all the trains attending of it.

Fort Edward.

Aug. 7th. Major-General Phillips signifies to the commanding officer of brigades that he has *reason to suppose that the ammunition and Canadian carts* breaking down have been owing to their being overloaded, whereas the proportion of ammunition and stores for each does not amount to more than 8 *cwt.* a calculation which they will very well bear; the overplus weight must therefore have been baggage or some other improper loading; and the commanding officers of brigades must be sensible that nothing ought to be loaded upon artillery carriages, but such stores as absolutely belong to the service; it is the Major-General's most positive orders that the officers are in a particular manner attentive in the examination of the ammunition carts upon a march, and whatever they find loaded in any of them, which is not a part of the artillery proportion, it is to be taken out, a fire to be made, and such baggage or luggage is to be immediately burned; and in order to prevent entirely any infraction of this order, the officers are to make this inspection of ammunition carts very frequently in a day's march, and whatever non-commissioned officer, soldier, or artificer shall be detected in having put anything into an ammunition cart or wagon, he is to be tried on the spot by a field regimental court martial; when it is not doubted but the most severe punishment will be inflicted; and the Major-General does in the most positive and direct manner, make the commissioned officers of brigades and the other officers answerable for strict observance and due obedience to this order; that the King's service may not suffer or be retarded from any motive of private convenience contrary to every custom and every strict rule of discipline and of service.

The men are to carry their knapsacks, haversacks, and blanket as is usual with the troops, but their tents, poles, &c. are to be carried for them in country carts, a proportion of which is fixed to each brigade.

Orders are given to the major of brigade to visit the artillery on their march, and to report whether these regulations are adhered to; and the Major-General will himself inspect the order of march, and if he finds any disobedience to this most serious necessary and positive order, he will, if a non-commissioned officer, or soldier, order him to be punished on the spot, if it should unfortunately happen (which can scarcely be imagined) that an officer should be in any shape neglectful of his duty, in these instances he must expect without distinction to person or rank, be brought to a public examination

Sept. 7th. By Major-General Phillips there is reason to suppose that the park of artillery does not get the general orders of the day, and that even the *parole* and *countersign* is not known in the camp of the park.

This seems to be so very uncommon a neglect that it must be owing to some particular cause; which Major Williams will point out that it may be remedied.

The dangerous consequences of a want of orders are too plain to need explaining—whenever the adjutant cannot go for orders, a non-commissioned officer should be sent to the Major of Brigade for them.

Sept. 14th, To all brigades of artillery there are certain proportions of powder and stores alloted, that in case any division is detached, it may always have with it every necessary *matériel* for the service, and the wagons, carts, and horses belonging to such proportions of stores are to be under the immediate care of the conductor of horse belonging to such brigade to which they are alloted: the remaining wagons and carts containing powder, entrenching tools and other various stores, is usually called the reserve of the park—is to be drawn up in the rear of the brigade of artillery—is to have a conductor of horses for its service, and has attached to it such clerks of stores, conductors and artificers as do not immediately belong to the brigades.

When all the park division are together, they form one brigade, and the line of march should not be intermixed with any carts, or wagons, containing any other stores than the ammunition: the baggage, powder, entrenching tools, and wagons belonging to the several divisions are to fall into the rear immediately after the guns and ammunition. Captain Carter's brigade of the artillery of the park under Major Williams is to be formed into three divisions.

A Right, Centre, and Left.

The right and left divisions to consist of the 12 and 6-prs. as before.

The centre division to consist of the howitzers and 24-prs., the line of the park is to be drawn up as before, the two 24-prs. being the centre pieces of the artillery.

Line of March by the Right.

Right division	Two light 6-prs. Two medium 12-prs.
Centre division	One royal howitzer. One 8-in. ,, Two 24-prs. One 8-in. howitzer. One royal ,,
Left division	Two medium 12-prs. Two light 6-prs.

The ammunition wagons and carts belonging to each nature of artillery to follow immediately after their proper guns and howitzers.

To follow immediately this Line of March.

Baggage wagons of the companies.
Spare carriages.
Entrenching tool wagons.
Powder wagons.

Conductors and artificers carts of the three divisions.
One forge cart.
Surgeons and mates medicine carts.
Major Williams's baggage.
Captain Carter's ,,
Officers ,,
Baggage of the civil branch.

The Reserve Train.

Whenever the artillery is ordered to march without baggage, there will nothing presume to follow the line of march but the artillery, its ammunition, spare carriages, and entrenching tools and surgeons' and medicine carts, carts with artificers' tools, and forge.

Major Williams' and Captain Carter's companies to furnish an equal proportion of men for the centre division. Subalterns for the right division are, Lieuts. Rimington and Cox; left divisions, Lieuts. York and Davids; centre division, Lieuts. Houghton, Dysart, and Collier.

These officers are on this day to make a general survey of the ammunition wagons and carts, to see that the stores are all in order, and to instruct the non-commissioned officers in what manner they are to be got at when wanted; the arms of the guns as well as their boxes and vents are to be examined, to see that no dirt be lodged, or any obstacle to their service.

A general exercise of the detachment to be on this day at the most convenient *hour*, and everything prepared for immediate service and action, that Major Williams may report it accordingly at gun firing this evening, in order that the *Major-General* may make his report to the Commander-in-Chief.

Whatever men may be wanting to make up the number of eighteen to each piece of artillery are to be given this day by the detachment of the 83rd Regiment. Lieuts. Dysart and Collier to immediately join the park and encamp with it till further orders.

Captain Bloomfield, major of brigade, having desired in the present want of captains to do his duty in the park, the Major-General allows of it, and he will be ordered to such parts of the artillery occasionally as may most require it; he is therefore to make himself acquainted with the *right* and *centre division* in order that he may be posted to either of them when ordered.

Captain Hosmer will have such parts of the artillery as move with the left wing as usual.

Captain Carter will inspect every part of his brigade. Major Williams will take his post and change it as he sees most for the good of the service.

The detached brigades will take their orders from the generals with whom they immediately serve, and report directly to the Major-General.

End of the extracts.

ERRATUM.

Page 214, lines 3, 4 from bottom, *for* "Round-ended 0·39″," "Flat-ended 0·14″," *read* "Round-ended 0·14″, "Flat-ended 0·39″."

ERRATA.

Table C, facing p. 220, sixth line from *top*, in column "Result," *for* "Penetrated plate, and about 17″ of wood," *read* "Penetrated plate, and about 12″ of wood."

Table A, at back of Table C, sixth line from *bottom* in column "Plate or target," *for* "Scott Russell's target," *read* "Warrior Section."

MEMOIRS

OF THE

ROYAL REGIMENT OF ARTILLERY,

BY COLONEL FORBES MACBEAN, 1743–1779.

[No. II.]

[Printed from MSS. in Royal Artillery Library, Woolwich.]

In June 1743 the Royal Regiment of Artillery consisted of eight companies, commanded by a Colonel (Lieut.-General Albert Borgard), Lieut.-Colonel (Thomas Pattison), and Major (Jonathan Lewis), with the following staff officers, viz. Chaplain, Adjutant, Quarter-Master, Bridge-Master, Surgeon and Mate.

N.B. The first who had a commission of Colonel of the Royal Regiment of Artillery was Lieut.-General Albert Borgard; it is dated November 1st, 1727, and the Regiment consisted then of four companies.

The establishment of each company was, one captain, one captain-lieut., one first-lieut., one second-lieut., and three lieut.-fireworkers; three serjeants, three corporals, eight bombardiers, twenty gunners, sixty-four mattrosses, and two drummers, making one hundred and seven each company.

The pay of the officers was the same then as at present (1783), that of the lieut.-fireworkers three shillings per diem—two shillings and three pence subsistence, and ninepence arrears.

The uniform dress of the officers, was a plain blue coat lined with scarlet, a large scarlet Argyle cuff, double-breasted, and with yellow buttons to the bottom of the skirts, scarlet waistcoats and breeches, the waistcoats trim'd with a broad gold lace, and a gold laced hat.

The serjeants coats were trim'd, the lappels, cuffs and pockets with a broad single gold lace, the corporals and bombardiers with a narrow single gold lace; the gunners and mattrosses, plain blue coats; all the non-commissioned officers and privates having scarlet half-lappels, scarlet cuffs, and slashed sleeves with five buttons, and blue waistcoats and breeches; the serjeants hats trim'd with a broad and the other non-commissioned officers and privates with a narrower gold lace—white spatterdashes were then worn.

The regimental clothing was deliver'd to the non-commissioned officers and privates once a year, excepting regimental coats, which they received only every second year, and the entermediate year a coarse blue loose surtout which served for laboratory works, cookings, fatigues, &c. was deliver'd with the usual small mounting.

The arms of the officers were fuzees, without bayonets, and not uniform; the serjeants, corporals, and bombardiers were arm'd with halberts and long brass hilted swords, the gunners caried field staffs about two feet longer than a halbert, with two linstock cocks branching out at the head, and a spear projecting between and beyond them; great attention was paid in keeping these very bright; a buff belt over the left shoulder slinging a large powder horn, mounted with brass over the right pocket, and the same long brass hilted swords worn by the non-commissioned officers. The mattrosses had only common musquets with bayonets and cartouch boxes.

The regiment was distributed in the following manner, viz. one company in Minorca, one at Gibraltar, one at the fishing ports in Newfoundland, three with the army in Flanders, and two at Woolwich; the two last furnished all detachments, which at that time were only those on board the bomb vessels on service with the fleets in the Mediterranean and West Indies.

1744 In March, two companies were rais'd and added to the regiment, which now consisted of ten, and were disposed of as follows, viz.

In Minorca, Gibraltar, and Newfoundland, one company at each—one company was sent to Flanders in addition to the three already there, and three remained at Woolwich.

In June, His Royal Highness William Duke of Cumberland came to see some expertments and a proof of guns at Woolwich, when the three companies there were under arms, commanded by Major Lewis; about twenty cadets then at Woolwich, were form'd in a rank entire on the right of the companies, without arms or uniform and no officer at their head. The officers did not then practice saluting with the fuzee, and only pull'd off their hats as the duke pass'd them.

A circumstance which does so much honour to the corps of Artillery as the following, ought to be mentioned.

The King of Sardinia then in alliance with Britain, being threaten'd with an invasion by the combined armys of France and Spain; apply'd to Admiral Mathews commanding the fleet in the Mediterranean, and prevail'd with him to consent that the detachments of artillery serving on board the four bomb ketches in the fleet, should be sent on shore to take charge of the most important posts and batterys on his frontier, from a persuasion as may be justly presumed, that they were more to be depended on than his own artillerists. This detachment consisted of one captain, four lieutenants, and twenty-four bombardiers, and perform'd all that was required of them perfectly to the satisfaction of His Sardinian Majesty; they were taken prisoners in the defence of Montalban and Montleuze, two strong posts which were taken by the French and Spaniards by assault in April.

1745 In January, a company of gentlemen cadets was first established and added to the regiment. The cadets mention'd before were two cadet gunners and two cadet mattrosses, hitherto mustered in each company—the former received one shilling and fourpence, and the latter one shilling per diem, paid them monthly by the captains in whose companies they were mustered. A few of these young gentlemen, who were generally the sons of officers, resided at Woolwich, and attended the Royal Academy when they pleased; were under no command, wore no uniform, and were generally so young that few of them were fit to be prefer'd to commissions. So little were these young gentlemen under any kind of order, that it was the business of the officer on duty in the Warren, who visited the Academy occasionally, to endeavour to preserve good order.

N.B. The Royal Academy was first established in 1741 by the Duke of Montague then Master-General.

The disposition of the three companies at the fixed stations of Minorca, Gibraltar, and Newfoundland continued the same.

Three companies remain'd at Woolwich till August, when upon the taking of Cape Breton, one of these was sent to garrison Louisbourg, and in the month of October, the four companies in Flanders were order'd home in consequence of the rebellion in Scotland, and were employ'd in N. and S. Britain with the several corps of troops which assembled on that occasion.

A detachment of three officers and fifty men was sent from Woolwich in August, with a battalion of guards and the 15th Regiment, to strengthen the garrison of Ostend, then beseiged by Count Lowendahl, which held out about fourteen days. A circumstance so different from the present mode should not be omitted to be noticed. At the camp of the allied army near Brussels, on receiving the news of the taking of Cape Breton (or Louisbourg), the army was drawn up in order of battle and reviewed by the Duke of Cumberland; the park of artillery was form'd in great order, on a fine extensive plain near Vilvorden; the four companies of artillery under arms, drawn up, two on the right and two on the left of the park; Colonel Pattison then lieut.-colonel, Colonel Lewis then major of the regiment, and Major Belford, then a captain but doing majors duty to the artillery in Flanders, posted themselves on horseback in front of the park, where they saluted His Royal Highness as he pass'd, by dropping their swords; the other officers carrying fuzees, only took off their hats as he pass'd them.

December 8th. Two companies with a train of artillery commanded by Colonel Lewis, marched from Woolwich to Finchley Common, where a corps of troops was to have assembled under the immediate orders of the King, had the rebels advanced to London as was then apprehended, but they retired northward from Derby, and these two companies and the train of artillery return'd the 11th to Woolwich.

1746 The disposition of four companies in Minorca, Gibraltar, Newfoundland, and Louisbourg, continued the same as last year, one company was station'd in Scotland, and five companies remain'd at Woolwich till after the suppression of the rebellion in April, by the victory of Colloden, when two of these companies were sent in June with seven battalions to join the allied army in Brabant, and one company embark'd in May, with six battalions commanded by Lieut.-General Sinclair, on an expedition to the coast of France, where a fruitless attempt was made on Port L'Orient—this expedition was originally intended against Quebec. Two companies remained then at Woolwich.

N.B. The company detach'd on the expedition to the coast of France was commanded by Captain Chalmers. He and the company under his command were put by express orders of the Master-General under the command of Mr Armstrong the chief engineer on that service, who had not at that time nor ever had, before or since, any rank or commission in the army; for the corps of engineers had no military rank or title till the year 1757; and the circumstance just now mention'd, is the more remarkable, as hitherto on all services, whatever engineers were employ'd were immediately under the command of the officer commanding the artillery, and always encamp'd and mess'd with that corps, and were detach'd by him as occasions required.

During this campaign in Brabant, two field pieces, being heavy 3-prs. commanded by a lieut. and a detachment of artillery, were for the first time attach'd to each regiment, and encamp'd with it.

1747 Early in this year three companies were raised and added to the regiment, now consisting of thirteen.

About the same time three regiments of cavalry being reduced to dragoons (now the three regiments of dragoon guards) and the troopers having it in their option to remain as dragoons or be discharged, many of them chose the latter, and above two hundred of these inlisted in the artillery; from this period the regiment improved much in appearance and in the size of the men, neither of which had been hitherto much attended to, but receiving at once so many tall men in the corps, may be said to have given rise to the change that has taken place in regard to the height, figure, and strength of the men which now compose it.

The thirteen companies were disposed of during this year as follows. Five companies continued stationary in Minorca, at Gibraltar, in Newfoundland, at Louisbourg, and in Scotland.

The two companies which were sent last year to serve in the army in Brabant were augmented to five, by the junction of two companies from Woolwich, and also, of that which was employ'd last year on an expedition to the coast of France.

One company was embark'd on an expedition to the East Indies, commanded by Admiral Boscawen, who fail'd on an attempt on Pondecherry.

Two companies remain'd at Woolwich, from which a detachment commanded by a captain-lieut., with three lieuts., and seventy non-commissioned officers and men were sent in July, to assist in the deffence of *Bergenop Zoom*—this detachment lost fourteen men during the seige.

This year the corps of artillery in Flanders, commanded by Lieut.-Colonel Belford and Major Borgard Mitchelson was well train'd in the use of small arms; for the first time there were field days and the corps had improved so much in the manual exercise and common manœuvres of the infantry which had never been hitherto practis'd in the regiment, that His Royal Highness the Duke of Cumberland review'd the five companies. Upon this occasion the gunners of each company with their field staffs form'd upon the right as a company of grenadiers, and the mattrosses with their musquets as a battalion, in which manner they pass'd in review.

During this campaign a quarter guard of the regiment of artillery, commanded by a subaltern (as usual in the infantry), was first mounted, and encamp'd opposite the Flag Gun and Kettle Drum,—a detachment from the infantry commanded by a captain, with from sixty to an hundred men were always mounted upon the park of artillery, and encamp'd opposite the centre of the park, being relieved every forty-eight hours.

1748 January 28th. On Lieut.-Colonel Thomas Pattison and Major Jonathan Lewis retiring from the regiment on account of their old age and infirmities (who were succeeded by Lieut.-Colonel Belford and Major Borgard Mitchelson) the King signed a warrant authorising the Master-General to make a provision of full pay for them: the warrant begins thus, "Whereas the four field officers of the Royal Regiment of "Artillery, are the Master-General of our ordnance, Colonel Commander-in-"Chief of the said Regiment, a Colonel of Artillery Colonel Commandant of "the same, a Lieut.-Colonel and a Major."

February 11th. The King sign'd a warrant directing that from henceforth, when any vacancy or vacancies of a matross or matrosses shall happen in any of the companies of the Royal Regiment of Artillery, the said vacancy or vacancies shall be continued until the money arising therefrom shall be sufficient to procure a proper recruit or recruits, and no other allowances shall be made for that purpose.

Before the army took the field this year—the gunners field staffs, powder horns with slings and swords, and the mattrosses musquets were laid aside, and both these stations were arm'd with carbines and bayonets; all the non-commissioned officers still continued to have halberts.

Black spatterdashes were likewise introduced about this time in the regiment, and for the first time in any British corps.

The same distribution and establishment of the companies last mentioned continued without any material variation, till the latter end of this year, when upon the peace of Aix-la-Chapelle and the return of the British troops from Flanders; three entire companies, officers included were reduced, who afterwards came into their former ranks in the regiment as vacancies happen'd; the junior of these came into full pay in 1753.

During the war from 1742 to 1748 Flanders was the great school for military discipline, particularly after the Duke of Cumberland was appointed in 1745, captain-general and commander-in-chief of the British troops, and took the command of the allied army.

In 1742 and 1743 the British troops there consisted of nineteen battalions and nineteen squadrons, with twenty-four heavy 3-prs.

In 1744 there were twenty-two battalions and twenty-nine squadrons with the allied army, with ten heavy 6-prs., thirty heavy 3-prs., and four 8-in. howitzers.

In 1745 the British troops in Flanders consisted of twenty-seven battalions and twenty-six squadrons, ten heavy 6-prs., twenty-seven heavy 3-prs., six 1½-prs., and four 8-in. howitzers.

In 1746 there were no more in Flanders than seven battalions and nine squadrons, with fourteen heavy 3-prs. for the battalions.

In 1747 there were fourteen battalions and fourteen squadrons with six heavy 12-prs., six heavy 9-prs., fourteen heavy and twelve light 6-prs., fourteen heavy 3-prs., two 8-in. howitzers, and six royal mortars.

In 1748, being the last campaign of the war, the British troops in Flanders consisted of twenty-two battalions and fourteen squadrons, six heavy 12-prs., six heavy 9-prs., fourteen heavy and forty-four light 6-prs. (these last for battalions) two 8-in. howitzers, and six royal mortars.

N.B. The above abstract of the troops and artillery in Flanders during the war of 1741 is given to mark the utility the artillery was found to be of, by the quick progress it made in the addition of it in proportion to the number of troops employed during that period.

It is a justice due to the regiment of artillery to mention here that on all occasions during this war wherever the corps or any part of them was brought to act, their behaviour was such as to distinguish them greatly, gain'd them great applause from the troops with which they served, and thereby established the reputation of the regiment.

The regiment of artillery owes much to the memory of Colonel Belford and Major Borgard Mitchelson for their zeal and diligence, and their influence during the campaigns 1747 and 1748, while they commanded in Flanders; for the corps then began to emerge from that state of oblivion and obscurity in which it had hitherto remained. It now began to bear a regular military appearance; great attention was paid to good order and strict discipline and subordination, a change, that was far from being agreeable to the older officers, who being promoted from the ranks had grown up with erroneous notions and bad habits, inconsistent with any military system; but the junior officers who of late had been promoted from the Cadet Company being of a different stamp, and better educated, and being now the majority, enter'd with great zeal and a military spirit into the newly adopted alterations and improvements that were introduced by these two officers.

N.B. The first fifers in the British service were established in the Royal Regiment of Artillery at the end of this war, being taught by John Ulrich, a Hanoverian fifer, brought from Flanders by Colonel Belford when the allied army separated.

1749 During the peace, the Royal Regiment of Artillery consisting of ten companies continued on the same establishment as last mentioned, and station'd as follows, viz. in Minorca, Gibraltar, Newfoundland, and Scotland, one company at each; the company heretofore at Louisbourg was on the giving back of that fortress to the French in 1749 sent to Nova Scotia, a new colony, and the remaining five companies station'd at Woolwich, one of which was generally at Greenwich for the ease of quarters.

On occasion of the peace of Aix-la-Chapelle a magnificent firework was exhibited in the Green Park, and the corps of artillery was then review'd for the first time by the King.

The two companies in Minorca and Gibraltar were this year relieved from Woolwich for the first time since these places came into the possession of Britain.

July 6th. On occasion of the death of the late Master-General the Duke of Montagu, the King sign'd a comission constituting and apointing General Sir John Legonier then lieut.-general of the ordnance to be colonel en second of the Royal Regiment of Artillery and captain of the company of Gentlemen Cadets.

1750 The regimentals of the non-commissioned officers and men underwent an alteration. The serjeants coats were laced round the button holes with gold looping; the corporals, bombardiers, and rank and file had yellow worsted looping in the same manner. The corporals and bombardiers had gold and worsted shoulder knots, the surtouts were laid aside and complete suits of clothing were deliver'd yearly.

1751 In March this year, Lieut.-General Borgard died, who was the first colonel of the regiment of artillery in Britain; he form'd and founded the corps as well as the science of artillery in the British dominions, he was succeeded by Colonel Belford.

The 30th of April this year, the King was pleased to issue a declaration and order under his sign manual, ascertaining the rank of the officers of His Royal Regiment of Artillery, to be the same as that of the other officers of his army of the same rank, notwithstanding their commissions having been hitherto sign'd by the Master-General, the lieut.-general or principal officers of the ordnance, which had been the practice hitherto—and from this period all commissions of officers in His Royal Regiment of Artillery, have been sign'd by his Majesty and countersign'd by the Master-General of the Ordnance.

Hitherto all non-commissioned officers, privates and even drummers had warrants, sign'd by the Master-General and countersign'd by his secretary, appointing such a one, a serjeant, bombardier, gunner, mattross or drummer in the Royal Regiment of Artillery; for which a serjeant paid * a mattross or drummer and the other stations in proportion; a custom that with great propriety was now abolish'd, as no one purpose appears to have been answer'd by it.

February. The majority of the officers of the regiment enter'd into an agreement for the establishing a fund for the benefit of the widows of the corps, no sort of provision having been hitherto made for the widows of the officers in the Royal Regiment of Artillery.

1753 On the death of Colonel Thomas Pattison, who had retired from the regiment as noticed in 1748 on his lieuts.-colonel pay; the lieut. fireworkers presented a memorial to the King supported by the Duke of Cumberland and Sir John Legonier then lieut.-general of the ordnance, requesting that his pay might be applied to the making up theirs equal to that of an ensign at three shillings and eightpence per day; this was granted, and took place in March this year, their subsistence being now two shillings and ninepence per diem, and elevenpence per diem arrears, instead of two shillings and threepence per day, and ninepence arrears which they had hitherto.

June 13th. The King review'd in the Green Park five companies of the regiment then at Woolwich and the cadet company—the detail of their

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* Not stated in MSS.

strength in the field was one colonel, one lieut.-colonel, one major, five captains, six captain-lieuts., four first and seven second-lieuts., and seventeen lieut.-fireworkers, chaplain, adjutant, quarter-master, bridge-master, surgeon and mate; fifteen serjeants, fifteen corporals, one drum-major, ten drummers, and six fifers; forty bombardiers, forty-eight cadets, ninety-eight gunners, and two hundred and ninety-one mattrosses, total four hundred and seventy-seven. The cadets form'd on the right of the battalion as grenadiers, and there were three light 6-prs. on each flank of the battalion.

1754 In March a detachment commanded by a captain-lieut. with five officers, twelve cadets, and about sixty non-commissioned officers and privates embark'd for the East Indies.

The halberts were taken from the corporals and bombardiers, and they fell into the ranks with carbines.

In November this year, a detachment of fifty men of the regiment of artillery embark'd with the two battalions No. 44 and 48, under the command of Major-General Braddock for America. Captain Ord being then with his company in Newfoundland was by desire of the Duke of Cumberland order'd from thence to command this detachment, which was mostly cut to pieces near Fort Du Quesne, on the Monongahela, on the 9th of July 1755.

This was the first detachment of the corps sent to America; and it was on this occasion that the officers of the Royal Regiment of Artillery serving in the field received for the first time batt money, or an allowance *in cash* for the carriage of their baggage; for as neither horses or carriages could be contracted for, nor procured in any manner in the country which was the scene of Major-General Braddock's operations, Captain Ord commanding the artillery on that service, order'd each officer to be paid in cash a sum equal to what was allowed by the Board of Ordnance in their contract for horses and carriages in the campaigns during the last war in Flanders, where a captain was allow'd a waggon with four horses for the transport of his baggage, and the same to two subalterns, and so in proportion to the other ranks, which mode has been continued ever since in America.

During the peace from 1748 to 1756, the Duke of Cumberland review'd the corps annually at Woolwich.

List of the Officers of the Royal Regiment of Artillery, as they stood in February, 1755.

Colonel, William Belford.
Lieut.-Colonel, Borgard Mitchelson.
Major, George Williamson.

Captains.	Capt.-Lieuts.
1 James Mace, Minorca.	1 Samuel Shepardson.
2 John Chalmers, Woolwich.	2 Edward Sibbet.
3 Thomas Disaguliers, Woolwich.	3 John Farquharson.
4 Thomas Flight, Woolwich.	4 Thomas James, Gibraltar.
5 Thomas Ord, Newfoundland.	5 William Hislop, E. Indies.
6 James Pattison, N. Britain.	6 Robert Hind, America.
7 Alexander Leith, Gibraltar.	7 Charles Farrington.
8 John Skeddy, Woolwich.	8 Jacob Gregory, Newfoundland.
9 Charles Brome, N. Scotia.	9 Joseph Brome and adjutant.
10 John Godwin, Woolwich.	10 John Northal, Minorca.

First Lieuts.	Second Lieuts.
1 Abraham Tovey.	1 John Straton.
2 Charles Stranover.	2 John Innes.
3 Richard Mason.	3 Thomas Smith.
4 John Dovers.	4 William Macleod.
5 Robert Smith.	5 Peter Innes.
6 Leonard Pattison.	6 Alexander Campbell.
7 William Hussey.	7 Jacob Tovey.
8 Samuel Strachy.	8 Thomas Pike.
9 William Martin.	9 Joseph Winter.
10 Nathaniel Jones.	10 Edward Whitmore.

Lieut. Fireworkers.

1 Forbes Macbean.	16 Andrew Ferguson.
2 Griffiths Williams.	17 David Rogers.
3 F. James Buchanan.	18 Horatio Spry.
4 John Macculloch.	19 Benjamin Stehelen.
5 Sir Charles Chalmers.	20 Duncan Drumond.
6 George Charleton.	21 James Lawson.
7 Robert Hind.	22 Charles Torriano.
8 Joseph Barret.	23 Thomas Howdel.
9 Richard Edlin.	24 James Butler.
10 Thomas Hussey.	25 David Mukle.
11 David Hay.	26 George Forman.
12 James Stephens.	27 James Halsal.
13 William Phillips.	28 John Mullonan.
14 John York.	29 Thomas Baker.
15 George Anderson.	30 Sir John Witlewronge.

Staff Officers.

Chaplain............Montagu Barton.	Bridge-Master...Nathaniel Marsh.
Adjutant............Joseph Broane.	Surgeon ....James Irwine.
Quarter-Master...William Phillips.	Mate...............David Vans.

1755 In March, four companies with an additional major were added to the regiment, which now consisted of fourteen companies, the cadets not included.

These four companies were raised and compleated in about thirty days and immediately embark'd for the East Indies, one of them was lost in the "Doddington" E. Indiaman on her passage, all except three private men; as soon as this was known at home, a company was raised to replace it, and embark'd for the E. Indies.

In May, a detachment of a first lieut. and twenty-four non-commissioned officers and private men were this year sent from Woolwich to Ireland at the request of the Lord-lieutenant, towards the forming a battalion of artillery for that kingdom.

In October, two more companies were raised and added to the regiment, which now consisted of sixteen companies, exclusive of the cadets.

1756 In April, two companies were raised and added to the regiment, now consisting of eighteen companies exclusive of the cadets.

In May, a company of miners consisting of two hundred was raised for the purpose of being sent to assist in retaking Minorca. First-lieut. William Phillips then the youngest of that rank in the regiment being aide-de-camp to Sir John Ligonier, was thro' that interest and the indolence and supineness of the officers of the corps appointed captain of this company, which was then consider'd as no more than a temporary affair of short duration, that would end when the service they were raised for was perform'd; but on the return of this company to Woolwich, the miners who did not chuse to remain as private in the regiment were discharged, and the company added to and established in the regiment on the same footing as the others; this made nineteen companies besides the cadets.

In June, a great train of artillery with four companies of the regiment and the company of miners march'd from the Tower of London and encamp'd at Byfleet in Surry till October,—the guns composing this train were the following—eleven light 24-prs., fourteen light 12-prs., twenty light 6-prs., six light 3-prs., six royal mortars, total 57 pieces and 10 pontoons. The Duke of Marlborough then Master-General march'd at the head of this train, and pitch'd his tent in camp where His Grace remain'd during the campaign, attending various experiments in mining and the usual exercises with the guns and mortars, &c. &c. &c.

In November, a company embark'd for Gibraltar in addition to the one already there. And a company embark'd for the East Indies to replace that lost in the "Doddington"

1757 In February, two companies of the regiment under the command of Lieut.- Colonel Williamson, embark'd for America to serve with the army forming there by Lieut.-General the Earl of Loudon.

In April, four companies were raised and added to the regiment, now consisting of twenty-four companies, cadets and miners included.

On the 1st of August the regiment was divided into two battalions, each having its own field officers and separate staff, and twelve companies in each, cadets included.

N.B. In May, the corps of engineers obtain'd military rank and title for the first time.

1758 In April, two companies were raised and added to the regiment, and each battalion composed of thirteen companies, cadets included.

In August, a detachment consisting of one captain, six lieuts., and one hundred and twenty non commissioned officers and men, embark'd with six battalions and twelve battalion guns, which were sent to join the allied army in Germany.

1759 January 1st. Four companies were rais'd and added to the regiment, which now consisted of thirty companies, cadets included.

In March a company and a half were sent to join the allied army, which with the detachment already there now formed three companies in Germany, and the British artillery consisted during this campaign of ten medium and six light 12-prs., eighteen light 6-prs., and six royal howitzers.

In November, the regiment of artillery was form'd into three battalions with separate and distinct field officers and staff, and ten companies in each.

1760 The detachment of the Royal Regiment of Artillery serving with the allied army in Germany was augmented to five companies, and the guns with the army consisted of

Eight heavy	12-prs.	Thirty light	6-prs.
Ten medium	12-prs.	Three 8-in.........	Mortars.
Six light...............	12-prs.	Six royal	Mortars.

Total 63 pieces.

1761 In October, two companies were raised and added to the regiment.

1762 January 20th. The King sign'd a warrant establishing a fund for paying pensions to the widows of officers in the Royal Regiment of Artillery; to a colonel's £50, a lieut.-colonel's £40, a major's £30, to captain's £25, and to subalterns and staff £20.

In May, two companies of the regiment embark'd for Portugal to serve with six battalions and a regiment of light dragoons order'd to embark under the command of Lieut.-General Lord Tyrauley for the defence of that country.

The artillery destined for this service consisted of the following pieces, viz.:—

Two heavy	12-prs.
Six medium	12-prs.
Six medium	6-prs.
Twelve light	6-prs.
Two 8-in.	Howitzers.
Four royal	Howitzers.

Total 32.

This last campaign of this war, the British artillery in Germany consisted of the following pieces, viz.:—

Eight heavy	12-prs.
Six medium	12-prs.
Four light	12-prs.
Twenty-four heavy	6-prs.
Thirty-four light	6-prs.
Eight 8-in.	Howitzers.
Four royal	Howitzers.

Total 88.

N.B. During the campaigns in Flanders in the war of 1741, the great kettle drums mounted on a triumphal car finely ornamented and drawn by six horses, marched at the head of the train of artillery (excepting the campaign of 1746 when there were only fourteen light pieces for battalions in the field). In these campaigns the artillery of all the nations forming the army marched in one continued column, but whenever the heavy baggage was ordered away from the army, the kettle drums was consider'd as part of it.

The kettle drums were not in the field in Germany during the war which ended in 1762. The artillery did not march then in long columns, but were reduced into various brigades, which were distributed so as to be ready to act on all situations in every part of the army.

1763 On the conclusion of the war at the latter end of last year by the peace of Paris; the three battalions, consisting of thirty companies and a company of cadets with their respective field and staff officers were kept up; but the establishment of the companies as detail'd in anno 1743, which had been invariably the same from that period, was now altered, and each company reduced to two lieut.-fireworkers, two serjeants, two corporals, four bombardiers, eight gunners, thirty-two mattrosses, one fifer and two drummers; and the sixty junior lieut.-fireworkers were reduced on half-pay, the last of whom came into the regiment on full pay at the latter end of 1767.

During the peace, one battalion was station'd in North America, and distributed at the several posts on that continent; another in the Spanish garrisons of Gibraltar and Minorca, and one remain'd in Great Britain which relieved the others.

1768 The regiment adopted white wastecoats and breeches in the uniform of officers and men.

1770 The fuzees which were hitherto the arms of the officers were laid aside, and uniform broad swords were adopted.

The regiment adopted the German mode of wearing the sashes round the waste, instead of over the right shoulder.

1771 January 1st. The Royal Regiment of Artillery was form'd into four battalions, each composed of eight marching and two invalid companies with distinct and separate field and staff officers.

On this occasion the rank of lieut.-fireworker was suppress'd, and the establishment of officers to each of the thirty-two marching companies, was, one captain, one captain-lieut., one first and two second lieuts.; and that of each of the eight invalid companies, was one captain, one first and one second lieut. Colonel Ord, being appointed colonel to the new or fourth battalion, form'd a band of eight musicians, which he and the captains supported till the next year, when this battalion embark'd to relieve the first battalion in America, the battalions remaining at home took on themselves to support it till 1774, when the master and lieut.-general of the ordnance were pleased to ease the regiment of that expence.

1772 By the King's warrant and order, dated June 22nd, the captain-lieuts. in the Royal Regiment of Artillery are to take rank as captains in the army and corps from the 25th of May, and all future captain-lieuts. from the date of their respective commissions.

1774 The foundation of the barracks on Woolwich Common was laid for a battalion on the present establishment, viz. eight companies, the plan was brought forward and approved by General Conway while he was lieut.-general, and at the head of the ordnance.

1775 The King review'd the first and third battalions on Blackheath, on July 10th.

1776 The barracks on Woolwich Common were inhabited early this year.

1779 In July, the following alterations and additions took place in the regiment, viz. the four battalions were made to consist of ten marching companies each, by the addition of eight new ones.

The eight companies of invalids were augmented by the addition of two new ones, and form'd into a battalion of invalids, commanded by a lieut.-colonel commandant, and a major.

The establishment of each of the forty marching companies was augmented thus,—one captain, one captain-lieut., two first and two second lieuts., four serjeants, four corporals, nine bombardiers, eighteen gunners, 69 mattrosses, one fifer, and two drummers.

RELATION OF THE POWER TO THE WEIGHT IN THE VARIOUS MACHINES, IN GENERAL USE, FOR THE MOUNTING, MOVING, AND TRANSPORTING, OF THE HEAVY ORDNANCE, CARRIAGES, AND PLATFORMS IN THE SERVICE.

COMMUNICATED BY CAPTAIN H. W. BRISCOE, R.A.

A full description of the different machines and carriages, for the above-mentioned purposes is contained in the "Manual of Artillery Exercises," but thinking that the relation of the power to the weight, on purely mechanical principles, and the dimensions necessary for these calculations, may be useful to many artillery officers as a reference, I have selected the following paper from the course of instruction in Artillery at the R. M. Academy, hoping it may prove acceptable.

Lifting Jack (*new pattern*).

Length of lever from centre of screw = $3'\ 4''$.
Diameter of screw = $2\frac{1}{4}''$.
Distance between threads = $\frac{1}{4}''$.

In this case if P = the power applied at end of lever,
and W = the weight to be raised.

Then $P : W ::$ distance between threads : circumference of circle described by lever.

$$\therefore P : W :: 1 : 1005{\cdot}312.$$

New Pattern Elevating Screw.

Length of lever = $2'\ 1''$.
Diameter of screw = $2\frac{1}{4}''$.
Distance between threads = $\frac{1}{4}''$.

$$P : W :: 1 : 628{\cdot}32.$$

Crab Capstan.

Mean diameter of windlass = $10''$.
Actual length of capstan bars = $16'$.
Effective length of do = $12'$.*
Taking diameter of fall = $1''$.

$$\text{or } P : W :: 1 : 13.$$

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* The power is not applied at the extremity of the bars, but is distributed over a space of 4 ft. from each end by two men, each occupying a space of 2 ft. The mean of this distance is taken, which will give the power applied at a distance of two feet from each extremity, consequently making the effective length of bar or lever = $12'$.

Triangle Gyn.

Diameter of square of windlass = 0′ 9″.
„ barrel „ = 0′ 8″.
Length of socket = 0′ 11½″.
Length of lever = 7′ 1″.
Depth of lever in socket = 0′ 7″.
Distance of rope from end of lever = 0′ 5″.
∴ effective length of lever = 7′ 4½″.
The diameter of the fall may be taken as = 1″.

$$\therefore P : W :: 1 : 98{\cdot}33.$$

Gibraltar Gyn.

The Gibraltar gyn which is used for mounting and dismounting ordnance on, or from standing carriages, in situations where it would not be convenient to use the triangle gyn, possesses the following mechanical powers combined in it, viz.:—

A compound wheel and axle.
A tackle, consisting of two triple blocks.

Radius of circle described by handle of windlass = 13″.
Radius of windlass = 3″.
The fall is 3½-in. rope.
The large wheel has 57 cogs.
The small do has 11 do.
Assuming diameter of rope as 1 in.

$$\therefore P : W :: 1 : 115{\cdot}4;$$

of which a very considerable amount is lost by friction, &c.

Sling Wagon.

Diameter of square of windlass = 0′ 9″.
„ barrel „ = 0′ 8″.
Length of socket = 0′ 11½″.
Length of lever = 7′ 1″.
Depth of lever in socket = 0′ 7″.
Distance of rope from end of lever = 0′ 5″.
Effective length of lever = 7′ 4½″.

Taking the diameter of sling as 2 inches.

$$\therefore P : W :: 1 : 35{\cdot}4.$$

Sheers.

The runner tackle and guys of sheers give the relation $P = \frac{W}{10}$, when two double blocks are used for the runner tackle, but when luff tackles are employed $P = \frac{W}{8}$.

The relation of the power to the weight in the working of the sheers may be calculated.

1st. When a crab capstan is used to work the main fall;

$$\therefore P : W :: 1 : 78.$$

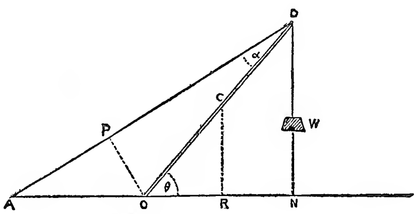
2nd. When the main fall is worked by a luff tackle;

$$\therefore P : W :: 1 : 24.$$

3rd. When a gyn windlass is used;

$$\therefore P : W :: 1 : 118.$$

The strain on the guy rope of sheers may be calculated by regarding the sheers as a lever.



A rope AD supports a pole OD resting on the ground at O, and carrying weight W suspended from D, it is required to find tension of rope AD.

Draw OP at right angles to AD, and DN to ON.

The centre of gravity of the pole is at C, the middle, as the pole is uniform. Draw CR perpendicular to ON.

Taking O as the axis of moments,

$$OP \times \text{tension of rope} = ON \times W + \text{weight of pole} \times OR \;\ldots\ldots\; (1)$$

Let $\theta =$ the angle DON,
$\alpha =$ the angle ODA,
$w =$ the weight of pole;

then
$$OP = OD \sin \alpha.$$
$$ON = OD \cos \theta.$$
$$OR = \tfrac{1}{2} ON = \tfrac{1}{2} OD \cos \theta.$$

Substituting in (1),

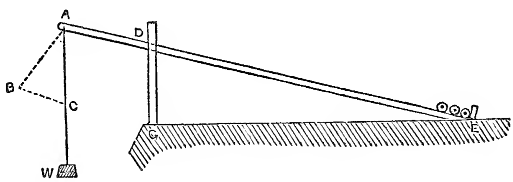
$$\text{Tension of rope} \times OD \sin\alpha = W.OD \cos\theta + w\tfrac{1}{2}OD \cos\theta.$$

$$\therefore \text{ Tension of rope} = \frac{\cos\theta}{\sin\alpha}\left(W + \tfrac{1}{2}w\right) \quad \ldots\ldots\ldots\ldots\ldots \quad (2)$$

This divided by 8 or by 10, as the case may be, for the mechanical advantage gained by the arrangement of the guy and runner tackle will give the force to be applied at the running end of the tackle of the guy.

Lever Sheers.

If the spar be inclined at an angle α to the horizon, to find breaking strain.



AD is the part of the spar bearing the strain acting vertically in the direction AC, it may be resolved into two forces,

AB tending to break the spar, and BC tending to force the end at E into the ground.

The triangles ABC and EGD are similar,

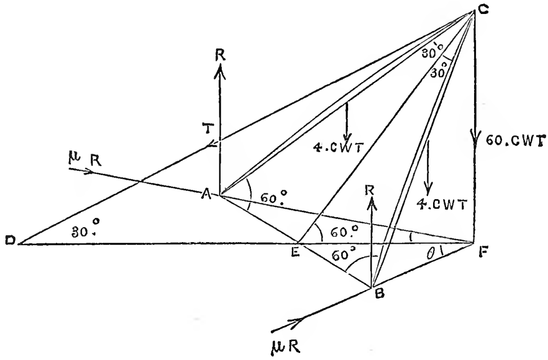
$$\text{and } AB = AC \cos BAC$$
$$= W\cos\alpha;$$

$$\therefore \text{ breaking strain} = W \cos\alpha.$$

NOTE.—All these calculations have been made without taking into account the stiffness of ropes, or friction, which of course is very considerable and absorbs a great quantity of the work done, but is useful in assisting to sustain a machine in a state of rest; as for instance, passing a rope round the windlass of a gyn, capstan, &c.

PROB. What will be the greatest strain upon the points of support to which the feet of sheers are attached, under the following conditions? Weight of each cylindrical spar, 4 cwt.—weight of gun and blocks hanging from the top of the sheers, 60 cwt.—inclination of the plane containing the axis of the spars, 60° to the horizon—the back guy makes an angle of 30° to the horizon; and the spars make an angle of 60° with each other. The coefficient of friction between the feet of the spars and the platform ·15.

Let AC, BC be the two spars, and CD the "guy," or rope; then, if AC, BC be of the same length, ABC will be an equilateral triangle, since $ACB = 60°$.



The guy or cord will lie in a vertical plane bisecting AB perpendicularly. Let $DCFE$ be this plane, intersecting the plane which contains the axes of the spars in EC, and the horizontal plane in DEF. Consequently the angle CEF, which measures the inclination of the plane ACB to the horizontal plane, is equal to 60°. Now the point B is kept at rest by the pressure along CB, the normal pressure R, and the friction, and because when three forces are in equilibrium, they are in the same plane, it follows that the normal pressure R, the friction μR, and the pressure along CB, are proportional to CF, BF, and CB; that is, the friction at B acts along BF.

Similarly, the friction at A, acts along AF. Let T be the tension of the guy. Then resolving vertically and horizontally,

$$R + R + T \sin 30 = 4 + 4 + 60,$$

or

$$2R + \tfrac{1}{2}T = 68; \quad \ldots\ldots (1)$$

and

$$T \cos 30 = \mu R \cos \theta + \mu R \cos \theta = 2\mu R \cos \theta,$$

or

$$\text{or} \quad \tfrac{1}{2}T\sqrt{3} = 2\mu R \cos \theta \quad \ldots\ldots (2)$$

Eliminating T between (1) and (2), we get

$$R = \frac{136\sqrt{3}}{4(\mu \cos \theta + \sqrt{3})} = \frac{34\sqrt{3}}{\mu \cos \theta + \sqrt{3}} \quad \ldots\ldots (3)$$

It remains to find $\cos \theta$.

Now because BEF is a right angle, EF being perpendicular to AB,

$$\cos \theta = \frac{EF}{BF}.$$

But

$$EF = EC \cos 60° = BC \sin 60° \cos 60°$$

$$= \frac{\sqrt{3}}{4} BC;$$

and

$$BF^2 = BE^2 + EF^2 = \frac{1}{4} BA^2 + \frac{3}{16} BC^2$$

$$= \frac{1}{4} BC^2 + \frac{3}{16} BC^2$$

$$= \frac{7}{16} BC^2;$$

$$\therefore \cos \theta = \sqrt{\frac{3}{7}}.$$

Substituting this in (3), and writing ·15 for μ, we get

$$R = 32{\cdot}17 \text{ cwt.}$$

Let P be the strain at B or A; then

$$P^2 = R^2 + \mu^2 R^2$$

$$= R^2 (1 + \mu^2),$$

$$\text{or} \quad P = R\sqrt{1 + \mu^2} = 32{\cdot}17 \times 1{\cdot}01$$

$$= 32{\cdot}5 \text{ cwt. nearly.}$$

REPORT OF AN EXPERIMENT CARRIED ON BY THE ORDNANCE SELECT COMMITTEE, AT SHOEBURYNESS, 28TH NOVEMBER, 1864, TO TEST SHOT MADE OF VARIOUS KINDS OF STEEL, FIRED FROM 68-pr. AND 100-pr. SMOOTH-BORED GUNS.

COMMUNICATED BY THE ORDNANCE SELECT COMMITTEE.

THE shot, which were all spherical, were fired at $5\frac{1}{2}$ in. rolled plates supplied by the Millwall Iron Company; the plates were fixed vertically, without backing, against a wooden frame. The range was 200 yds., and the charges used were 16 lbs. with the 68-pr. gun, and 25 lbs. with the 100-pr. gun. The velocity on impact was 1380 ft. in the case of the 68-pr. shot, and 1500 ft. in that of the 100-pr.

No. of round.	Photographic No.	Nature of ordnance.	Projectile. Supplied by	Projectile. Weight in lbs.	Projectile. Diameter in inches.	Elevation.	Diameter of shot after firing, in inches. Greatest.	Diameter of shot after firing, in inches. Least.	Effects. Depth of indent in inches.	Effects. Bulge of plate, in inches, measured at indent.	Remarks.
1	880	*	Attwood & Co...	71·5	7·928	20′	8·85	6·62	2·48	1.5	Plate bulged in rear 1·5″ and cracked vertically, shot much set up and broken.
2	881	〃	〃	71·25	7·928	〃	...	...	2·15	1·5	do do do
3	882	〃	Marsh Brothers	71·5	7·89	〃	...	...	2·60	2·0	Plate cracked in rear; shot broke up.
4	883	〃	〃	71·5	7·89	〃	8·16	7·27	3·65	...	Struck 7″ below 882, plate cracked in rear and laminæ broken off 20″ × 10″; shot set up and broken.
5	884	〃	Bessemer & Co.	73·5	7·93	〃	8·68	6·79	2·20	2·0	Struck partially on an iron railway bar supporting plate, plate cracked behind 14″; shot set up and cracked a little.
6	885	〃	〃	73·5	7·93	〃	8·21	7·09	3·15	...	Stuck in plate, base projecting 4″·5; laminæ of plate off in rear 14″ × 8″; shot a little cracked.
7	886	〃	Naylor, Vickers, & Co.	73·0	7·91	〃	8·17	7·17	2·625	2·2	Struck on railway bar 7″·5 from edge, plate cracked longitudinally, buckle 1″·25; shot slightly cracked.
8	887	〃	〃	73·5	7·91	〃	8·29	6·86	2·9	...	Laminæ of plate off in rear, and cracked 15″; shot slightly cracked.
9	888	〃	Heintzmann&Co	72·625	7·91	〃	8·36	6·83	2·9	3·5	Plate cracked behind crossways 14″; shot slightly cracked.
10	889	〃	〃	72·0	7·91	〃	8·28	7·09	2·4	1·5	Struck bar 7″·5 from edge of plate (2″ on bar), plate cracked star fashion over bulge, buckled 1″·25.
23	902	〃	Sanderson & Co.	71·5	7·88	〃	8·27	7·23	2·875	2·0	Plate cracked behind 14″; shot cracked and broken.
24	903	〃	〃	73·0	7·88	〃	8·19	7·25	3·675	...	Stuck in plate 7″ from previous round, projecting 4″; laminæ off plate in rear 12″ × 15″; shot cracked and pieces broken off.
25	904	〃	Cammell & Co...	79·5†	7·92	〃	8·68	6·52	2·9	...	Plate cracked through vertically at centre of indent 14″ long; shot a little cracked.
26	905	〃	〃	78·5	7·92	〃	...	...	...	...	Struck close to 904, carried away top of plate, over and into sea.
27	906	〃	〃	76·0	7·92	〃	8.50	6·72	2·625	...	Stuck in plate, projecting 4″; shot cracked a little.
28	907	〃	Firth & Sons ...	73·5	7·91	〃	8·19	7·25	3·125	...	Stuck in plate, a lamina of plate nearly off in rear; shot cracked.

* Service cast-iron. 68-pr. gun. † Including wooden bottoms.

No. of round.	Photographic No.	Nature of Ordnance.	Projectile. Supplied by	Weight in lbs.	Diameter in inches.	Elevation.	Diameter of shot after firing, in inches. Greatest.	Least.	Effects. Depth of indent in inches.	Bulge of plate, in inches, measured at indent.	Remarks.
29	908	*	Firth & Sons ...	72·0	7·91	′ 20	8·45	7·01	2·8	2·25	Plate cracked behind; shot cracked.
30	909	†	Brown (R. L. Contract).	not weigh'd	...	〃	...	...	2·5	...	Plate cracked behind; shot very much set up.
11	890	〃	Attwood & Co ...	102·0	8·90	16	...	...	...	...	Stuck in plate, projecting 2″ in front and 3″ behind; large piece of plate carried away.
12	891	〃	〃	101·0	8·90	〃	...	...	...	...	Through plate; shot broke up.
13	892	〃	Marsh Brothers	102·0	8·865	〃	9·49	7·57	...	...	Stuck in plate, piece of plate punched out; shot set up 1″·3, and cracked.
14	893	〃	Bessemer & Co...	104·5	8·8	〃	...	...	...	...	Struck edge of plate, and punched a piece out 8″·5 × 4″·5.
15	894	〃	〃	104·375	8·88	〃	9·97	7·27	...	...	Through plate; shot set up 1·6″.
16	895	〃	〃	104·0	8·88	〃	...	...	...	...	Through plate 14″ from previous shot.
17	896	〃	Naylor, Vickers & Co.	104·375	8·90	〃	...	...	...	...	Grazed edge of plate.
18	897	〃	〃	103·5	8·90	〃	...	...	...	...	Grazed left edge of plate punching a piece out.
19	898	〃	〃	104·375	8·90	〃	...	...	...	...	Through plate.
20	899	〃	Heintzmann&Co	102·0	8·82	〃	...	...	...	...	Through plate.
21	900	〃	〃	102·0	8·82	〃	8·95	8·20	...	...	Through plate 9″ from previous shot.
22	901	〃	〃	103·5	8·82	〃	...	...	...	...	Through plate 13″·5 from top; shot set up 0·6″.
31	910	〃	Sanderson & Co.	102·625	8·864	〃	...	...	...	...	Through plate, shot more than half broken up.
32	911	〃	〃	103·0	8·864	〃	8·92	8·52	...	...	Through plate, 7″·5 from bottom; shot set up 0″·3.
33	912	〃	Cammell & Co...	107·0‡	8·915	〃	8·88	8·85	...	...	Through plate; shot set up 0·07″.
34	—	〃	〃	107·5	8·915	〃	...	...	...	...	Missed.
35	913	〃	〃	107·0	8·915	〃	9·32	7·82	...	...	Through plate, 17″ from centre of 912, and 14″ from 907; shot set up 1″·1.
36	—	〃	Firth & Sons ...	104·0	8·86	〃	...	...	...	...	Missed.
37	—	〃	〃	104·0	8·86	〃	...	...	...	...	Missed.
38	914	〃	〃	194·0	8·86	〃	...	...	...	...	Struck left edge of plate cutting a piece out 9″ × 4″·5; shot broke up in 3 or 4 pieces.

* 68-pr. gun. † 100-pr. M. L. W. I. gun, Expl: No. 282. ‡ Including wooden bottoms.

From a consideration of the results of the experiments with the 8-in. spherical shot from the 68-pr. gun, the order of merit of the shot seems to stand as follows:—

	Amount of penetration.	Set up of shot.		Amount of penetration.	Set up of shot.
1 Sanderson	3·275 inch.	0·54 inch.	5 Cammell...........	2·76 inch.	1·30 inch.
2 Marsh..............	3·12 〃	0·62 〃	6 Bessemer	2·67 〃	0·99 〃
3 Firth	2·96 〃	0·78 〃	7 Heintzmann......	2·65 〃	0·95 〃
4 Naylor & Vickers	2·76 〃	0·89 〃	8 Attwood...........	2·31 〃	1·3 〃

With regard to the experiments with the 100-pr. spherical shot, it is difficult to form an opinion of the comparative merits of the several shot, as nearly all of them pierced the plates, and buried themselves in the earthwork erected in rear. But the Committee consider that the experiments with the smaller shot are likely to indicate the probable comparative effects of the larger shot upon thicker plates, or upon the same plates at a greater range; and think that the list above points out, with as great accuracy as the experiments admit of, the order of merit of the several shot.

ARMSTRONG'S (C) PERCUSSION FUZE, DYER'S PATTERN.[1]

BY CAPTAIN VIVIAN DERING MAJENDIE, R.A.

CAPTAIN INSTRUCTOR, ROYAL LABORATORY.

Some little time back[2] I furnished a description of a new time fuze which had been recently adopted for the higher natures of Armstrong shells, on the grounds that "the means of access to sections or specimens of this fuze, or other opportunities of becoming acquainted with its construction, being wanting to many officers in the Regiment," I thought such a description "might be acceptable, and perhaps, in some cases, useful."

For the same reason, and because some officers have expressed a favourable opinion as to the value of the paper, I am induced to give a description of a new percussion fuze, designed by Major Dyer, R.A., which has recently been adopted for the four lower natures of Armstrong segment shells.

This fuze is a modification of Armstrong's brass percussion fuze, pattern C—the object sought to be attained being greater security from accidental explosion.[3]

It consists of six principal parts, viz. Body, Bottom, Pellet, Detonator, two Suspending Pins, and four Washers.

The *Body* (*aaa*) is made of an alloy similar in character and appearance to gun metal, but rather softer for convenience in working.[4] It is a hollow cylinder about an inch in length and the same in diameter.[5] The cylinder is closed at the top with the exception of four small "flame holes" (*bb*), equidistant from one another, which are drilled vertically through the top, for the purpose of affording a passage to the flash of the time-fuze when the time and percussion fuzes are used conjointly. These holes are closed by means

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1 Approved 6th Sept., 1864. Sec. W. O. C. No. 3 (New Series), par. 955.

2 See "Proceedings", R. A. Institution, Vol. IV. p. 171.

3 The security of this fuze against accidental explosion has been tested in the Royal Gun Factories, by "jumping" several of the fuzes in a wooden box, which was raised two inches by means of a cam, and allowed to fall by its own weight 140 times in a minute. Fifty-five hours of this treatment had no effect upon the fuzes, (*Extracts from Reports and Proceedings O.S.C.* Vol. II., p. 142), although sufficiently severe to wear some of the cases considerably.

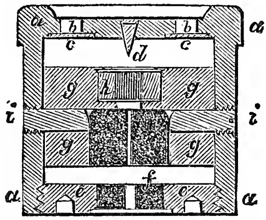
4 The alloy is—Copper 30 lbs., Tin $1\frac{1}{4}$ lb., Zinc 2 lbs., Lead $1\frac{1}{4}$ lb.—*Specification.*

5 The actual dimensions are—

Length	High gauge......	1·051 inches.
	Low „	1·039 „
Diameter (not over rim).	High gauge......	1·057 „
	Low „	1·047 „

Ibid.

of a brass washer (*cc*),[1] countersunk into the lower side of the top of the fuze; a drop of shellac varnish being deposited in each hole to exclude moisture. In the centre of the group of holes is fixed a small steel point (*d*) which projects into the fuze about one-tenth of an inch.[2] The body is open at its lower end, and tapped[3] for the reception of the bottom.



About half-way down the body, and on opposite sides, two small holes are drilled, and tapped[4] for the reception of the suspending pins.

The upper part of the body projects slightly,[5] forming a rim or shoulder round the top of the fuze, which prevents it from being placed topsy-turvy into the shell.

The *Bottom* (*ee*) is a stout disc[6] of the same alloy as the body, into which it screws,[7] forming, as its name implies, the bottom of the fuze. It is provided with a small fire-hole (*f*) in the centre, closed on the lower side by a brass disc,[8] and driven and pierced above this disc like a tube. On either side of the fire-hole are two small wrench or key holes.

The *Powder pellet* is a cylinder of the same alloy as the body, equal in diameter to the interior of the body, but shorter. The upper part of the pellet is recessed for the reception of a boxwood detonator; the lower part is hollowed out, driven and pierced like a tube, a central fire-hole being made through the intervening metal, communicating from the detonator to the tube. Two horizontal holes are drilled into the opposite sides of the pellet for the suspending pins; and two (nearly) vertical holes are provided on either side of the detonator to assist in the passage of the flame from the time fuze.[9]

The *Detonator* (*h*) is a hollow boxwood cylinder which fits into the recess made for its reception in the pellet, and is filled with the same detonating composition as Armstrong's E pattern time fuze, viz.

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[1] Brass-plate ·015 in. thick.—*Specification.*

[2] "The projection of the needle is not to exceed ·1, nor to be less than ·08 of an inch."—*Ibid.*

[3] With a right-handed thread of 26 to the inch.—*Ibid.*

[4] With a right-handed thread of 36 to the inch.—*Ibid.*

[5] The projection of this rim is about five hundredths of an inch; the dimensions laid down in the Specification being—Diameter of rim, high 1·11 inches, low 1·10 inches.—*Ibid.*

[6] The thickness of the bottom is ·12 inches. Its diameter, high ·854 inches, low ·850 inches.—*Ibid.*

[7] With a right-handed screw 36 threads to the inch.—*Ibid.*

[8] Brass plate ·015 inch thick.—*Ibid.*

[9] These holes do not appear in the drawing, being in a vertical plane at right angles to that in which the suspending pins, through which the section is taken, are situated.

Phosphorus (amorphous) 8 parts mixed with 10 per cent. of calcined magnesia.

Of the above mixture ...	8 parts.	Shellac	$5\frac{1}{2}$ parts.
Potash, chlorate of	16 ,,	Glass, ground	6 ,,

the whole damped and made into a paste with about 30 minims of methylated spirits.

The detonator rests upon a small india rubber washer, and is protected on its upper side by a thin brass disc.[1]

The two *Suspending Pins* (*ii*) are small pins of copper[2] by means of which the pellet is suspended in its position: they are screwed at one end[3] to fit the holes in the sides of the body.

The four *Washers*, or discs, have been mentioned in the above description. The body of the fuze is lacquered externally.[4]

Action:—Before the fuze is fired the pellet is suspended by means of the two suspending screw pins, within about one-tenth of an inch of the needle point, about the same distance intervening between the bottom of the pellet and the bottom of the fuze.

On the discharge of the gun the inertia of the pellet breaks the suspending pins, and the pellet rests during the flight of the projectile through the air on the bottom of the fuze. On the shell striking an object the pellet is thrown violently forward, the needle point being thus brought into contact with the brass disc, which it pierces, and so fires the detonating composition, the flame from which flashes through the pellet, blowing out the disc with which the fire-hole is closed, and communicating with the bursting charge of the shell.

This fuze may be used with the four lower natures of segment shells,—with or without the brass time-fuze.

It may be distinguished from Sir Wm. Armstrong's field service percussion-fuze C, by the presence of the two suspending pins and by the absence of a safety pin;[5] also by the two small key-holes in the bottom; in other respects the appearance and dimensions of the two are almost identical.

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1 Brass plate ·005 inch thick. The necessity for thus protecting the detonating composition requires a word of explanation. In Sir Wm. Armstrong's first experimental brass percussion fuze the composition was not thus protected, and it was found in practice with the 9-pr. shell that explosions frequently occurred during the flight of the projectile through the air. This was explained by the fact that the 9-pr. shell being light it lost its velocity very rapidly, but the initial velocity having been communicated to the parts of the fuze, the pellet had a tendency to retain the higher velocity, or rather, to lose its velocity less rapidly than the shell, and thus had a tendency to work forward, whereby the detonating composition and needle point were brought into gradual contact, and premature explosions were the result. To obviate this defect the brass disc was added, its strength being sufficient to guard the fuze against premature explosions arising from this cause, but not sufficient to interfere with the action of the fuze on the shell striking an object. The disc is retained in the present fuze.

2 The plain part of the pins is in diameter:—High, ·11 inch; low, ·108 inch. The screwed part of pins is in diameter ·125 inch.—*Specification.*

3 With a right-handed screw 36 threads to the inch.—*Ibid.*

4 With ordinary brass lacquer.

5 Some of the first C percussion fuzes were issued without a safety pin; but even in this case there will be no difficulty in distinguishing the two fuzes.

REPORT OF AN EXPERIMENT CARRIED ON AT SHOEBURYNESS, ON THE 16TH DECEMBER 1864, AND 5TH AND 6TH JANUARY 1865, BY THE ORDNANCE SELECT COMMITTEE,—

(1) To test the relative powers of the 100-pr. S. B. gun, of $6\frac{1}{4}$ tons, and the 7″ M. L. shunt rifled gun, of 134 cwt., fired with $\frac{1}{4}$th charges, and steel shot, of Brown's and Firth's manufacture, against "Warrior" target.

(2) To ascertain the relative penetration of shot cast in chill and steel shot as above, when fired from the same gun.

COMMUNICATED BY THE SECRETARY O. S. COMMITTEE.

The 7″ elongated shot used in this experiment were of three kinds, viz. Firth's steel, steel manufactured at the Atlas Works, Sheffield (Brown's), mean weight 100 lbs., and iron cast in chill, manufactured in the Royal Laboratory, on the plan proposed by Major Palliser, mean weight 102 lbs.

The charges used were 25 lbs. and 17 lbs. The 9″ spherical shot were of Brown's and Firth's steel only, mean weight $104\frac{1}{2}$ lbs., the charges used were 25 lbs. and $9\frac{3}{4}$ lbs. The range was 200 yds., and the general results obtained may be stated as follows:—

7″ M. L. W. I. Shunt Rifled Gun of 134 cwt.

Firth's Steel.—Four shot of Firth's steel were fired, two rounds with a full charge of 25 lbs., and two rounds with a reduced charge of 17 lbs., or the equivalent of the striking velocity at a range of 1200 yds. when the full charge is used. The target was penetrated in the former case, but not in the latter. These shot were all hemispherical headed.

Brown's Steel.—Four shot of Brown's steel were fired, viz. two rounds with the full charge, and two rounds with the reduced charge of 17 lbs. The result was similar to that obtained from Firth's shot, viz. penetration of the target with the full charge, but no damage to the skin when the reduced charge was used. The shot were hemispherical headed.

Shot cast in Chill (Major Palliser's).—Seven chilled shot were fired, but one missed the target; of the remaining six rounds, two hemispherical headed shot, and two elliptical headed shot were fired with a full charge; the former penetrated about 9 inches into the backing, but did not damage the skin; the latter completely penetrated the target, doing as much damage to the structure as the steel shot, and considerably more damage after penetration, owing to splinters of the shot.

Two rounds of elliptical headed shot, which were fired with the reduced charge, did not penetrate the target, although in one instance the skin was fractured and opened 2 inches.

Number of round.	Photograph No.	Nature and weight of ordnance.	Projectile.				Charge in lbs.	Range in yds.	Elevation.	Deflection.	Radial deviation from bull's eye to centre of shot mark.	Diameter of hole.	Initial velocity in feet.†
			Nature.	Weight in lbs.	Form, cylindrical.	Length and diameter in inches.							
									′		ft. in.	in.	
1	933	7″M.L. W.I. 134 cwt. R shunt.	Firth's steel.	100	Hemispherical head.	10·5 / 6·91	25	200	20	5 R	5 2 high.	...	1618
2	934	"	"	100	"	"	"	"	0	"	1 5 low.	8· × 7·5	1625
3	935	"	Brown's steel.	100	"	"	"	"	6	nil.	1 9	...	1601
4	936	"	"	100	"	"	"	"	10	"	nil	10· × 8·5	1606
5	937	"	Shot cast in chill.	104	"	11·52 / 6·89	"	"	"	"	5 4 left.	8·5 × 7·5	1516
6	938	"	"	104	"	"	"	"	"	"	1 3 high	7·	1538
7	939	"	"	101	Elliptical head.	12·34 / 6·89	"	"	"	"	3 3 right.	8· × 7·5	1558
8	940	"	"	102	"	"	"	"	"	"	...	7·	1560
9	943	"	Firth's steel.	100	Hemispherical head.	10·5 / 6·91	17*	"	20	"	7· left.	7·75	1358
10	944	"	Brown's steel.	100	"	"	"	"	"	"	1 8 left.	7·5 × 7·25	1355
11	—	"	Shot cast in chill.	101	Elliptical head.	12·34 / 6·89	"	"	"	"	...	...	1315
12	945	"	"	100	"	"	"	"	"	"	...	7· × 6·5	1332
13	946	"	Firth's steel.	100	Hemispherical head.	10·5 / 6·91	"	"	"	"	0 8 low.	8·	1352
14	947	"	Brown's steel.	100	"	"	"	"	"	"	1 0	7·5	1352
15	948	"	Shot cast in chill.	101	Elliptical head.	12·34 / 6·39	"	"	"	"	0 10 high.	8· × 7·5	1317

* The striking velocity equiva'ent to that produced by a charge of 25 lbs. at a range of 1200 yds.

† The difference between the initial velocity of the steel and chilled shot is due to the greater weight and smaller diameter of the latter.

100-pr. S. B. Gun of 125 cwt.

Firth's Steel.—Two shot of Firth's steel were fired, one round with a full charge of 25 lbs., and one round with a reduced charge of 9·75 lbs., or the equivalent of the striking velocity due to a range of 1200 yds. when the full charge is used. The shot did not penetrate, although the skin was injured in the former case, and only made but a slight indent, 1·7″ in the latter.

Brown's Steel.—Two shot of Brown's steel were fired, both of them with the full charge, the first round having struck on the hole made by previous round. The

REMARKS.
16th December, 1864.
Struck 8″ from top of target; piece of plate $9\frac{1}{2}$″ x 8″ broken out and fracture at back of plate measured 16″; timber backing in rear of hole carried away; six armour plate bolts and two rivets broken; shot glanced upwards and went out to sea.
Struck lower edge of centre plate between two ribs; through target; crack $3\frac{1}{2}$″ long from bottom of plate at 2″ from the edge of the hole, and parallel to its circumference; hole in skin 18″ x 12″; one rib and angle iron broken; portion of skin 14″ x 8″ driven to rear; seven backing bolts and two rivets broken; piece broken out of the bottom of the shot.
Struck 8″ to the right of last round on a rib; through target; two holes measured 15″ x 8″ in armour plate, and 3′ 6″ x 1′ 8″ in the skin; 1′ 9″ of rib and angle iron carried away, and 13″ timber supporting baulk cut through; seven rivets broken. Shot went out to sea.
Struck top edge of centre plate between two ribs; through target; centre plate buckled out 1·3″ at right end; hole in skin 18″ x 14″; rib and angle iron cracked, the latter in two places; one armour plate bolt, four backing bolts, and one rivet broken. Shot broke up.
Struck 12″ from bottom of centre plate and 12″ to the right of 820; shot broke up and penetrated to a depth of 9″; crack 0·5″ wide across plate passing through indents 819–820; three armour plate bolts, four backing bolts, and two rivets broken.
Struck 7·5″ from bottom of upper plate, and 3·5″ from a bolt; shot broke up; depth to fragments of shot 5″; crack 3″ long from bolt hole; centre plate is now out at right end 2·78″ at top and 2·18″ at bottom; two armour plate bolts, one backing bolt, and one rivet broken.
Struck 10·5″ from bottom of centre plate, between two ribs on uninjured portion of target; penetrated and broke up, daylight through target; ripple round hole; hole in skin 18″ x 14″, and portion of skin 18″ x 8″ carried away. Two armour plate bolts, (one ordinary and one Major Palliser's), two backing bolts and one rivet broken. The plate was a good deal laminated by the penetration of the shot, and seemed brittle and largely crystalline in places. This shot struck a portion of the plate which was entirely secured with Major Palliser's bolts, only one of which was broken.
Struck at the junction of the centre and lower plates, 10″ from last round from centre to centre of holes; 3·5″ of hole on lower plate; piece of plate 12″ x 10″ between the two plates detached; shot penetrated the target and broke up; skin fractured by this and last round over space of 24″ x 14″; wood target (14 ft. in rear of "Warrior") penetrated by portions of shot, and very much marked by splinters; no injury to fastenings.
Struck 17″ from bottom of centre plate, on a bolt; nearest point to base of shot from face of target 0·5″, deepest point 3·5″; shot slightly cracked at base, and inclined to the right after penetration; no damage to skin; one rib and angle iron cracked; one armour plate bolt, two backing bolts and one rivet broken, and one backing bolt driven out 1″. The bolt on which the shot struck (one of Major Palliser's) was not injured, the washer only being a little loosened.
Struck centre plate 12″ above last round, (target weakened by penetration of 943); depth to base of shot 9·5″; shot slightly cracked and inclined to the left after penetration; five backing bolts broken; no damage to skin or ribs.
Missed target.
Struck at vertical junction of two centre plates; shot broke up in hole, depth to fragments of shot 8″; no damage to skin, ribs, or fastenings.
Struck centre plate 16″ from the top; depth to base of shot 2″ and 0·5″; shot cracked at the base. Skin slightly bulged; two armour plate bolts (one Major Palliser's, and one ordinary), four backing bolts, and one rivet broken.
Struck 18″ from bottom of centre plate, and 12″ right of 943; depth to base of shot 2·25″; shot cracked vertically; one armour plate bolt (Major Palliser's) and one backing bolt broken.
Struck the centre plate 15·5″ from the bottom and 12″ right of 947 partly on a rib, shot broke up; target nearly penetrated; skin cracked between two ribs and opened 2″, the fracture, joining that made by rounds 7, 8; no damage to fastenings.

result was similar to that obtained from Firth's shot fired with full charge, viz. no penetration, but considerable damage to skin.

The result of this experiment shows that while a structure such as the "Warrior" can be penetrated at 200 yds. range with elongated steel shot and shot cast in chill, when the form of the head of the latter is elliptical, fired from a 7″ rifled gun with $\frac{1}{4}$th charges, it is safe from penetration by a spherical shot of the same weight, and fired with the same charge from the 100-pr. S.B. gun.

The target was not penetrated by any of the 7″ shot, which struck with a velocity equivalent to that produced by the full charge at a range of 1200 yds.; but it is probable that had the 7″ steel shot been elliptical headed, instead of hemispherical headed, penetration would also be effected at the longer range. This may be deduced from the comparative results obtained with elliptical headed and hemispherical headed chilled shot; the advantage derived from the elliptical form of head in that material being very great.

It may be inferred from round No. 19, fired with reduced charge, that the effect of the 100-pr. S.B. gun, at a range of 1200 yds., would be perfectly insignificant upon an iron-plated ship.

The fastenings of the target suffered very severely. During the nineteen rounds which were fired in this experiment, nineteen armour-plate bolts, thirty-seven backing bolts, and twenty-seven rivets were broken; but the armour-plate bolts on *Major Palliser's plan proved much stronger than the ordinary bolts, only three having broken during the experiment, notwithstanding that more than two-thirds of the number of rounds were fired at a portion of the target which was secured by these bolts.

J. H. LEFROY, Brigadier-General,
President.

FEBRUARY 12, 1865.

Number of round.	Photograph No.	Nature of ordnance.	Projectile. Nature.	Projectile. Weight in lbs.	Projectile. Form cylindrical.	Projectile. Length and diameter in in.	Charge in lbs.	Range in yds.	Elevation.	Radial deviation from bull's eye to centre of shot mark.	Indent. Depth of	Indent. Diameter of hole.	Initial velocity in ft.	REMARKS.
									′	′ ″		″		5TH JANUARY, 1865.
16	972	†	Firth's steel.	105	Spherical	8·7	25	200	16	0 12	—	9 × 9	Not obs.	Struck on centre plate 16″ from bottom and 10″ right of centre of target; struck between two ribs and on a bolt (Major Palliser's), which was driven out 2″, but not broken; shot slightly cracked, depth to nearest part of shot 6·5″; skin cracked longitudinally, and bulged two ribs, and two angle irons cracked; five wood bolts and one rivet broken; one wood bolt driven in 4″.
17	973	"	Brown's steel.	104·5	"	"	"	"	"	2 6	—	12·5 × 9	—	Struck on same hole as No. 972, increased the hole to 12·5″ × 9·0″; sho tbroke up; skin opened to 2′ 3″ × 1′9″; piece of skin 1′4″ turned back, remainder 1′6″ × 10″ broken off; fragments of both shot driven through target; one ordinary armour plate bolt and two rivets broken; right rib broken in fresh place; one Palliser armour plate bolt remaining in bent part of skin and not broken.
18	974	"	"	"	"	"	"	"	"	1 9	—	—	—	Struck close to No. 946, distance from centres of holes 10″; struck between two ribs; shot broke up; inner skin opened over an area of 1′6″ × 1′3″, and much bulged; piece of skin turned back measuring 1′6″ × 1′3″; five rivets and two wood bolts broken.
														6TH JANUARY, 1865.
19	979	"	Firth's steel.	104	"	"	9·75	"	34	—	1·7″	—	—	Struck on bolt between two ribs 8″ from top and 7′ from left of right lower plate; slight crack in indent; plate buckled out 0·8″ over a length of 4 ft.; one rivet broken, and a portion of one bolt driven out.

* Reduced in the shank to the size to which the bolt is reduced at the screwed end by the screw thread.
† 100-pr. S.B. gun, of 6¼ tons, Expl. No. 282.

ANCIENT CANNON IN EUROPE.

PART I.

FROM THEIR FIRST EMPLOYMENT TO A.D. 1350.

BY

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THE researches of antiquaries have as yet failed to bring to light any contemporary voucher, establishing the date of the first introduction of gunpowder as a propelling agent into European warfare. Many suppositions, and many confident assertions have been made as to the individual by whom, and the country in which gunpowder was invented. The Asiatic races in general, the Chinese and Arabs in particular, have been most frequently regarded as the inventors of this great power of modern war. Among Europeans, Marcus Græcus, Albertus Magnus, Berthold Schwarz, the German monk, and our own Roger Bacon, each in turn has been hailed as its discoverer.

It is not, however, in the province of this paper to discuss the merits of these various claimants, or to trace the apparently gradual manner in which the Greek fire, and the combustible compounds, thrown from the mediæval warlike engines, became developed, whether by accident or design, into that mixture of saltpetre, sulphur, and charcoal, which, from almost its earliest employment in war, bore the name in this country which it still bears, "gunpowder".

We have only to deal with the application of this mixture to purposes of warfare, in relation to the tube or instrument from which, by its agency, the missiles were thrown.

These tubes we shall find under the names of "cannon," "bombards," "tubes of thunder," &c.; and at this stage we must observe how much the difficulty of tracing their first employment is increased by the fact that, even as late as the middle of the fifteenth century, we meet with tubes, projecting balls by the action of gunpowder, called by the names of those engines, which were employed to throw stones and darts in the sieges of days long before gunpowder was known.[1]

Unquestionably before the use of gunpowder as an agent of propulsion, fiery substances were thrown in or from tubes; and tubes holding fire were attached to lance or pike heads. In time these or similar tubes were used for the projection of missiles by the force of powder, and about the date of their first employment for this purpose, they appear to have been called in the Latin of the period "canones"; a word which, spreading universally in slightly modified forms, has kept its hold to this day. This word is apparently derived from the Latin "canna," a reed or tube. In speaking of "cannon" in this paper, the word must always be understood in the sense in which we now employ it.

As to when and where these "cannon" were actually used for the first time there exists no information of value; that is to say, no contemporary document. Indeed, the authorities on which we may depend for any account of their early history are very restricted in number. There does not exist, as far as is known, the figure of a cannon in any illuminated manuscript of earlier date than the beginning of the fifteenth century; and it is almost entirely among the accounts of payments for provisions and stores of all kinds, that any mention of cannon is found at an earlier time. The loose statements of historians of a later period, and the anachronisms of the illuminators of the MSS. of the fifteenth century would lead us far astray as regards dates, were we to place confidence in their information regarding the employment of cannon in times anterior to their own. From the illuminators we should gain such information as that Gideon used field pieces on wheeled carriages with shafts, when he fought against the Midianites, as in a MS. in the British Museum.[2] Among the chroniclers and historians we should have difficulty in choosing a guide. Many of them make unsupported assertions; some, confusing the fiery projectiles of the ancient engines with the fire of the later cannon, date back the latter to far too early a period; while others again assign their first employment to a period at least sixty years after we have clear proof of their use. Some again confound the projectile and the cannon, and tell us quaint tales, as where Lenfant, in his history of the Hussite war, says that Ziska, the famous Hussite chief, became blind at the siege of Raby, because a "bombard" fell into his eye; while by far the greater number of those who have endeavoured to give us sound information, neglect to state the source from whence it is derived, and so to the antiquary or careful investigator their statements are worthless.

It is through such a tangled maze of misstatements and contradictions that the student of the early history of cannon has to make his way; neither rejecting, nor too credulously accepting any statement, till he has traced it back to its origin, and read it as far as possible by the light of contemporary facts and documents.

Of late years the spirit of enquiry has spread abroad. The long

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[1] Thus Valturius, writing in the middle of the 15th century, calls the crossbow and the cannon alike "Balista."

[2] MS. Royal 18 E.V. fol. 54 b.

slumbering archives of the middle ages have been disturbed, and so searched on behalf of the disciples of science, that much valuable information has been obtained on this subject.

The researches of M. M. Reinaud and Favé, of Colonel Omodej of the late Piedmontese army, of M. Lacabane, &c., and most especially of the Emperor Napoleon III., have thrown great light upon our subject; and it is by the aid of their learned works, and those of many minor contributors, that the author has endeavoured to make his way to some understanding of this question; tracing back to its original source, wherever possible, every statement on which any doubt may be cast, or where two opinions clash; and referring to, and being guided by the original text, not trusting to translations.

In this paper, as a rule, those numerous alleged instances of the early employment of cannon, which upon careful investigation have not proved trustworthy, will, except in some case of peculiar interest, be omitted; and we will confine ourselves to the unquestionable authority of contemporary public documents, and in some instances contemporary chroniclers.

These will carry us back no farther than the year 1326, in which year dates the earliest authentic document hitherto found proving the existence of cannon.

This record, which is still in existence, gives authority to the priors, the gonfalonier, and twelve good men, to appoint persons to superintend the manufacture of cannons of brass, and iron balls, for the defence of the commune, camps, and territory of Florence.

It bears date the 11th February, 1326, and is as follows:—

"Item possint dicti domini priores artium et vexillifer justitiæ una cùm dicto officio duodecim bonorum virorum,[1] eisque liceat nominare, eligere et deputare unum vel duos magistros in officiales et pro officialibus ad faciendum et fieri faciendum pro ipso communi pilas seu palloctas ferreas et canones de metallo, pro ipsis canonibus et palottis habendis et operandis per ipsos magistros et officiales et alias personas in defensione communis Florentiæ et castrorum et terrarum quæ pro ipso communi tenentur, et in damnum et prejudicium inimicorum prò illo tempore et terminio et cùm illis officio et salario eisdem per commune Florentiæ et de ipsius communis pecunia per camerarium camere dicti communis, solvendo illis temporibus et terminis et cùm eâ immunitate et eo modo et forma et cum illis pactis et conditionibus, quibus ipsis prioribus et vexillifero et dicto officio XII. bonorum virorum placuerit."[2]

Now, about this time, the Genoese and English came frequently in contact on the sea, and it is possible that through the former the use of cannon might have been communicated from Italy; so that at the first glance there appears no reason why we should refuse to admit that as early as 1327,

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[1] In 1321, during the wars made by Castruccio de Lucques on the Florentines, the latter, casting the blame of their ill success on the gonfalonier and priors, joined to them these twelve councillors (boni viri), as a check upon their actions.

[2] Vol. XXIII. (dist. II. class 2.) of the Riformagioni of Florence, p, 65. This document was first published by M. Libri in his Histoire des Sciences Mathém. en Italie, tom IV., p. 487, and was verified by M. de Mas-Latrie of the Ecole des Chartes. It has since been more than once published.

Edward III. may have used cannon in his northern expedition against the Scotch. The statement that he did possess cannon in his camp in that expedition is made by John Barbour, archdeacon of Aberdeen, who wrote in 1375 his poem, "The Bruce, being the life and acts of the most victorious conqueror Robert Bruce, King of Scotland." Here, noticing this campaign, and speaking of that night when Douglas descended from the Scotch camp, and penetrated as far as the English boy-king's tent, he says of the Scotch:—

"Twa noweltyis that day thai saw,
That forouth in Scotland had bene nane:
Tymmris for helmys war the tane,
That thaim thoucht than off gret bewté,
And alsua wondre for to se.
The tothyr crakys war off wer,
That thai befor herd nevir er."[1]

There cannot be any doubt that Barbour by "crakys of war" meant cannon; and moreover that he distinctly intended to mark this as their first appearance in that land, for, in an earlier place in his poem, speaking of the siege of Berwick by Edward II. in 1319, and of Robert Bruce's famous defence, we find

"Jhone Crab, a Flemyng, als had he
That wes off sa gret sutelté
To ordane, and mak apparaill,
For to defend, and till assaill,
Castell off wer, or than cyté,
That nane sleyar mycht fundyn be.
He gert engynys, and cranys, ma,
And purwayit gret fyr alsua;
Spryngalds, and schot, on fer maners
That to defend castells affers,
He purwayit intill full gret wane;
Bot gynnys for crakys had he nane,
For in Scotland yeit than but wene
The uss off thaim had not bene sene.[2]

But Barbour was only born between the years 1320 and 1326; and he can therefore be speaking only from hearsay: so that unless we can obtain some corroborative evidence, we are not justified in calling this an authentic instance of early cannon.

Such corroborative evidence, however, has never yet been produced; and there is, on the other hand, strong negative evidence that Barbour is antedating a fact of much later occurrence. All the army accounts of this period relating to this northern expedition, which are among the Queen's Remembrancer's Miscellaneous Papers at the Public Record Office have been searched either by or for the author of this paper, but no mention of guns or gunpowder or of anything of the kind is there to be found: nor does

[1] The Bruce ed. Pinkerton, 1790, Vol. III., p. 136.
[2] Ibid, p. 68.

there appear in other documents likely to yield such information, any notice of cannon under any name at this period.

This question has been thus carefully investigated, because almost every writer on the subject mentions this as an authentic case of the early employment of cannon.

A manuscript in the British Museum[1] called the "Kalendare of Brute" is quoted by Strutt[2] as an authority for the employment of cannon in 1332, but from internal evidence it appears that the MS. is of a date certainly as late as the fifteenth century, so that this again cannot be considered of any value.

In the year 1338, however, we come upon unquestionable testimony that cannon, both of iron and brass, were employed at that date on board English ships of war. We find an "indenture between John Starlyng, formerly clerk of the Ships, Galleys, Barges, Balingers, and other the King's Vessels, and Helmyng Leget, keeper of the same, 22nd June, 12 Edward III. 1338.[3]

The said John delivered to the said Helmyng in a ship called the "Bernard de la Tour" "ij canons de ferr sanz estuff."

The same delivered to the same the barge called "La Marie de la Tour," whereof John Brambehill is master, with the "apparaill," &c., "un canon de ferr ove ii chambres, un autre de bras ove une chambre, un ketill, un spogeour, &c. &c.

Also, "La nief appelle la carake dont Petre de Lenant est meistre," amongst other articles, "un canon."

Also, "La hulke appellee 'X'pofre de la Toure[4] dont John Kyngeston est meistre"—among other things, "iii canons de ferr ove v chambres, un handgone, un. . . . . de ferr p^r les canons."

It must be observed here that these cannon, whether of brass or iron, appear to have been, as we shall presently find was the case at about the same period in France, breech loaders, with moveable chambers to contain the charge; each gun being provided with more than one of these chambers.

Among the parcels in the storehouse in the same day was "un petit barrell de gonpouder le quart' plein;" and there is no other mention of powder for the service of these guns.

This same year, 1338, gives us the first French document relating to cannon which has been hitherto discovered. It is in the Cabinet des Titres of the Imperial Library at Paris,[5] and relates, according to Lacabane, to provision for the expedition to attack Southampton, which was fitted out at Leure and Harfleur in this year.[6]

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[1] Harleian, No. 24.

[2] Manners and Customs, &c. Vol. II. p. 32.

[3] Roll T. G. 11,097. This was first published by Sir Nicholas Harris Nicolas, in his History of the Royal Navy. London, Bentley, 1847, Vol. II. Appendix, p. 475.

[4] Later in this same year, a ship "Christopher" was taken by the French from the English, after a fight of nine hours, when according to Grafton (p. 236, ed. prin.), guns were fired.

[5] B. R. original parchemin parmi les titres scellés de Clairambault, Vol. XXV. fol. 1825.

[6] This document was first published by M. Léon Lacabane, in his Bibliothéque de l' Ecole des Chartes, 2nd série, tom. I. p. 51.

It is as follows:—

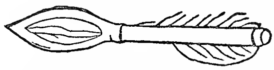
"Sachent tous que je Guillaume du Moulin de Bouloigne, ai eu et receu de Thomas Fouques, garde du clos des galées du Roy nostre sire à Rouen, un pot de fer à traire garros à feu, quarante-huit garros ferrés et empanés en deux cassez, une livre de salpêtre et demie livre de souffre vif pour fare poudre pour traire les diz garros; desquelles choses je me tien à bien paié, et les promets à rendre au roy nostre sire ou à son commandement, toute fois que mestier sera. Donné à Leure sous mon scel, le IIe jour de juillet l'an mil ccc trente et huit."

This proves that there existed in the marine arsenal at Rouen in the year 1338, an iron fire-arm, which was provided with forty-eight bolts (carreaux), made of iron and feathered; also one pound of saltpetre and half a pound of sulphur to make powder to propel the said arrows: these two ingredients being unmixed.

It may also be fairly assumed that the instrument from which these projectiles were to be fired had no special name, or if it had, that such name was so uncommon as to be unknown to this William; for otherwise, in a receipt of this formal nature, that name would have been specified, and the cannon would not have been merely called an iron pot.[1]

The bolts, garros or carreaux, which were the projectiles, were similar to those used for cross-bows and other engines before the invention of powder. The only known figured example of the cannon arrow, is of a date much later, in a work of the 15th century; but as the arrow there depicted so exactly corresponds with the description we have in the text above related, and with more minute details which we shall meet with further on, it may be here engraved.

Fig. 1.



British Museum, Add. MS. 24,945. fol. 94.

The word "carreau" is evidently derived from carré (square); the head of the bolt being frequently pyramidal, or square terminating in a point.

The arrows for this piece cannot have been large or heavy, as a pound of saltpetre and half a pound of sulphur was the quantity apportioned for 48 arrows. These ingredients, when mixed with charcoal, would not have made more than two pounds of gunpowder. This allows about seven-tenths of an ounce for each charge. Now supposing that the projectile was even ten times as heavy as the charge of powder, (and, with such powder, it would have thus received but a feeble impulse), the arrow would only have weighed about seven ounces.

Here we must note the fact that the ingredients of the powder were kept separately; being probably mixed when required for use.

In the same year dates a document now unfortunately not forthcoming, but which we cannot doubt was known by Ducange to exist in the Chambre

[1] Etudes sur le passé et l'avenir de l'artillerie, par L.N. Bonaparte, tom iii. p. 73.

des Comptes at Paris. This author, whose care and correctness are unimpeachable, quotes a passage from the accounts of Bartholomew du Drach, treasurer of wars, who paid money "à Henri de Faumechon pour avoir poudres et autres choses nécessaires aux canons qui estoient devant Puy-Guillaume."[1]

It is to be regretted that Ducange did not give the entire document, from which we might probably have gathered the cost and consequently approximately the size of these cannon.

About the same date, however, we find two receipts in the same chamber of accounts, one of which supplies us with the data to estimate the size of the cannon then in use: the other with the price of the materials of gunpowder. Both of these documents were published by M. Léon Lacabane, in his learned treatise on gunpowder.[2]

The first is a receipt for 25 livres,[3] in payment for ten cannon, five of brass, and five of iron, for the defence of Cambray. It is as follows[4]:—

"Sachent tuit que nous, Hugues, sires de Cardilhac et de Bieule, chevaliers, avons eu et receu de mons^{r}. le Galois de la Balmes, maistre des arbalestriers, pour

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[1] Ducange. Glossarium. article 'Bombarda. "Illius ab ann. 1338, in Galliâ usum fuisse docet Computum Bartholomæi du Drach Thesaurarii guerrarum istius anni: à Henri &c.'"

[2] De la poudre à canon et de son introduction en France, par M. Léon Lacabane. Paris, 1845.

[3] It is very difficult to obtain sound information as to the value of money at the period we are discussing, as so many points have to be considered before a correct estimate can be formed.

First, we must determine the actual weight of silver represented by the term 'livre' or 'pound,' and then, the weight of metal being known, its value in relation to the ordinary commodities of life must be ascertained.

French money especially was from time to time degraded by the rapacity or ignorance of the kings, who, to conceal their tampering with the coin, compelled the people to reckon at one time in crowns or écus, at another time in livres and sols, and sometimes in fractional parts of one or the other.

From the days of Charlemagne to 1103, the livre contained exactly one pound weight of pure silver, and was divided into twenty sols, and each sol into twelve deniers. The weight of the livre was first reduced by Philip I; and its value was constantly lowered by one method or another, till, in the reigns of Charles IV. and Philip VI. (1322–1350), it did not contain more than between one-fifth and one-sixth of a pound weight of silver; and, at the Revolution in 1789, it contained less than one seventy-eighth part of a pound.

As far as weight of silver is concerned, the livre of the second quarter of the fourteenth century was equal to about 14½ francs of the present coinage.

English money, though much depreciated, never sunk to the same extent as the French; nor was it tampered with till the 28th year of Edward the First (1300). Previous to that year, the pound (tower weight, rather less than troy weight), was coined into twenty shillings, and each shilling into twelve pence or sterlings; and, till the end of the first half of the fourteenth century, the decrease in value was very small.

One pound (troy weight) of silver is now coined into sixty-six shillings, so that the shilling of the earlier part of Edward the Third's reign was worth about three and a half shillings of the present day, as far as weight of metal is concerned.

The method generally adopted to estimate the relative value of money as an article of exchange is to compare the prices of corn at different periods. By this test, which is not altogether fair, the pound or shilling in the first half of the fourteenth century was worth about fifteen times as much as the coin of the same denomination is now.—Encyclopædia Britannica. Article, Money.—Le Blanc, Traité Historique des Monnayes de France—Ruding, Annals of the Coinage of England.

[4] B. R. original parchemin, parmi les titres scellés de Clairambault. Vol. 25, fol. 1825.

dis canons, chinq de fer et chinq de metal, liquel sont tout fait dou commandement doudit maistre des arbalestriers, par nostre main et par nos gens, et qui sout en la garde et en la deffense de la ville de Cambray, vingt et chinq livres deus sous et sept deniers tournois, liquel sont délivrés audit maistre et à la ville. Donné souz nostre saiel, à Cambray, le VIII[e] jour d'octobre mil CCCXXX et noef."

Here again we come upon the iron cannon (canon de fer), and the brass cannon (canon de metal); and we find that the ten cannon cost only 25 livres.

The other document enables us to conjecture the size of these cannon by the charge of powder which was apportioned to them. It is a receipt for eleven livres for saltpetre and sulphur for the above-named cannon. The original is as follows[1]:—

"Sachent touz que je Estienne Marel, escuiers, ay eu et receu de François de Lespitaul, clerc des arbalestriers du roy, nostre sire, par la main de Raoulet Haymon, lieutenant dudit François, pour salpetre et suffre vif et sec achetez pour les canons qui sont à Cambray, onze livres quatre soulz III deniers tournois. Desquelles XI livres IIII soulz III deniers, je me tiens à bien paiez.

"Donné à Cambray, souz mon seel le VI[e] jour de décembre, l'an mil CCCXXXIX, laquelle poudre a esté délivrée à monsieur le maistre des aubalestriers."

Comparing these two documents with others which give authentic information of the cost of the materials for gunpowder in 1342, and of the cost of wrought-iron and brass guns in 1375, we may arrive approximately at the weight of these pieces. From these authorities we will quote more fully further on; it is sufficient for our present purpose to say, that this sum of 25 livres, in 1375, (that is 37 years later, when the cost of manufacture would have probably been less than in 1338,) would have sufficed to purchase five cannon of wrought-iron weighing about 25 lb. each, and five of brass weighing about 22 lb. each; and secondly, that the 11 livres, given for saltpetre and sulphur, would in 1342 have produced enough to make from 25 to 30 lb. of powder, or from $2\frac{1}{2}$ to 3 lb. for each of these cannon; about the same amount as we estimated to have been the allowance for the "pot de fer à traire garros" already mentioned.[2]

Froissart, whose chronicle, although not written till some years later, is so faithful as to be looked upon as almost equal to that of an eye-witness, makes no mention of the use of cannon until the attack upon Quesnoy by the French in 1340. He says, "Mais on les fit retraire, car ceux du Quesnoy desclignèrent canons et bombardes qui jetoient grands carreaux."[3]

The word bombard is here used in relation to 1340, but it is not found till a later date in any contemporary account. It here doubtless signifies the small cannon throwing arrows.

We find again in this same year 1340, in the accounts of the town of Lille, where the document is still preserved, that there was paid to "Jehan

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1 B. R. &c., vol. 78, fol. 6119.

2 Etudes sur le passé &c. tom iii., p. 76. Lacabane estimates that the 25 livres would have purchased 10 iron guns of about 46 lbs. weight each.

3 Liv. I. part 1, ch. cxi. ed. Buchon.

Piet de Fur pour IIII tuiau de tonnoire et pour cent garros VI livres XVI sous."[1]

These tubes of thunder throwing arrows are doubtless nothing else than cannon, and from their price evidently very small; in fact, the "pot de fer" of Rouen is repeated over again in each of these examples; the 25 arrows for each of these cannon, and the price, are almost identical with what we have previously observed.

But, in the following year, 1341, we read in the same accounts, "A un mestre de tonnoire pour ledit tonnoire faire XI livres XII sous VIII deniers:" that is to say, as much money is here paid for one cannon as was paid at Cambray in 1338 for four: which would allow to this piece a weight of from 100 to 120 lb., still however a very small gun, scarcely so large as a wall piece of the present day.

In an account of the bailiffs of St Omer in 1342, we find the detail of the artillery of the castle of Rihoult in Artois. This is printed entire in the Emperor Napoleon's work, vol. iii. p. 77. It was first published in the Mémoires de la Societé des Antiquaires de la Morinie, and gives us more complete information of the cost of the material of ordnance at this early period than any other existing record.

From it we learn that two brothers, Pierre and Jehan, of Hedin, "traieurs de canon," were employed for more than two months, being paid from three to four sous a day each. We find 400 shafts of arrows "pour traire de canons" made at a cost of 5 sous per 100, and winged with brass, consisting partly of old pots cut up and melted down for the purpose; the wings or feathers so made being nailed to the shafts, which also had leather bound round them at their extremities to prevent the wings touching the sides of, and to keep the arrow fitting closely to, the bore.

The cannon itself, though very small, was in two parts, the tube which received the arrow, and the box in which was placed the charge of powder. This box, when loaded was placed in the end of the tube, and a wedge called a "laichet" kept it in its place. The powder was ignited by an iron rod heated in a charcoal fire.

The material for the powder consisted of $2\frac{5}{8}$ lb. of saltpetre, which cost 30 sous per lb., and $2\frac{1}{2}$ lb., of sulphur, which cost a little more than 7 sous per lb. Allowing for the charcoal being added, this quantity would only give from 7 to $7\frac{1}{2}$ lb. of powder; about $1\frac{1}{2}$ lb. of powder for 80 arrows, or less than $\frac{1}{3}$ oz. for each discharge.[2]

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[1] These extracts were first published by M. de la Fons Mélicocq, in an 8vo. pamphlet. Paris, 1855.

[2] It may be interesting here to note the price of the articles used in comparison with the wages already mentioned.

The following articles were bought amongst others:—

An old brass pot, 20 sous.
$16\frac{1}{4}$ lbs. of brass at 2 sous, 6 deniers, per lb.
6500 nails, at 3s. 6d. per 1000.

These must have been small nails, for 400 nails for the leather cost 4s. 8d.; $2\frac{5}{8}$ lbs. of saltpetre at 30 sous per lb.; $2\frac{1}{2}$ lbs. of sulphur at 7s. 2d. per lb.; a wedge 2 sous.

Froissart mentions that at the attack on the "chatel de Sturmelin" in Scotland in this year "Les Seigneurs d' Escosse se hâterent tellement et contraignirent ceux de la dite garnison, par assauts d'engins et de canons, que par force les convint rendre aux Escots; &c."[1]

He also states that when Charles de Blois was besieging Hainebon in the same year, the Countess of Montfort, who was defending the place, "faisoit apporter bombardes et pots plein de chaux vive pour jeter sur les assaillans;"[2] but in neither of these instances does he give us any clue to the size of these cannon.

It was probably either in this or the following year that Petrarch writes in his dialogue "De remediis utriusque fortunæ."

"I wonder that thou hast not also brazen globes, which are cast forth by the force of flame with a horrible sound of thunder. Was not the wrath of an immortal god thundering from heaven sufficient, that the small being man,—oh, cruelty joined to pride—must even thunder on earth! Human rage has endeavoured to imitate the thunder which cannot be imitated (as Virgil says,)—and that which is wont to be sent from the clouds, is now thrown from an infernal instrument of wood, which some think was invented by Archimedes when Marcellas besieged Syracuse; but he, to protect the liberty of his fellow citizens and to avert or put off the destruction of his country, devised what you are using to crush under the yoke or to exterminate a free people. This plague was only lately so rare as to be looked on as a great miracle; now, so easily taught the very worst matters are human minds, it has become as common as any other kind of weapon."[3]

It has been a disputed question whether the "flammis injectis" applies to the manner of propelling the brazen globes, or whether the latter were a kind of shell; but the latter interpretation, in the author's judgment, cannot be sustained.

Here we have cannon mentioned as in common use at the time of this dialogue being written. That date we will venture to call 1344; which year is also fixed upon by the Emperor Napoleon. It certainly cannot have been later, as Petrarch dedicates the treatise to Azzo da Correggio, Prince of Parma; and Azzo ceased to be Prince of Parma in 1344, when he sold his principality to Obizzo, Marquis d'Este.[4] It may have been written earlier; at all events, Petrarch did not know the name of the inventor of these instruments only lately become so common.

The word "ligneo" is in some editions written "igneo." If the latter is correct, it merely applies to the method of propelling with flame. If

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1 Liv. I. ch. 159.

2 Ibid. 173.

3 Mirum, nisi et glandes æneas, quæ flammis injectis horrisono tonitru jaciuntur. Non erat satis de cœlo tonantis ira Dei immortalis, nisi homuncio (o crudelitas juncta superbiæ!) de terra etiam tonuisset: non imitabile fulmen (ut Maro ait) humana rabies imitata est, et quod e nubibus mitti solet, ligneo quidem, sed tartareo mittitur instrumento, quod ab Archimede inventum quidam putant, eo tempore, quo Marcellus Syracusas obsidebat; verum ille hoc, ut suorum civium libertatem tueretur, excogitavit, patriæque excidium vel averteret, vel differret; quo vos, ut liberos populos vel jugo, vel excidio prematis, utimini. Erat hæc pestis nuper rara, ut cum ingenti miraculo cerneretur; nunc, ut rerum pessimarum dociles sunt animi, ita communis est, ut unum quodlibet genus armorum.—De remediis utrius que fortunæ. Genevæ, 1645, p. 303.

4 Muratori—Antiquitates Italici mediæ ævi. tom. 2, p. 514.

"ligneo," there is no evidence to support the idea that the actual cannon were wooden.

Evidently metallic balls were projected by them; and this is corroborated by other testimony; for, while as yet the only projectile which has been met with in France is the cannon arrow, or *carreau,* a document dated 29th April 1345, existing in the Imperial Library at Paris, proves the use of leaden balls in France at that epoch.

This document, printed in extenso in the Emperor Napoleon's Etudes &c., Vol. iii. p. 80, is a receipt given by one "Ramundus Arqueru, artillerist to the French king at Toulouse for sundry material of war, including two iron cannon, two hundred leaden bullets, eight pounds of powder for cannon, and two hundred wedges furnished with leather for the same cannon—"duobus canonibus ferri; ii^c plumbatis; viii libris pulveris pro canonibus; ii^c cavillis pro eisdem canonibus munitis de tachis."

Applying again the same test as before we find that about $\frac{2}{3}$ oz. of powder is the allowance for one charge, and estimating the projectile at ten times that weight, each leaden ball would only have weighed about 7 oz., much the same as the cannon arrows already named at an earlier period. Hence we may again conjecture that the piece from which they were fired was of the same weight, or nearly so, and not exceeding 25 lb. These cannon seem to have been loaded at the breech, and the wedge or plug covered with leather stopped the breech, and, being destroyed by the action of the powder, was renewed after each discharge.

At Cahors in the same year it appears by the accounts of the consuls of the town, that cannon were cast.[1] These accounts speak of 24 cannon, 36 lb. of saltpetre, and 25 lb. of sulphur; which would allow about 3 lb. of powder as the supply for one cannon. This shows that the cannon must have been very small.

The following year, 1346, is ever memorable in our history, for in July of that year Edward III. sailed on the expedition into France, during which, a few weeks later, was fought the famous battle of Creçy. It has been popularly considered as an established fact, that cannon were employed by the English in that action; and that it was owing to the terror caused by these new and dreadful weapons, as much as to the valour and skill of their archers, that the English gained so signal a victory on this field. This theory has however been more than once called in question; and the point has been discussed with more than usual warmth. It is a matter of some importance, for this reason: if cannon were used at Creçy, this is an instance of their employment in the field; no other instance of which is known at so early a period; the only mention made of them hitherto being at sieges, and for the defence of towns and castles.

For this reason it seems desirable to enter into the argument here, and to state the grounds of the opinions of those who hold different views in the matter. But we must bear in mind, that all our evidence as yet has gone to show, that the cannon employed at this period were of such small dimensions, and the powder was of so feeble a nature, that it is utterly impossible that three or four of such weapons, especially when we consider how

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[1] Etudes &c., vol. iii. p. 80.

comparatively long must have been the time between the discharges, could have exercised any overpowering influence on the fortunes of the battle. Three or four or even more arrows or bullets from these pieces resembling blunderbusses of the present day in size would have scarcely been noticed among the hail of shafts from the bows of the archers.

Those, who uphold the opinion that cannon were used in this action, originally based their belief on the statement of Giovanni Villani, a Florentine chronicler, who details the events which took place in this century until the year 1348, when he died of a pestilence which ravaged the city of Florence. He, speaking of the battle of Creçy, says :—

"E ordino il re d'Inghilterra i suoi arcieri, che n'harea gran quantità su per le carsa, e tali di sotto, e con bombarde, che saeltavano pollottole di ferro con fuoco per impaurire e disertare i Cavalli de'Francesci........sanza i colpi delle bombarde che facieno si grande tremuoto e romore che parea che iddio tonasse, con grande uccisione di gente e sfondamento di Cavalli."[1]

Secondly, they based their belief on a passage in the "Grandes Chroniques de Saint Denis" which runs thus :—

"Lisquieulx Anglois getterent trois canons dont il advint que les Genevois arbalestriers, qui estoient ou premier front, tournerent le dos et laissierent le traire, si ne scet ou si ce fut traison, ou non."[2]

Thirdly, they based their belief on the fact that Froissart, in speaking of the attack by the English on the castle of la Roche-sur-yon in 1369, says they were accustomed to carry cannon with their armies, in these words :—

"Et encore plusieurs canons et espringalles, qu'ils avoient de pourvéance en leur ost, et pourvus de longtemps et usagés de mener."[3]

Taking these three statements together, it is argued by the one party that the use of cannon at Creçy by the English is fairly proved.

There is another statement on the subject, which appears of some value, but which has been overlooked by all writers on the subject except Colonel Omodej. A history or chronicle is published by Muratori, under the name of the "Historie Pistolesi Dall' anno M.CCC. al. M.CCC.XLVIII." In the preface Muratori speaks to this effect. "The author of this writing is unknown to us. He relates what occurred, especially in Tuscany, from 1300 to 1348. There is no room for doubt that he lived at this time, and probably the same pestilence, which carried off Villani in 1348, and to which 80,000 people fell victims, destroyed the author of this chronicle. His history is even more minute than that of Villani."

If Muratori is right, the statement which we find in this chronicle of the employment of cannon at Creçy, is contemporary with, and strongly corroborates that of Villani. The original text runs thus :—

"Quando li Cavalieri d'Inghilterra vidono feriti grandè quantità de' Franceschi, montarono a cavallo, e menarono con seco lo figliulo del Re d' Inghilterra, ; e molti Gallesi, li quale sono come huomini salva ichi, & altri assai con molte bombarde,

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[1] Hist. di Giov. Villani, Muratori, Rerum Italicarum Scriptores, tom. xiii., col. 947, 948.

[2] British Museum MS. Cotton, Nero E ii. part 2, fol. 397.

[3] Liv. I. ch. 585.

& assalirono lo campo del Re di Francia virilmente, facendo soccare tutte le bombarde a uno tratto: si chel li Franceschi si cominciarono a mettere in fuga."[1]

To these statements, those holding the theory that cannon were not employed in the field at so early a date, and consequently were not used in the battle of Creçy, opposed that, in the numerous MSS. of Froissart, where he has related so carefully, and with such minute detail, all the events of this battle, no mention is made of any cannon or gunners; but, on the contrary, Froissart distinctly asserts that the rout of the Geneose is to be attributed to the English archers; and they further hold, that Froissart must have known if cannon were used, as he takes his version of the action and the march preceding it from the testimony of those actually engaged therein.

A further branch of the argument is, that the portion of the Grandes Chroniques which contains this statement is anonymously composed, and consequently of little value. This would apply equally to the "Istorie Pistolesi." It is also urged that Villani, whose assertion is in fact the most difficult to oppose, was so far distant from the scene of action, that he cannot have known much about it. Besides, as Mr Hewitt says,[2] "both writers may be pardoned for seeking to refer the disaster that befell their countrymen to the employment of some new and terrible instrument of destruction."

To these arguments it is replied that Villani, at the time of the action, was an old man well used to courts and camps, while Froissart was only nine years old, and did not begin to write his chronicle till ten years later: and that, therefore the word of the former implies a great deal more, and is far more trustworthy, than the negative evidence afforded by Froissart's silence, which in fact, they contend, may mean nothing but that cannon were in such common use as not to require any special mention.

At this stage of the argument M. F. C. Louandre in his "Histoire d' Abbeville et du comté de Ponthieu,"[3] published a passage from a MS. Froissart in the library at Amiens, the text of which is this:—

"Et li Angles descliquerent aucuns canons qu'il avoient en la bataille pour esbahir les Genevois."

Napoleon accepts this as a genuine voucher:[4] but it will scarcely bear scrutiny. If it were an early MS. other transcripts would contain the same words, but this is unique. If it is, as is most probable, a late MS., the words are an interpolation, and therefore, the MS. is not a good authority.[5]

As regards the actual battle of Creçy, the author has been unable to find any further matter bearing on the question of cannon; but we have most important evidence that Edward III. was supplied with cannon shortly before he set sail for France. This, as usual, is supplied by the accounts of the period, and was first discovered, part by the Rev. Joseph Hunter,[6] and part by Joseph Burtt, Esq.,[3] assistant keepers of the Public Records.

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1 Muratori, Rerum Italicarum Scriptores, tom. ii. col. 516.

2 Ancient Arms and Armour, vol. ii. p. 297.

3 Tom I. p. 236. Paris, 1844.

4 Etudes, &c. vol. i. p. 41.

5 Hewitt, Ancient Arms and Armour, vol. 2. p. 297.

6 Published in Archæologia, vol. XXXII. p. 379.

7 Published in Archæological Journal, vol. 19, p. 68.

Now, in order thoroughly to understand the bearing of these documents upon this French campaign of 1346, we must keep in mind that on the 1st July of that year Edward III. was at Freshwater, in the Isle of Wight, waiting for a fair wind to carry him across the channel. On the 12th July he landed at La Hogue in Normandy, devastated the country for a considerable distance, and returning northwards, fought the battle of Creçy on the 26th August. He then marched on Calais, where he arrived on the 4th September, and the siege of that place lasted until late in the year 1347.

At the time in question, the Tower of London was the great repository of the king's weapons of war, which were considered as belonging to one of the king's wardrobes; and the officer in charge was called the clerk or keeper of the king's privy wardrobe at the Tower. During the years of which we are now treating, this office was held by Thomas de Roldeston; whom we also find employed in making powder for the king's use a little time before or during the expedition.

In a book of accounts of money, paid out of the king's chamber in the time of Robert de Burton, receiver of the king's moneys in the said chamber, from 25 December, 18 E. iii. 1344 to 18 October 1347, deposited among the records of the Exchequer, are sundry payments to Roldeston for things provided for the king's use by him, including cases for bows and arrows, a tent for the king's own use, &c., &c., and "Eidem Thomæ super facturam pulveris pro ingeniis, et emendatione diversarum armaturum—XL sol."

Was this "pulver pro ingeniis" gunpowder? Mr Hunter maintains that it was, and that the fact of the king's own tent being one of the items of this account, proves that these articles were provided before the king's departure. It is scarcely necessary to discuss either of these points, for we possess stronger and more conclusive evidence than this document affords.

John Cook, the clerk of the king's great wardrobe, (not the Tower wardrobe), renders accounts of moneys received and expended by him from 22nd December 19 Edw. III. 1345, to 31st January 23rd Edw. III. 1349; and gives the dates of the king's writs authorizing the payments. We have an entry for wax for the manufacture of the king's tent, under authority of the king's writ 4th May, 1346; and immediately following, and in connexion with this entry appears:—

"Et eidem Thomæ de Roldeston per manus Willielmi de Stanes, ad opus ipsius Regis pro gunnis suis, IX^{c} XII lib. sal petræ, et DCCC IIII^{xx} VI lib. sulphur vivi, per breve Regis datum x die Maii, dicto anno XX^{o}: per quod Rex mandavit prefato custodi quod computaret cum prefato Willielmo de Stanes de sal petra et sulphur vivo per ipsum provisa et de precepto ipsius Regis, allocando eidem rationabile precium percellarum quas idem Willielmus per indenturam prefato Thomæ liberavit, per indenturam ipsius Thomæ receptionem ejusdem sal petræ et sulphur vivi testificantem, sicut continetur ibidem."

This quantity of 912 lb. of saltpetre, and 886 lb. of sulphur for the use of the king's guns is a larger amount than we have yet met with, but it seems to us a small provision for a large army. Whatever quantity of powder it may have made, when mixed with the charcoal, seems to have been either consumed or approaching its end, when the king had been between two and three months before Calais, and a fresh supply seems to have been urgently required; for, on the 25th November, 1346, he issued a writ, commanding all the saltpetre and sulphur that could be found to be sold to the said Roldeston. Only 750 lb. saltpetre and 310 lb. sulphur were produced by this edict.

We hear of this writ and its results in an entry of these same accounts of John Cook :—

"Et eidem Thomæ ad opus Regis pro gunnis suis DCCL. lib. sal petræ, et CCCX lib. sulphur vivi, per breve Regis datum XXV die Novembris, per quod Rex mandavit prefato custodi quod provideri faceret ad opus Regis totum salte petre et sulphur vivi quod inveniri poterit vendendum, et illud prefato Thomæ liberari faceret per indenturam ipsius Thomæ receptionem ejusdem sal petre et sulphur vivi testificantem, sicut continetur ibidem."

This quantity appears to have been found insufficient to complete the siege operations, for again on the 15th September 1347, the king, being still before Calais, where he had now remained for more than a year, issues a writ, and Cook again pays to William de Stanes money for saltpetre and sulphur supplied by him to Thomas de Roldeston. On this occasion 2021 lb. of saltpetre, and 466 lb. of sulphur were bought, at a very high price. We read :—

"Et Willielmo Stanes pro MM.XXI. lib. de saltpetra et CCCC.LX.VI. lib. sulphur vivi ab eodem Willielmo ad opus Regis per Thomam de Roldeston clericum Privatæ Garderobiæ Regis emptis C.LX.VII^{l}. II^{s}. II^{d}., precium cujuslibet libræ sal petræ XVIII^{d}., et sulphur vivi viii^{d}."

Mr Hunter considers that this price of eighteenpence a pound for saltpetre, and eightpence for sulphur, was far beyond the usual price; in all probability the war had increased the value of these commodities.

Although the above accounts are for powder, and do not relate except indirectly to cannon, they shew that Edward III. must have made what in those days was extraordinary use of cannon at Calais; and, read by the light of a series of entries produced by Mr Burtt, they are full of interest. This series is a *compotus* of accounts, and recites that by virtue of a writ under the Great Seal directed to the Barons of the Exchequer, 28th Jan. anno regni 27 (1353), Robert de Mildenhale, keeper of the king's wardrobe, had furnished his account of all his receipts and expenses between the 17th Oct. anno regni 18 (1344) and 29 Sept. anno regni 25 (1351). The extracts are of considerable length, and it is only necessary here to name the munitions which have reference to our own subject.

"Et par aliud breve Regis de predicto sigillo Griffon' datum primo die Februarii, anno XIX^{o}, (1345) per quod Rex mandavit eidem custodi quod omnes arcus, sagittas, balistas, baudic', quarell', haucepes, armaturas, gunnis cum sagittis et pellotis, reparare, et coffras (et) dolia pro eis imponendis et trussandis providere et emere, et ea in manibus pro passagio Regis eskippare faceret, sicut &c. &c.

Again,

"per breve Regis de sigillo predicto datum iiij die Marcii eodem anno (XX^{mo}...1346) per quod Rex mandavit eidem custodi quod omnes pavillones, arcus, sagittas, balistas, baudric' hausepes, armaturas, gunnis cum pelotis et pulvere pro eisdem gunnis &c. &c." to be repaired and shipped &c.

Again,

"pro eisdem et aliis rebus infrascriptis ducendis usque Caleis ad Regem provisas, et eciam portagio x. gunn' cum telar', IX coffrarum cum armaturis, vj peciarum plumbi, v. barellorum pulveris, et c. magnorum pelot' plumbi pro eisdem gunn' ....&c. &c.

Again,

" per breve Regis de privato sigillo datum primo die Septembris predicto anno xx°. per quod Rex mandavit eidem custodi quod omnia ingenia etgunn' cum eorum apparatu in Turri Regis predicta et alia diversa,.........pellot', barellos, et salpetre, et pulver', et omnimodas res alia et ingenia et gunn' illis spectantes eskippari ...... &c. &c."

Again, "Ingenia et Instrumenta Fabrorum et Balistariorum."

"Idem reddit compotum de ij ingeniis cum apparatu, x. gunnis cum telar' unde ij gross', v. parvis barellis cum salpetre, sulphure vivo et alio pulvere pro dictis gunnis, lxxiij. pellot' plumbi grossis, xxxj. parvis pellot', vj peciis plumbi.........Et missis Regi usque Calesiam, inter alias armaturas et res Regis ibidem missas per Clementem Atte Merke valettum camere sue, ij ingeniis cum apparatu, x. gunnū cum telar', quorum ij gross', v. parvis barellis cum salpetre et sulphure vivo, lxxiij pellot' plumbi grossis, xxxj. parvis pellot', et vj. peciis plumbi pro gunnis predictis, per duo brevia Regis, quorum j. datum primo die Septembris, et aliud secundo die Septembris, anno xx°," &c. &c.

We will sum up briefly and in chronological order the facts contained in the above extracts:—

"By the King's writ, dated

1345, 1st Feb. Guns with arrows and shot repaired and shipped for passage.

1346, 4th March. Guns with shot and powder for the same guns to be repaired and shipped.

„ 4th March. 10 guns with *telar'*, six pieces of lead, 5 barrels of powder, 100 large leaden shot for the same guns.

„ 10th May. 912 lb. saltpetre, 886 lb. sulphur, purchased.

„ 1st Sept. All engines and guns in the tower to be shipped: shot, barrels, saltpetre and powder, and guns.

„ 1st and 2nd Sept. 10 guns with telar', two of which are large; 5 barrels with saltpetre and sulphur and other powder for the said guns; 73 large leaden shot; 31 small shot; 6 pieces of lead for the same guns, were sent to Calais.

„ 25th Nov. 750 lb. saltpetre, 310 lb. sulphur, purchased.

1347, 15th Sept. 2021 lb. saltpetre, 466 lb. sulphur, purchased.

From this we may conjecture that the orders of the 4th March and 1st February 1346, were preliminary to the equipment to the expedition to France, when 10 guns were shipped, with 10 large leaden shot and half a barrel of powder for each gun, and 6 pieces of lead to make extra shot with. Now, if these pieces of lead would each make only sixteen shot, we might have altogether 20 shot for each gun, and there were probably, as we gather from the writ of 1st February, arrows also for the guns; how small then must these guns have been when half a barrel of powder was sufficient for so many charges. On the 10th May however, when the expedition was nearer to its complete organization, an additional quantity of powder was purchased and shipped. The king then sails, lands, and fights the battle of Creçy, and four days afterwards, when marching for Calais, he writes to order all his engines and guns, shot, barrels, saltpetre, sulphur, powder, and guns to be shipped for Calais at once, and again on the following day he writes again to the same effect. The result of this was that 10 guns, two of which are said to have been large, 5 barrels with saltpetre and sulphur and other powder for the said guns—(notice again this proportion of half a barrel of powder for each gun), 73 large leaden shot, 31 small shot, 6 pieces of lead for the same guns were sent to Calais; (again the same proportion of ten shot for each gun, and the same quantity of lead in reserve). The king has now therefore to our knowledge 20 guns at Calais, two of which appear to be of larger calibre than the others, and his ammunition seems to have lasted for three months or so; for it is not till the 25th November that he writes for more powder, and receives enough sulphur and saltpetre to make with charcoal added some 1200 or 1500 lb. of powder 60 or 70 lb. per gun; which lasted 10 months in a large siege. Clearly these guns must have been but small when 3 oz. or 4 oz. of powder per diem was sufficient for each gun.

Froissart tells us that at this siege the King of England caused to be built on the shore a strong castle of wood, to cut off the communication between the town and the sea; "et le fit pourvoir moult bien d'espringales, de bombardes, et d'arcs à tour, et d'autres instrumens."[1]

A manuscript in the British Museum[2] tells us that Edward took with him "Ingyners lvii. artellers vi. gonners vi." This is in an account of household expenses, and these men were paid in war time at the rate of 6d. each per diem. We find here again evidence of the very small size of the guns, for even supposing that this is only a portion of the gunners whom he may have taken, we find them very few in number as compared with the men to work the great engines; and it is highly probable that here, as at Bioule in 1347, one man was able to work two cannons.

This is corroborated to some extent by the fact that in the later MSS., where cannon are depicted, the manipulation of each gun appears nearly always to be in the hands of one man unassisted.

There is no mention of any but leaden projectiles, if we except the arrows; neither iron nor stone shot appear to have been supplied. The ingredients of the powder, as in other instances already found, were kept separate; at all events in the greater number of the cases mentioned. The *telar'* with which these guns were supplied were probably the stocks or wooden supports of the guns.[3] The same word occurs in the same account clearly as the stocks of the crossbows.

In these documents and in the contemporary chronicle of Villani we have met with the words "gunnis" and "bombarde" used for the first time.

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[1] Liv. I, part 1, ch. 315.

[2] Harleian 782, fol. 63.

[3] See Mr Burtt's note on this word in Archæological Journal, vol. 19, p. 72.

The former word "gunnis," elsewhere spelt "gonnes," and finally guns, appears to be derived from the "mangona" or "mangonel" which was one of those engines of war throwing stones, pots or barrels of flaming matter, or putrid carcasses, by means of counterweights[1], and from which on one occasion the Earl of Derby returned a messenger into the town of Auberoche in 1345.

The word "gonne" indeed seems to have been used in place of "mangonel" to denote these engines in more than one instance.[2]

The etymology of the term "bombard" is somewhat doubtful. It has generally been ascribed to the Greek *βόμβος*. Valturius, writing in the middle of the fifteenth century, says:—

"Hoc autem nomen Bombarda apud idoneos latinæ linguæ scriptores nusquam invenio, quamquam hujusmodi nominis impositio a sonitu tracta mihi nequaquam videatur absurda. Quid enim est Bombarda quam bombus sive bombizatio ardens?"[3]

At all events this is the first distinctive word coined to give the new weapon a suitable name. It held its ground in France and Italy for a long time; but did not apparently find favour in England, in which country only the word "gun" was adopted.

This year 1346, is fruitful in matters of interest on our subject. In September, the consuls of the town of Tournay, having heard that one Peter of Bruges was skilled in making certain engines called "connoiles" to be let off in a good town, if it should be besieged, desired him to make one, promising that if he made it well, and they approved it, he should have an order for more. Upon this Peter made one, and by desire of the consuls, proceeded to prove it, that they might learn how to use it. Peter took his cannon outside the gate "Noire aux Champs," inserted in it a quarrel (cannon arrow), which had at the end a piece of lead weighing about 2 lb., and fired it off. He laid it so that it pointed against a door and a wall. But, according to the narrator, it made such a cruel noise that the arrow passed out of the town, contrary to the expectation of Peter and the spectators, who could not tell what had become of it, and struck on the head a fuller who was near a monastery, and killed him. When Peter heard of this, he threw himself into a sanctuary. The consuls deliberated over the affair: and considering that it was entirely by their order that Peter had fired the gun, and that he was not known to have any spite against the fuller, held him blameless in the matter, and decided that it was a case of misfortune, and a sad pity.

The original document is as follows:—

"Comme li consauls de le ville euist ordené par ancun raport que on leur en fist, que Pieres de Bruges, potiers destain, savoit faire aucuns engiens appiellés con-

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[1] This early artillery is ably discussed by the Emperor Napoleon III., in his Etudes, &c. One or two illustrations of the mangonel are also given in a very interesting popular sketch of the history of our "Engines of War, and how we got to make them," by Captain Jervis-White-Jervis, R.A.

[2] Mr Burtt in Archæological Journal, vol. 19, p. 69.

[3] De re militari Lib. XI. There is a very good copy of this work, ed. Paris 1532, in the R.A. Library at Woolwich.

noilles pour traire en une boine ville quand elle soit assisse; liquels Pieres fu mandés et li commanda lidis consauls qu'il en feist j et se il le faisoit bien et que on sen loast il en feroit pluiseurs. Liquels Pieres en fists j et depuis aucun doudit consel vaurent savoir comment on sent poroit aidier et dirent audit Pieron qu'il le voloient faire esprover. Liquels Pieres porta sen engien dehor Moriel porte as cans et mist j quariel ens auquel avoit ou bout devant une piece de plonch pesant ij lb. u environ et fist cestuy engien traire et la porta pour jeter quant j huis et j muret. Liquels engiens fist si cruel noise et si grant que li quariaus vint par dedens le ville, et ny eust personne qui la fu, ne le dit Pieron, neant que le dit quariet veust ne ne peuist pierchevoir et passa les ij murs de le ville, jusques en le plache devant le moustier S. Brisse et la atainst j homme appielle Jakemon de Raisse foulon ou kief et le jeta mort. Lyquels Pieres pour le doubte de la loy de le ville se traist en saint lieu quant on li raporta le nouvielle. Sour cou li consauls de le ville par grant deliberation ent avis sour che e boin consel, considérant que on avoit commandé audit Pieron a faire ledit engien et que di celui lidis consauls lavoit fait traire pour exprouver comment il se porteroit, comment il avoit pris se visée de traire cont le dit huis et muret et que hayne aucune lidis Pieres navoit audit Jak qu'on seoist et comment li quariaus sans viser sa dreta de-dans le ville; qu'il ne veoient cose aucune pour quoy li dis Pieres ne deuist estre de ceste cose purs innocens et sans coupes de le mort le dit Jak et que ce que li dis Pieres en fist fu cas de meskance et de pitey, pour quoy audict Pieron il perdonnerent çou que par meskeance il lenestoit. Ce fu fait ou mois de septembre lan de grace mil iijc et xlvi."[1]

To this the registrar appended a foot note:—"Ce canon était carré, on le chargeait d'un dez de fer. Il fut emporté par les Français au dernier siége de 1745." If the registrar speaks correctly, this was a square cannon, breech loading.

In the same year, 1346, Hugues, Seigneur of Cardailhac and Bioule, under whose direction in 1339 were constructed the ten cannon for the defence of Cambray, drew up directions for the defence of Montauban; and in 1347, for the defence of the castle of Bioule.[2] In the first of these documents we find among the ammunition great abundance of sulphur, of saltpetre, of camphor, and of glass, and of everything necessary to make gunpowder, or to cast fire on the "chateaux" or "chattes" of the besiegers. After the detail of other descriptions of warlike engines, such as cross-bows of different natures, &c., we come to "great abundance of stones, of cannons, and of lead;" so that apparently these cannon threw both leaden and stone shot.

In the list of warlike stores for the defence of the castle of Bioule, dated 1347, we find, following cross-bows &c., 22 cannons. These were worked by 11 men, though there were but 70 in the whole garrison, so that evidently great importance was attached to them. But the chief interest of this document lies in its proving that the cross-bows were actually superior to the cannon; for, the defenders of the large tower are directed not to embarrass each other, but, as the enemy appears, to use first the "arbalêtes à tour, which carry furthest," and then the "arbalêtes de deux pieds," stones, and cannons: so that throwing stones, and firing cannon are classed together.

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[1] This piece has been published in many places; amongst others, in the Etudes &c. of Emperor Napoleon, vol. i, p. 357.

[2] Published at length in the Etudes, &c. vol. 4, Appendix 1 and 2.

The difference in point of size between the arbalête à tour and the cannon is illustrated by the fact, that, while it took two men to work one of the former, one man sufficed to serve two of the latter.

In this year (1347) in the accounts of the town of Lille we find,

"A un maistre qui vint chigieler d'un tonnoile donnet en courtoísie viii s."

"A maistres de la ville et plusieurs ouvriers qui burent à la bienvenne dou maistre qui gieta dou tonnoile parmi le salaire d'un vallet qui ra la guerre des quarriaux xi s. vi d."

The word here used "tonnoile" corresponds with the "connoile" made by Peter of Bruges the preceding year. The word seems to have descended from the "tuyau de tonnoire" spoken of in the accounts of this same town seven years earlier. In 1341 also, we found that a "mestre de tonnoire" was spoken of. Napoleon argues from the similitude of the latter expression with the term "maquinas de truenos" which Condé states he borrowed from the Arabs, that the Flemings learnt their use of fire-arms directly from the Arabs, for, in a charter of Brussels written in the Flemish language, the gunner is called "donderbusmeester."[1]

That cannon were not universally employed in attack or defence at this period, or else that their effects were so comparatively slight as to be unworthy of mention beside the crushing blows of the great stones thrown from the engines acting by the force of counterweights, may be inferred from the account which Froissart gives of the siege of Aiguillon in 1346, where the English were besieged by the Duke of Normandy. He tells us how the French sent to Toulouse for great engines to throw stones; and how the English made martinets which threw such large stones that they broke down all the French scaffolds; but no cannon are named on either side.[2]

In 1348, we find in the accounts of the town of Lille,

"Pour un canon dont on giete garos acaté iii escus val lvii s. Pour poure dont on asaia che chanon et pour ii garos et le faichon vi s. viii d."

Again, in 1349,

"Pour un canon dont on trait garos acaté par eschevins iii escus et vi garos val iiii l. xviii d."[3]

These from their price must have been even smaller than the cannon bought in 1341, which weighed about 100 lbs.

In 1349, in the artillery of the town of Agen, were cannon throwing small leaden balls. An original register, containing the deliberations of the consuls, &c. of the town, runs as follows:—

"Anno domini M°CCC°XL° nono, en Novembre fo balhada la artilharia de la vila à las personas dejus escritas........., item, an Guillem de Taliva e an Guillem de Lestroa.........e I. cano.........Item XLVI liuras de plom per far plumbadas...... Item, à M Guilhem de Cassanhas.........e I cano........."[4]

These cannon were employed for the defence of the gates of the town in conjunction with cross-bows &c.

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1 Hence our word "blunderbuss."

2 Liv. I. part 1, chs. 258, 259, &c.

3 Etudes &c. vol. 3, p. 84.

4 Original Register, fol. 91 and 92. Archives de la Mairie, published in Etudes, vol. 3, p. 84.

The same cannon arrows, however, were still employed in 1350; for under date of that year we read in the accounts of the town of Lille:[1]

"A Jacquart le Fèvre, pour XL clous pour fierer les quariaux des canons as de bons, pour II caces de fier pour chacier les quariaux ens.........&c."

This "cace" was probably a description of rammer rendered necessary by the close fit of the leather on the arrow against the sides of the bore.

We have now traced these cannon from their first authentic and contemporary mention, to the end of the first half of the 14th century; and we have found them throughout but feeble weapons in comparison with the great warlike engines of the period, which still were employed for the more serious operations; the largest cannon of which we have read being not more than 120 lbs. weight.

We have found them constructed of brass, and of iron, breech-loading, the charge being placed in a chamber which was kept in its place by a wedge.

The projectiles were in some cases leaden, iron, and stone shot; in some cases arrows with an iron or leaden point, with leather bound to the shaft to keep them firmly in the tube, and winged with brass—but no one of these projectiles appears to have exceeded 2 lbs. in weight, and the greater number were far smaller. The powder was made when required for use, the saltpetre and sulphur being kept in store, and the charcoal made when wanted; the three ingredients being then mixed together by hand. This powder was of course very weak in its action, giving but low velocity to the projectile; and this fact, joined to the small size of the cannon, caused the latter to be considered of less value, for anything but close quarters, than the "arbalêtes à tour."

Such cannon, however useful in a defence, where we generally find them employed, had little or no effect against the walls of cities or castles; they were quite incapable of making, or even assisting to make, a breach; and the engines already spoken of were the great weapons of assault, and also for destroying the towers, chats, and other means by which the besiegers endeavoured to gain an entrance into the besieged place.

Whether cannon were ever used in the field at this early stage is a question which it is difficult to solve. It rests almost entirely on this problem of the battle of Creçy. Napoleon has answered the question in the affirmative, but on grounds which do not appear sufficient to justify his conclusions.

It is however a matter of little moment, except to the antiquary; for the diminutive size of the cannon, the want of velocity of the projectiles, and the length of time elapsing between the discharges, must have made the cannon of little value; and we cannot for an instant doubt that these disadvantages would have more than counterbalanced any advantages they might have possessed over the longbow.

We have found them under the names of "cannon," the word being variously modified—"bombardes," "lignea instrumenta," "pots de fer," "tuyaux de tonnoire," changed before long into "tonnoilles" and "connoilles," and lastly our English word "guns," which we retain in common use to the present time.

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[1] Etudes &c., vol. 3, p. 87.

In this paper the author has endeavoured to place before his readers every trustworthy piece of information which it was in his power to obtain; and has omitted those numerous statements, which, after careful investigation, he has been unable to trace back to an authentic and reliable contemporary source. In the next paper on the subject he hopes to bring down the history of cannon to the close of the 14th century, before which epoch great changes had occurred in these weapons.

REPORT

ON THE

"GENISTA"* CAVE, WINDMILL HILL, GIBRALTAR.

[Published in the Gibraltar Chronicle, January 23, 1865.]

The following highly interesting report on the subject of the Bone Cave at Windmill Hill, was addressed by the late Dr Falconer and Professor Busk to His Excellency General Sir William Codrington, Governor of Gibraltar in October last: so many officers of the Regiment have at some period or other served in that Fortress, that it has appeared to the Committee worth while to give publicity to it in these "Proceedings," for their information, illustrating as it does in a remarkable manner the discoveries which still await intelligent research even in quarters the most unpromising.

To His Excellency

General Sir W. J. CODRINGTON, K.C.B., &c.,

Governor of Gibraltar.

SIR,

The circumstances which have led to our visit to Gibraltar, and the objects we have had in view are so well known to your Excellency, that it is unnecessary on our part to do more than refer to one or two incidents in the early history of the Cave.

2. When the interesting objects contained in the upper chambers of the "Genista" cave on Windmill Hill were brought to light by Captain Brome, your Excellency addressed a letter to the Secretary at War, giving a preliminary report on the results. That communication was forwarded from the War Office to the President of the Geological Society of London, with a request for an opinion as to the importance, in the interest of science, of following up the exploration, and for suggestions as to the manner in which it could be best conducted. The reply led to the sanction, by the Secretary at War, of the further exploration of the cavern, by means of the labour of the military prisoners, under the able superintendence of Captain Brome,

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* "Genista—a species of the broom plant. The planta-genista gave its name to the great house of Plantagenet. The Professors name the cave, under a Latin guise, after its discoverer, Captain Brome. This kind of transmutation was formerly a favourite conceit of the learned. The real name of Luther's friend Melancthon (Μελαν χθων) was Schwarzerde, *anglice* Black-earth."—*Note of Editor Gibr. Chron.*

and to pass over minor incidents well known to your Excellency—the objects discovered were forwarded to us in London for identification and scientific examination.

3. Having devoted several months to the study of the cave collections successively transmitted to us, which were so carefully classified by means of distinctive marks by Captain Brome, the governor of the military prison, as to place the main facts clearly before us, we were so strongly impressed with their importance that we determined, on your Excellency's invitation, to visit Gibraltar, and examine the general conditions of the cave, on the spot. For the discoveries in the Windmill Hill cave have not only yielded unexpected results regarding the former state and ancient animal population of the Rock itself, but they further point to a land connexion between the Southern part of the Iberian peninsula and the African continent at no very remote geological epoch.

4. Captain Brome's report dated the 21st August, 1863, with the plan and section which accompany it, so clearly explains the nature of the Windmill Hill cave, that it is unnecessary for us to enter on the present occasion into any detailed description of it. The rock abounds in caves which are of two classes: 1st, seaboard caves, at various heights above the level of the sea, and horizontally excavated on the ancient cliffs by the waves. 2nd, inland caves, descending from the surface, and in connexion with great vertical fissures, by which the mass of the rock has been rent at remote epochs during disturbances caused by violent acts of upheavement. Like the well known cavern of St Michael's, the "Genista" cave of Windmill Hill belongs to the second class. It forms part of a great perpendicular fissure which, by the vigorous measures adopted by Captain Brome, has either been excavated or traced downwards to a depth of upwards of 200 ft. below the level of the plateau of Windmill Hill. It was full of the fossil remains of quadrupeds and birds, of the former of which some are now wholly extinct; others extinct in Europe, and repelled to distant regions of the African continent; others either now living on the rock or in the adjoining Spanish peninsula. The following is a list of the species which we have at present identified:—

PACHYDERMATA.

Rhinoceros, *Etruscus* (?), Extinct.
Rhinoceros, *Leptorhinus Equus Megarhinus*, extinct, abundant.
Equus, ———, young animals only—species undetermined.
Sus, *Prisca* (?), extinct.
Sus, *Scrofa*, living.

RUMINANTS.

Cervus, *Elaphus var. Barbarus*, Fossil remains abundant.
Cervus, *Dama*, or a nearly allied form: abundant.
Bos, ——— a large form equalling the Aurochs in size, remains few and imperfect—species undetermined.
Bos, *Taurus*, abundant in the upper chamber.
Capra, *Hircus*, abundant in the upper chamber.
C. Ægoceros, form A. } Two forms of Ibex, probably extinct, in vast
C. Ægoc. form B, } abundance throughout the fissures.

RODENTS.

Lepus, *Timidus*, rare.
Lepus, *Cuniculus*, very abundant at all depths.
Mus, *Rattus*.

CARNIVORA.

Felis, *Leopardus*.
F., *Pardina*.
F., *Serval*.
Hyæna, *Brunnea*, now repelled in the living state to Southern Africa.
Canis, *Vulpes*.
Meles, *Tascus Ursus*, not *N. Spelæus*—species undetermined.

DELPHINIDŒ.

Phocœna, *Communis*.

BIRDS.—Remains numerous—genera and species undetermined.

TORTOISE.—Rare—species undetermined.

FISH.—Remains numerous in the upper chambers.

5. Apart from the still immature state of the investigation, it would be quite beyond the limits within which we are restricted in this communication for us to enter in detail upon the conclusions to which the data, furnished by the fossil remains, lead. We shall therefore confine ourselves to a few of the more important general points.

6. The rock is now bared of natural forest trees, and destitute of wild animals, with the exception of the hare, rabbit, fox, badger and a few *Magot* monkeys, the last in all probability the descendants of introduced animals. The fossil remains of the "Genista" cave establish beyond question that the rock was formerly either peopled by, or the occasional resort of, large quadrupeds like the elephant, rhinoceros, aurochs, deer, ibex, wild horse, boar, which were preyed upon by hyænas, leopards, African lynx and serval. That the remains were transported by any violent diluvial agency from a distance is opposed to all the evidence of the case. The manner in which they were introduced into the Windmill Hill cave we believe to have been thus. The surface of the rock, and its level in relation to the sea, were formerly different from what we now see. The wild animals above enumerated, during a long series of ages, lived and died upon the rock. Their bones lay scattered about the surface, and in the vast majority of instances, crumbled into dust and disappeared under the influence of exposure to the sun, and other atmospheric agencies, as constantly happens under similar circumstances at the present day. But a certain proportion of them were strewed in hollows along the line of natural drainage. When heavy rains fell, the latter, for the time converted into torrents, swept the bones, with mud, shells, and other surface materials, into the fissures that intercepted their course. There the extraneous objects were arrested by the inequalities of the passages, and subsequently solidified into a conglomerate mass by long continued calcareous infiltration. That elephants frequented the rock is proved by a valuable specimen of the molar tooth of an extinct

species which we have ascertained to be *Elephas antiquus* discovered in a sea-beach on Europa Point. That the hyænas were dwellers upon the rock is also established by the fact that in addition to numerous bones we have detected a considerable quantity of *Coprolites* of *Hyæna brunnea* among the "Genista" cave relics. Some of the species must have peopled the rock in vast numbers. We infer upon a rough estimate that we have passed through our hands bones derived from at least two or three hundred individuals of Ibex, swept into the Windmill Hill fissure. In no instance have we observed fossil bones attributable to one complete skeleton of any of the larger mammalia.

7. That the rock now so denuded of arboreal vegetation was then partially clothed with trees and shrubs as the corresponding limestone mountains on the opposite side of the Straits are at present, is so legitimate an inference as hardly to be open to rational doubt. It is now a pinch to find sufficient food, at the end of the hot season, for the flocks of goats which are reared on the promontory; while it is a matter of absolute difficulty to find fodder at all for the few cows that are kept by some of the officers of the garrison. When elephants, rhinoceros, wild oxen, horse, boars, deer, &c., either peopled or resorted to the rock in considerable numbers, there must have been abundant trees, and more or less of constant green food for them. Bare exposed masses of rock get intensely heated by a southern sun; they repel moisture by being thus heated, and raise the mean temperature of the locality by radiation. While on the contrary a clothing of trees and fruticose vegetation both tempers the heat, attracts moisture, and greatly increases the fall of rain. We are aware that your Excellency's attention has been directed to planting operations on the rock. Numerous and repeated failures must be looked for at the commencement; but the facts above mentioned would indicate that success may ultimately be attained with much benefit to the station.

8. The next prominent point in the cave is the character of the extinct Fauna of Gibraltar regarded as a group. Of the prevailing fossil forms which occur in England, Germany and France, as far south as the northern slope of the Pyrenees and the shores of the Mediterranean, such as the mammoth, *Rhinoceros tichorhinus*, *Ursus spelæus*, *Hyæna spelœa*, not a vestige has been detected among the fossil remains of Gibraltar. In the latter the carnivora are the most significant. The three species of *Felis* are of African affinities, and *Hyæna brunnea*, now for the first time ascertained to have existed formerly in Europe, is at the present day chiefly found near the Cape of Good Hope and Natal. Remains of the existing African elephant have been discovered in the neighbourhood of Madrid, by Don Cascano de Prado. That either of these wild animals could have crossed the Straits from Barbary to Europe is contrary to all probability. The obvious inference is that there was a connexion by land either circuitous or direct between the two continents at no very remote period, somewhere within the Mediterranean area. To arrive at any further evidence bearing upon this very important question, from the rock of Gibraltar becomes an object of the highest general and scientific interest.

9. Human remains were found in great abundance in the upper chambers. They appear to have belonged to between thirty and forty individuals. They were accompanied by stone implements of the polished stone period, broken querns, a large quantity of pottery, marine shells of edible species, and some other objects enumerated in Captain Brome's report. No way of access from the surface by which these materials could have been introduced has been discovered. But on carefully examining the ground, we believe with Captain Brome that the entrance lies somewhere under the southern half of the east wall of the prison enclosure. Until the aperture from the surface is discovered, no certain conclusions can be arrived at. Considering the time and labour which have been expended on the cavern, it would be a subject of great regret if the exploration were left incomplete on this important point, we would therefore venture strongly to recommend that the excavations be continued through the ground over which the east wall runs, until the external aperture is detected. We believe that it will be found in the fissure outside the east wall, which Captain Brome has so sagaciously and perseveringly explored.

10. The human bones are of high interest in consequence of certain peculiar characters which many of them present. They appear to belong to widely different epochs, although none of them of very high antiquity (*i.e.* before the historical period). That the upper chambers of the cave were ever inhabited by savage man, we consider to be highly improbable. It seems more likely that they were used for the funeral rites of the dead.

11. As regards the final disposal of the interesting and important relics discovered in the "Genista" cave, a complete series ought to be deposited in London, either in the British Museum or the Royal College of Surgeons, but we consider it to be of still higher importance that a collection should be retained for Gibraltar. In the progress of the vast defensive works which have been carried on during the past century in scarping and tunneling the rock, objects of high interest relating either to its natural history or archeology, have been brought to light. But in the great majority of cases they have either been disregarded or lost. Instances might be cited from Colonel James's history of the Herculean Strait, 1771, and Major Laurie's memoir on the Mineralogy of the Rock, in 1797. In 1844 a laudable effort was made by the late Archdeacon Burrow to establish a museum on the rock, but, after languishing for some time, it failed from the want of proper support. The relics of the collection were afterwards exhibited in the Soldiers' Home, but, when that institution was given up, no place remained either for displaying or taking proper care of the collection. Some of the brightest records of the military glory and prowess of our country are indissolubly connected with Gibraltar. A great nation like England cannot afford to neglect or disregard without reproach, whatever bears on the natural history or archeology of so renowned a possession. That the naval and military services take the liveliest interest in such objects, is placed beyond doubt, by the United Service Museum of London founded upon collections contributed by them from all parts of the world. But it

appears to us that the formation and maintenance of a local museum at Gibraltar, illustrative of its products and relics, ought not to fall upon the garrison, who are only temporary residents, and that it is more properly an Imperial obligation. The least expensive and best mode of carrying the object into effect, would probably be to have a room in the Library reserved for the purpose and under the management of the Library Committee. The only outlay would be in the construction of the apartment and in the glass cases for the objects. No establishment would be required.

12. In case of any proposal of this nature being entertained, we would venture to suggest to your Excellency that the collection should be strictly limited to objects of local interest, having reference to the rock, the bay, the straits and the immediate vicinity. Everything from beyond these limits should be excluded. A museum of reference of this nature should include:

A Herbarium collection of the plants yielded by the Rock.

A Zoological collection of all objects, terrestrial and marine, produced within the limits.

A collection of specimens and minerals of the Rock.

A complete collection of the fossil remains yielded by the ossiferous caves and bone breccia of Gibraltar.

An Archeological collection of coins, pottery and other antique relics occurring within the circuit of the bay.

13. In illustration of the absolute need there is of a local collection of the kind here indicated, we may mention that, being anxious to fix the age of the pottery yielded in such abundance by the Windmill Hill cave, no similar materials for comparison derived from the ancient ruins of Carteia, or from points in the Mediterranean resorted to by the Phœnicians, were to be found in the British Museum. The proofs of the antiquity of the human race is one of the leading questions that occupy the attention of educated and scientific men at the present day. That human remains and other objects bearing upon it are considered of high value, is sufficiently proved by the fact that a grant of £1000 was passed for the purchase of a collection of this kind from the valley of the Verère, in the south of France, during the last session of Parliament, for the British Museum. One of the human skulls yielded by the rock appears to us to point to a still higher antiquity. In fact, it is the most remarkable and perfect example of the kind now extant. In the absence of a properly organized museum, no record exists of the precise circumstances under which it was found; and that it has been preserved at all may be considered a happy accident. It has cost us much labour, and with but partial success, to endeavour to trace its history on the spot where it turned up.

14. Our time has been so fully occupied by the examination of the Cave collections and collateral subjects, that we have only been able to make a cursory examination of the geology of the rock. We entirely agree with the opinions expressed in the excellent memoir by Mr James Smith, of Jordan Hill, that it bears unmistakable evidence of having undergone extraordinary disturbances, both of upheaval and depression, during the quatenary

or immediately pre-modern period. But the data are complex and in some instances obscure. Now that a complete topographical survey of the Rock has been completed on a large scale, a geological survey would be a matter of comparative ease, and we should submit to your Excellency's consideration the expediency of an application being made for the services of an assistant upon the geological survey of England to be deputed for the purpose. The area is so compact and limited, that the survey, including that of the surrounding bay, need not occupy more than a couple of months.

15. We cannot bring this letter to a close without expressing our opinion of the value and importance of Captain Brome's exploration of the Windmill Hill cavern, under the support, enlightened countenance and encouragement which, we are well aware, he has uniformly received from your Excellency during the progress of his operations, and which have mainly led to their successful issues. The only account of the mineralogy of Gibraltar that has been published, is the excellent "Brief description" by Major Laurie, of the Royal Artillery, which appeared in the Edinburgh Philosophical Transactions in 1797. In 1844 Mr Smith, of Jordan Hill, brought out his valuable memoir on the "Geology of Gibraltar;" but the fossil mammalian remains of the bone breccia were only very cursorily noticed by both authors. In the latter half of the last century they attracted the attention of William and John Hunter, in papers which are to be found in the "Royal Transactions," but without an attempt at precise identification. Cuvier, in his great book the "Ossemens Fossiles," of 1824, gave a special chapter on the "ossiferous breccias," and devoted much attention to those of the Mediterranean. From the materials which passed under his hands, he was able to detect evidence only of two extinct species, one of which is doubtful. He concludes his remarks on the Gibraltar remains in the following terms:

"Voilà donc, dans ce petit nombre d'os de Gibraltar que j'ai en me procurer, au moins une espèce de lièvre et probablement une espèce de cerf, dont les pareils ne sont pas connus en Europe.

"Que serait-ce si quelque naturaliste résidant sur les lieux prenait la peine de recueiller et dégager avec soin ceux qui se decouvriraient pendant quelques années, comme je l'ai fait pour les ossemens de nos gypses! D'après ce que nous allons voir dans les articles suivans, on ne peut douter qu'il n'y fìt des récoltes abundantes et intéressantes." (op. cit. tom vi. p. 346).

From that period down to the present day, hardly any addition has been made to our knowledge of the subject during a lapse of forty years, until Captain Brome undertook the exploration of the *Genista* cave, and the best commentary upon the preceding citation is furnished by the fact that the materials collected by him have enabled us to determine upwards of twenty species of mammalia above enumerated, many of them extinct, and all of them bearing importantly on the ancient condition of Gibraltar. Indeed, it is within the facts of the case to say that in the important walk of the mammalian palæontology of Gibraltar, Captain Brome has done more than was effected by the united labours of his predecessors since the rock became a British possession. The persevering energy and vigour with which he has followed up the inquiry, and the minute and scrupulous care with which he has discriminated and arranged the objects, are worthy of the highest commendation, and more especially so as the subject was new to him. We are inclined to believe that the labour of military prisoners was never better directed in the interest of science.

16. We have to tender our best acknowledgments to your Excellency for the cordial reception which you have given us and for the pains you have taken to forward the object of our visit in every aspect. We beg leave also through your Excellency to offer our best thanks to the military, naval and civil departments of the service, for their hearty co-operation.

Our thanks are more especially due to Major General Frome and the officers of Royal Engineers, and to Captain Ommaney, R.N., the senior naval officer of the station, who have rendered us every assistance in their power.

We have the honor to be,

Your Excellency's most obedient humble servants,

(Signed) B. FALCONER,
Vice-President Royal Society.

GEORGE BUSK,
Secretary Linnean Society.

GIBRALTAR Oct. 10, 1864.

ANNUAL REPORT

AND

ABSTRACT OF PROCEEDINGS OF A GENERAL MEETING OF THE ROYAL ARTILLERY INSTITUTION, HELD ON TUESDAY, MAY 2, 1865.

MAJOR-GENERAL E. C. WARDE, C.B. IN THE CHAIR.

1. THE Committee of the Royal Artillery Institution have the honor to submit to the Annual General Meeting their Report and Abstract of Accounts for the year 1864-65.

It will be seen by the following Table that the increase to the number of Members during the year, after deducting all casualties due to death and other causes, amounts to 46. The total new members who have joined during the year is very satisfactory, amounting to 88,—but the Committee have at the same time to regret the loss of 25 Members by death, a number in excess of the average of past years. It is satisfactory to observe that 26 Officers of the late Indian Artillery have joined, since the last Annual Report was issued.

RANK.	£	s.	d.	April, 1864.	Since joined.	Promoted or withdrawn.	Deceased.	April, 1865.
EFFECTIVE LIST.								
General and Regimental Field Officers, paying annually	1	5	0	163	+20	−7	−9	167
Captains	0	16	0	389	+34	−19	−8	396
Lieutenants	0	10	0	487	+52	−28	−7	504
Quarter-Masters	0	10	0	8	+1	0	0	9
Riding-Masters	0	10	0	3	0	0	0	3
Surgeons-Major	1	5	0	4	0	0	0	4
Surgeons	0	16	0	5	+1	0	0	6
Assistant-Surgeons	0	16	0	22	+2	0	0	24
Veterinary Surgeons	0	10	0	2	+1	0	0	3
RETIRED LIST.								
General and Regimental Field Officers	1	5	0	18	+6	0	−1	23
do. do.	0	16	0	1	0	0	0	1
do. do.	0	10	0	6	+2	0	0	8
do. do.	0	7	6	7	0	0	0	7
Captains (D. W. Pack Beresford)	5	0	0	1	0	0	0	1
do.	0	16	0	12	+4	0	0	16
do.	0	10	0	5	0	−1	0	4
do.	0	5	0	7	0	−1	0	6
Surgeons-Major	1	5	0	1	0	0	0	1
Chaplains	1	5	0	0	1	0	0	1
				1141	+124	−56	−25	1184
Honorary Members	0	10	6	26	+3	0	0	29

2. The funds of the Institution, the Committee are glad to inform the Meeting, are in a sound and flourishing state. The abstract of the year's income and expenditure is shewn on the opposite page, and it will be seen by the Dr. and Cr. account, which is attached thereto, that the Institution has now a Balance Cr. of £1446. 9s. 5¼d.

3. *Printing and Publication.*—The amount of work done in this department has been considerable. In addition to seven numbers of Vol. IV. of the Proceedings which have been issued to all Members, a new edition of Major Owen's Lectures on Artillery (1025 copies) has been printed, and the work can, in consequence, be procured by Members through the Institution, at the rate of 9s. 6d. a copy, the publisher's price being 15s. To those Officers who have contributed papers to the Proceedings, as enumerated in the annexed list, the Committee express their thanks, and have pleasure in recording the growing desire which is manifested to obtain these Professional Papers. During the year presentation has been made, with the sanction of the Secretary of State for War, of the three completed volumes to the Russian Government, and to the Smithsonian Institute at Washington, in compliance, in both cases, with a request made to the Committee; a request which the Committee have had much pleasure in complying with, in acknowledgement of the many valuable contributions which have been made to the Library of the Institution by Lieut.-Colonel de Novitzky, military attaché to the Russian Embassy, and by Dr Henry, the Secretary of the Smithsonian Institute.

The Third Edition of the Handbook for Field Service being nearly exhausted, a new edition will shortly be commenced, and the necessary revision has kindly been undertaken by several officers. The Committee hope that the new edition will be ready for issue before the next Annual Report, and copies will be obtainable by Members at cost price.

It is also in contemplation to commence a new edition of Kane's List, as already notified with the November number of the Proceedings, provided a sufficient number of subscribers are obtained.

The monthly Regimental Lists are forwarded to members wishing to receive them on payment of postage,* and to meet the wishes of certain officers some copies are now printed on a single sheet of thin paper, by which means four copies can be transmitted to Foreign stations at a single rate of postage.

The constant demands upon the printing press, for other work for members has been so great, that an extra compositor has been employed; the cost for wages and materials is therefore in excess of previous years, but as this additional charge is balanced by largely increased receipts on this account, the Committee have pleasure in recording the fact as instancing the general usefulness of this part of the establishment.

List of "Proceedings," printed during the year.

Gun Cotton: an Introduction to the Properties and History of the substance. By Major F. Miller, VC, R.A.

Muzzle-pivoting Gun Carriage. By Lieut.-Col. G. Shaw, R.A., Assistant Superintendent, Royal Carriage Department.

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* Home, 1d. Colonies, 3d. India, 4d.

General Abstract of the Income and Expenditure of the Royal Artillery Institution,

From 1st April, 1864, to 31st March, 1865.

Dr.

	£	s.	d.
Printing and Publication. Wages	195	10	10
Paper	170	0	0
Type and Materials	110	10	11
Wood Cuts	44	18	6
Lithography	92	3	8
Chemistry	57	13	2
Photography: Chemicals and Apparatus	72	3	11
Photography: Printing, Mounting, &c.	341	7	9½
Drawing	48	1	11
Lectures	76	2	8
Taxidermy	10	8	1
Library, Books, &c.	160	2	4
Museum	65	12	10
Instruments	16	15	0
Carpenter, Materials	59	0	10
Carpenter, Wages	18	15	0
Insurance on £5000 (to 24th June, 1865)	12	18	3
Furniture and Repairs	65	7	10
Subscriptions to Societies	2	2	0
Stationery	158	3	2
Postage and Parcels	33	0	11
Wages, Clerks and Orderlies	102	4	9
Incidental	48	7	5½
Cash in hand, 31st March, 1865	17	7	1¼
	£1978	18	11¼

Cr.

	£	s.	d.
Cash in hand, 1st April, 1864	26	8	0
Dividend on £1200 Consols (to 5th Jan. 1865)	35	2	0
Subscriptions (to 31st March, 1865) Annual	867	12	0
Subscriptions (to 31st March, 1865) Entrance	84	0	0
General Printing	270	6	5
Chemistry	29	8	0
Photography: Chemicals and Apparatus	17	9	4
Photography: Printing, Mounting, &c.	381	12	6
Drawing	15	19	1
Taxidermy	4	17	1
Library, Books, &c.	59	2	11
Instruments	3	10	0
Carpenter, Wood, &c.	24	5	8
Stationery	147	19	11
Postage and Parcels	11	6	0
	£1978	18	11¼

DEBTOR AND CREDITOR ACCOUNT, 31st MARCH, 1865.

	£	s.	d.
Outstanding Debts, 31st March, 1865	231	19	9
Balance Creditor	1446	9	5¼
	£1678	9	2¼

	£	s.	d.
Balance Creditor, Consols Stock	1200	0	0
Balance Creditor, Cash in hand, 31st March, 1865.	17	7	1¼
Approximate value of Books and Stationery, for Sale.	75	0	0
" " Printing Paper, on Stock	42	15	6
" " Chemicals (Laboratory)	20	0	0
" " " (Photographical)	5	0	0
Amount owing by Officers'	296	5	7
" " for back Subscriptions	22	1	0
	£1678	9	2¼

WOOLWICH,
13th April, 1865.

A. HARRISON, Captⁿ. R.A.,
Secretary, R.A.I.

Remarks on the employment of the Sextant for observations requiring great Precision. By Captain R. W. Haig, R.A.

Annual Report and Abstract of Proceedings of a General Meeting of the Royal Artillery Institution, held on Monday, May 30, 1864. Major-General Sir R. J. Dacres, K.C.B. in the Chair.

On some Phenomena exhibited by Gun-cotton and Gunpowder under special conditions of exposure to heat: by F. A. Abel, F.R.S. (Communicated by the Secretary, R.A.I.)

Conclusions from the Results of Experiments on Wrought-iron and Steel: by Mr David Kirkaldy. (Communicated by Major C. H. Owen, R.A., Professor of Artillery, R.M. Academy).

Experiment carried on at Shoeburyness, on 17th June, 1864, to test the powers of resistance to projectiles of the "Lord Warden" Target. (Contributed by Captain E. J. Bruce, R.A.)

Method of obtaining the distance of objects at Sea (from elevated Shore Batteries), without the use of the Spirit-level, and without having to make any calculations with Tables of Natural Tangents, &c. By Lieut. H. A. Tracey, R.A.

On the causes which led to the supersession of the original Shrapnel Shell, and the adoption of the Diaphragm pattern. By Captain Vivian Dering Majendie, R.A., Captain Instructor, Royal Laboratory.

Report of Ordnance Select Committee, No. 3065, dated November, 6, 1863. On the relative penetration into earth of projectiles from Rifled and Smooth-bored Guns, and on several varieties of Percussion Fuze. Communicated by direction of the Secretary of State for War.

Description of Boxer's 2-inch Time Fuze for Rifled Ordnance. By Captain Vivian Dering Majendie, R.A., Captain Instructor, Royal Laboratory.

Experiment at Shoeburyness, on 15th August, 1864, to ascertain the effect of Steel Shell fired from a 13·3″ Armstrong M.L. wrought-iron Shunt Rifled Gun, on an iron-plated Vessel, at 2000 yds. range. (Communicated by Captain A. Harrison, R.A.)

Experiment at Shoeburyness, on 4th August, 1864, to test the "Small Plate" Target. (Communicated by Captain A. Harrison, R.A.)

The *Derivation* of Elongated Projectiles fired from Rifled Ordnance. By Major C. H. Owen, R.A., Professor of Artillery, R. M. Academy.

A few hints upon collecting objects of Natural History. By Mr H. Whitely, Curator of the Museum, Royal Artillery Institution.

Results of Experiments with Projectiles against Iron Armour. (Extracted from the Transactions and Reports of the Special Committee on Iron, 1861–1864). By Capt. A. Harrison, R.A.

On the duration of Wooden Carriages in a hot climate. By Lieut.-Colonel H. Clerk, R.A., F.R.S.

Remarks by the Ordnance Select Committee, on a Series of Experiments with Rope Mantelets. (Communicated by direction of the Secretary of State for War.)

On the objections which have been urged against the Diaphragm Shrapnel shells; and on the general merits of this construction. By Captain Vivian Dering Majendie, R.A, Captain Instructor, Royal Laboratory.

Contributions to Regimental History (No. I.) By Brigadier-General Lefroy, R.A., F.R.S.

Memoirs of the Royal Regiment of Artillery (No. II.) By Colonel Forbes Macbean, 1743–1779. (Printed from MSS. in Royal Artillery Library, Woolwich).

Relation of the power to the weight in the various machines, in general use, for the mounting, moving, and transporting, of the heavy ordnance, carriages, and platforms in the service. Communicated by Captain H. W. Briscoe, R.A.

Report of an Experiment carried on by the Ordnance Select Committee, at Shoeburyness, 28th November, 1864, to test shot made of various kinds of steel, fired from 68-pr. and 100-pr. smooth-bored guns. Communicated by the Ordnance Select Committee.

Armstrong's (C) Percussion fuze, Dyer's pattern. By Captain Vivian Dering Majendie, R.A., Captain Instructor, Royal Laboratory.

Report of an Experiment carried on at Shoeburyness, on the 16th December, 1864, and 5th and 6th January, 1865, by the Ordnance Select Committee. Communicated by the Secretary Ordnance Select Committee.

4. *Library.*—The books have been thoroughly re-arranged, and a new catalogue has been formed; the books of reference are now in the cases in the Reading Room, and a separate catalogue for these books has been made. For this useful work the Committee are much indebted to the Sub-Committee, who, as stated in the last Report, were formed for the purpose. The expenditure under the head of Library is exceptionally large owing to the outlay for binding, which was found necessary when the books were re-arranged.

The following list contains a statement of the books, plans, &c., purchased and presented, and the Committee desire to record their sincere thanks for the valuable addition which has been made to the Library through the liberal kindness of the Right Honourable the Secretary of State for War, in presenting to the Institution a copy of Lieut.-General E. de Todleben's work, " Defense de Sebastopol," and Atlas.

The Committee have arranged for an exchange of publications with the Royal Geographical Society.

The sale of War Office Photographs has been very great, exceeding 1200; lithographs of laboratory stores are now obtainable, price 9d. a sheet, and lists of both photographs and lithographs, corrected to the end of March, have been sent to Members. An alteration which has been made by the War Department, in issuing these articles as stores, whereby much extra work is entailed, has compelled the Committee to limit the sale through the Institution to Members only.

Books purchased.

	vols.
Militarische Werke	6
Percy's Metallurgy. Iron and Steel	1
Report of the Commissioners appointed to inquire into the Regulation and Distribution of Prize Money	1
Elementary Treatise on Recent and Fossil Shells. By S. P. Woodward	1
The Nature-printed British Ferns	3
Useful Metals, and their Alloys	1
Goodwin's Course of Mathematics	1
Life of General Sir Charles Napier	4
Life of General Sir William Napier	2
Drayson's Surveying and Sketching	5
Experiments on Wrought-iron and Steel. By D. Kirkaldy	1
Supplement aux Tables D'Integrales Definies	1
Royal Warrants, Circulars, General Orders, and Memoranda, from August 1856 to July, 1864	1

Page's Handbook of Geological Terms, and Geology	1
Modern Warfare, as influenced by Modern Artillery. By Lieut.-Col. P. L. Macdougall	1
Queen's Regulations, 1859	1
Mutiny Act, and Articles of War	1
Gould's Birds of Asia. Part 16	1
" " Great Britain. Parts 5 and 6	2
Aide Mémoire Portatif de Campagne a l'usage des Officiers d'Artillerie	1
Manœuvres of Cavalry combined with Horse Artillery	1
Histoire de Jules Cèsar	1
Treatise on Ordnance and Armour. By A. L. Holley, B.P.	1
Dr Lankester's Popular Lectures on Food	1

Books, Plans, &c. presented.

	vols.	
Ordnance Select Committee's Report on the Newhaven Experiment	2	Secretary of State for War, through the Director of Ordnance.
Transactions and Report of Special Committee on Iron. 1861 to 1864	3	
Photographs of Experiments carried on by the Special Committee on Iron	7	
Extracts from the Reports and Proceedings of the Ordnance Select Committee, Part 6, Vol. I., and Parts 1, 2, and 3, Vol. II. (6 copies of each).	24	
Defense de Sebastopol. By Lieut.-Gen. E. de Todleben. 2 vols. and Atlas	3	
Report upon the Military Affairs of the United States of America	1	
Journal of the Deputy-Quarter-Master-General in New Zealand	1	
Addendum to ditto	1	
Map (in two sheets) of the neighbourhood of the Waikato River, New Zealand	2	Secretary of State for War, through the Director, Topographical Department, War Office.
Map of part of Virginia, Maryland, and Pensylvania	2	
Map of part of the Northern Islands of New Zealand	2	
Army Equipment, Artillery. Part 2	2	
Map of the neighbourhood of Richmond and Petersburgh, Virginia	2	
The strength, composition, and organization of the Army of Great Britain, 1864–5. (2nd edition)	2	
Map, in 4 parts, of the Colony of Natal	2	
Photo-Zincographs of Netley Abbey	15	Secretary of State for War, through Director, Ordnance Survey Department, Southampton.
Russian Artillery Journal. Nos. 2, 3, 4, 5, 6, 7, 11. 1864	7	Colonel N. de Novitzky.
Russian Small Arms Journal. Nos. 1, 2, 3, and 4. 1864	4	

House of Commons Papers. Nos. 22, 28, 42, 42 I, 54, 68, 80 I, 95, 97, 144, 145, 151, 158, 176, 200, 239, 262, 265, 265 I, 268, 270, 276, 290, 320, 326, 290 I	26	The Secretary of State for War, through Librarian, War Office.
Report on the Realization and Distribution of Army Prize	1	
Affairs of New Zealand	1	
Report on the Memorials of Indian Officers	1	
Correspondence relative to affairs in Japan	1	
Report on the Ventilation of Cavalry Stables	1	
Examination Papers, used at the Examination of Candidates for direct Commissions	1	The Council of Military Education.
Examination Papers, used at the Examination of Candidates for appointment to the Commissariat. May, 1864	1	
Examination of Candidates for admission to the Royal Military College, Sandhurst. June, 1864	1	
do do Dec. 1864	1	
Report on the Examination for admission to the Royal Military Academy, Woolwich. July, 1864	1	
do do January, 1865	1	
Report on the Examination for admission to the Staff College	1	
Report on the Final Examination at the Staff College. Dec. 1864	1	
Second Report of the Council of Military Education, on Army Schools, Libraries, and Recreation Rooms	1	
Annual Report of the Smithsonian Institute, 1862	1	Smithsonian Institute.
Smithsonian Contributions to Knowledge. Vol. XIII.	1	
Smithsonian Miscellaneous Collections. Vol. V.	1	
Books (See List, p. 326)	24	R.A. Library, Woolwich.
Hart's Quarterly Army List. January, 1840, to December, 1864	96	
Drawings of Freeburn's Fuzes	14	Qr.-Mast. Freeburn, R.A.
Colburn's United Service Magazine. Oct. 1864.	1	Capt. W. B. E. Ellis, R.A.
do do January, 1865	1	
Bishop Colenso, on the Horns of a Dilemma	1	Anonymously.
Another Story of the Guns, or Sir Emerson Tennent and the Whitworth gun	1	Capt. T. A. J. Harrison, R.A.
Official Proclamation of William IV., at the Island of Cape Breton	1	

Pamphlet on Naval and Military Signals. By Lieut. P. H. Colomb, R.N.	1	The Author, through Capt. G. H. Colomb, R.A.
Translation of Schiller's "Song of the Bell." By Capt. G. H. Colomb, R.A.	1	The Author.
Pamphlet, copy of a letter to Capt. Heyman, R.A., Secretary O. S. Committee. By Capt. W. Palliser, 18th Hussars ...	1	The Author.
Elemens d'Histoire Militaire	1	
Theorie Nouvelle sur le Mécanisme de l'Artillerie	1	Colonel F. Eardley-Wilmot, R.A.
Rules and Orders for the Royal Military Academy, Woolwich, 1776	1	
Catalogue of the Museum of Artillery in the Rotunda, Woolwich	1	Brig.-General J. H. Lefroy, R.A.
Pamphlet "England's Navy Unarmed." By Rear Admiral Halsted, R.N.	6	The Author.
Examination Papers, Royal Mil. Academy, June and December, 1864	2	Inspector of Studies, Royal Military Academy.
Histoire de Turenne, 2 vols.	1	Lieut. E. Marshall, R.A.
Proceedings of the Geologists Association, 1863–4. No. 1, Vol. X.................	1	Professor J. Tennant, F.G.S.
Dana's Manual of Mineralogy	1	
Pamphlet. "Contributions towards the History of Mediæval Armour and Weapons in Europe. By J. Hewitt	1	The Author.
Negative Photographs of Malta	10	Lieut. H. M. Burgess, R.A.
Reports of the Juries of the International Exhibition of 1862	1	Maj.-Gen. J. St George, C.B., R.A.
Standing Orders and Dress Regulations, Royal Artillery, 1864	1	The Deputy-Adjutant-General, Royal Artillery.
Photographic Copies of Etchings of old Officers. Royal Artillery and Royal Engineers	3	Major-General H. Sandham, R.E.
Papers 2, 8, 9, 10, 11, 12, 13 Vol. III., and Paper 1, Vol. IV., R.E. Establishment. Lectures 4, 5, and 6 do	11	The Director, Royal Engineer Establishment, Chatham.
Pamphlet on some Phenomena exhibited by Gun-cotton and Gunpowder, under special conditions of exposure to heat. By F. A. Abel, F.R.S.	1	
Pamphlet on the Chemical History and Application of Gun-cotton. By Professor Abel, F.R.S.	1	F. A. Abel, Esq., F. R. S., Chemist to the War Department.
Pamphlet on the Non-Metallic Impurities of Refined Copper. By F. A. Abel, F.R.S..	1	
Photographic Portrait of Lieut.-General E. de Todleben..................................	1	

Professional Papers of the Corps of Royal Engineers. Vol. XIII.	1	Capt. C. S. Hutchinson, R.E.
Proceedings of the 33rd Anniversary Meeting of the Royal United Service Institution	1	The Council, Royal United Service Institution.
Journal of the Royal United Service Institution	1	
Royal Carriage Department Lithographs	5	Royal Carriage Department.
Proceedings of the Royal Geographical Society. Nos. 1 and 2, Vol. IX.	2	Council, Royal Geographical Society.
Lists of Stores manufactured in Royal Laboratory, Royal Gun Factories, and Royal Carriage Department (in duplicate)	6	Capt. H. W. Gordon, C.B. Royal Arsenal.
Pamphlet on Naval Armour. By James Chalmers	1	The Author.
Military Memoir of the late Lieut.-Gen. Sir J. Macleod, R.A., G.C.B., by Sir R. Gardiner	1	Col. H. L. Gardiner, R.A.
Memoir of Sir Graham Moore	1	
Reports on Artillery, 1848 to 1856	1	
War Office Photographs	177	Photographic Establishment, War Department.
Frontispiece, "Up the Alma's Height," or "The Fusilier." By Lieut. T. S. Seccombe, R.A.	1	Capt. G. H. Colomb, R.A.
Notes on Armour-plated Turrets, commonly called Cupolas. By Capt. E. H. Steward, R.E.	1	The Author.
Brief remarks on the present condition of the R.A. Marriage Society. By Brig.-Gen. J. H. Lefroy, R.A.	1	The Author.
Pamphlet on the causes of the Deviation of Projectiles unconnected with rifling. By Lieut. W. F. Richardson, R.E.	1	The Author.
Swedish Artillery Exercise	2	The Officers of the Foreign Tour of 1864, through Lieut. G. B. B. Hobart, R.H.A.
,, Infantry ,,	2	
,, Cavalry ,,	1	
,, Field Battery Equipment	1	
Dutch Field Artillery Exercises	1	
,, Rules and Regulations for Royal Military Academy at Breda	2	
,, Catalogue of Library at the Royal Military Academy at Breda	1	
,, Course of Lectures at the Royal Military Academy at Breda	1	
,, Work on Rifled Cannon	1	

List of duplicate Books, presented by the R.A. Library Sub-Committee to the R.A. Institution, Oct. 10, 1864.

	vols.
Gregory's Mechanics, 8vo. and Plates	2
Hutton's Mathematical Dictionary, 4to	2
D'Antoni Physico Mechaniques, 12mo.	2
Euler. Gunnery, 4to.	1
Flavigny. Examen de la Poudre, 12mo.	1
Experiments on Gunpowder made at Washington Arsenal, 8vo.	1
Fergusson's New System of Fortification, small folio	1
Mouzé Traité de Fortification, 4to	1
M. Gay de Vernon, Art Militaire et de Fortification, 4to.	2
King's Regulations, 1837, Cannons	1
Hamley's Campaign of Sebastopol, 8vo.	1
Defence of Lucknow. By a Staff Officer	1
Adye's Defence of Cawnpore	1
Russo-Turkish Campaign. Chesney	1
Creasy's Fifteen Decisive Battles of the World	1
Carlyle's Frederick the Great. Vol. III. 1740 to 1744, including events on accession, The First Silesian War and the Battle of Dettingen	1
Montalembert, Political Future of England	1
Humboldt's Kosmos, 8vo.	2
Youatt on the Horse	1

5. *Museum.*—The Committee regret that very little has been added to this branch of the Institution during the past year; but they gratefully acknowledge a valuable addition received from Lieut.-Col de Teissier, R.A., of a fine collection of skulls and horns from India; also a fine Tiger's skull from Major Goodenough, R.A.

It is most desirable to complete the collection of British Birds. And as very little exertion is required on the part of members to place this part of the Ornithological collection in a satisfactory state, the Committee hope that another year will not pass away without good progress being made towards this desired end.

The Committee gladly record the promise of assistance in this matter from Captain Dames, and as a guide to other officers who may also be willing to aid in completing this portion of the collection, a list is added of the species most in request. Lieut. O. Annesley has also kindly promised to give similar assistance in species from India.

The collection of shells is very deficient in many families, and some are not even represented. Donations from all parts of the world would therefore be acceptable, and however common the specimens may be in the locality in which collected, they would be of value to the Institution.

British insects are nearly a blank, a few beetles comprising all in this department of the Museum. The Committee hope that Members will by their contributions assist in remedying this deficiency.

Presentations to the Museum.

Article	No.	Presented by
Royal Artillery Officer's Coatee, prior to 1856	...	Major-General R. Burn, R.A.
Brass shell, taken from a rebel limber-box on the iron bridge, Lucknow, 1857	...	Capt. V. D. Majendie, R.A.
Geological Specimens	7	Capt. T. L. Dames, R.A.
Russian Shot Gauge and Quadrant	2	Major R. J. Hay, R.A.
Pouch, Belt, and Powder-horn, taken off a rebel Hottentot (Cape Corps Deserter) who was shot near the Barracks, Graham's Town, Cape of Good Hope, 22nd August, 1851, by Corporal Wynne, C.M.R.	3	
Old Dress sword	1	M. Harrison, Esq.
Snake Skins	2	
Barnacles (Pentelasmis Anatifera)	2	
Fossil Oyster Shells	2	Lt.-Col. G. Shaw, R.A.
Gun Locks	6	Qr.-Mast. G. Marvin, R.A.
Horns from India	7	Lt.-Col. H. P. De Teissier, R.A.
Skull and Horns of Capra megacaoos, or Morkhor	...	
Female skulls of do	3	
Antelope do	2	
Mountain sheep	1	
Medallion of Field Marshal the Duke of Wellington (iron)	1	Surg.-Major J. M. S. Fogo, R.H.A.
Casts of Horses' feet, illustrating the process of shoeing	3	Mrs. Bingham.
Old Flint Firelock	1	Qr.-Mast. Nelson, R.A.
Specimens of Swedish Iron	3	Officers of the Foreign Tour, of 1864, through Capt. W. R. Lluellyn, R.A.
British Birds' Eggs	...	Lieut. H. Brackenbury, R.A.
Flying Lizards	2	R. H. Peirce, Esq., through Major J. Gore, R.A.
Russian Girth, and Ashantee Spoon	2	Capt. J. L. Clarke, R.A.
R.A. Officer's Sash, prior to 1854	1	
Chinese Wood Fuze	1	Capt. H. W. Gordon, C.B., Royal Arsenal.
,, Metal Friction Tubes	3	
Skull of a male Bengal Tiger (in glass case)	1	Maj. W. H. Goodenough, R.A.

6. *Taxidermy.*—The Committee are glad to be able to report that several Officers have received instruction during the year from Mr Whitely, the curator of the Museum, in preparing and setting up birds, &c.

7. *Languages.*—The classes for the study of French and German have met as usual.

8. *Surveying and Practical Astronomy.*—There has been a regular attendance at the classes when the weather has been suitable. At the present time three officers are members of the class, and others will shortly join.

Arrangements are being made to place in working order a large telescope at the observatory, which it is expected will shortly be available for the use of officers.

9. *Photography.* The Photographic department is in most excellent working order. During the past year several officers have taken advantage of Resolution IV, passed at the last Annual Meeting, and have obtained instruction in Photography from the Serjeant-Major in charge.

The Committee have fixed the charges for instruction at 10s. for the first five lessons, and 2s. for each subsequent lesson.

The arrangement sanctioned by the Committee, whereby the Serjt.-Major is allowed to devote certain hours to take likenesses of members and their friends has proved most successful, as evidenced by the large number of photographs which have been taken in the year, amounting to over 1200 negatives, from which 13,800 copies have been printed.

The Committee have to record their thanks to Captain Blackwell, R.A. who has placed at their disposal, for copying, some excellent views in Rome. Good negatives have been obtained and copies of these views can now be purchased by Members. This plan might be advantageously extended if Officers, who are in possession of engravings &c. of interest would lend them in the same manner.

Several of the old cameras of obsolete patterns have been disposed of, and an excellent portable camera with triple lens has been purchased. This will be found a great convenience by Officers wishing to take photographic pictures in the country during the summer months.

10. *Chemistry.*—The Laboratory has been in regular use by the Officers engaged under the Director of Artillery studies, but it is to be regretted that no members have availed themselves of Mr Bloxam's liberal offer, (notified at the last Annual Meeting), which would enable them to practice chemistry without incurring any outlay for instruction.

11. *Lectures.*—In addition to the Lectures enumerated in the following list which have been delivered in the Theatre of the Institution to Members and their friends during the year, the Committee have instituted a course of Lectures on the Art of War, with a view of placing within reach of officers a means of instruction in Military History, Strategy and Tactics. Great difficulty was experienced in securing the services of an Officer to deliver a Course of this nature, but the Committee were at length successful in prevailing on Major Goodenough, R.A. to undertake a duty, for which they knew he was eminently qualified, having been specially mentioned for

proficiency in Military History at the final examination of the Staff College. To this Officer the thanks of the Committee are specially due. The Committee gladly acceded to a request made by the Inspector of Studies at the Royal Military Academy for the attendance of a limited number of Cadets at these Lectures.

The Committee also desire to express their thanks to Major-General Wilford, R.A., for an introductory Lecture kindly delivered by him on the general subject of the Study of Military History and the Art of War, and also for a Lecture on the Defence of Canada; likewise to Colonel F. Eardley-Wilmot, R.A., to Captain Chesney, R.E., to Mr Bloxam, and to Mr Warriner, for the interesting Lectures stated opposite their names.

Lectures have also been delivered in the Theatre of the Institution on Friday mornings and afternoons to the Advanced Class of Artillery Officers, by Dr Percy, F.R.S. on Metallurgy, by Mr Bloxam, F.C.S. on the Chemistry of Warlike Stores, and by Mr Anderson on Practical Mechanics. Members and Honorary Members are invited to attend.

Lectures delivered during the year, 1864-5.

		Subjects.
1.	Dr Lankester, F.R.S	On Narcotics—Alcohol.
2.	Captain Chesney, R.E. Professor of Military History, Staff College, Sandhurst	Campaigns of General Grant.
3.	Dr Gottfried Kinkel, F.R.G.S. (formerly Professor of the History of Art and Literature in the University of Bonn)	The Pompeian House at the Crystal Palace, or how people were lodged in olden times.
4.	The Rev. A. J. D'Orsey, B.D., Lecturer in Public Reading at King's College, London.	The birth, growth, and kindred of our mother tongue.
5.	John Bennett, F.R.A.S.	Clocks and Watches.
6.	Frederick Field, F.R.S	On the colours derived from Coal Tar.
7.	Dr Lankester, F.R.S.	On Narcotics—Tea, Coffee, and Tobacco.
8.	J. K. Lord, F.Z.S.	A ramble along the Boundary Line from the Fraser River to the Rocky Mountains.
9.	Edmund Wheeler, F.R.A.S.	The Planets and their Attendants.
10.	Robert Hunt, F.R.S.	The Physics of the Sun's surface.
11.	Col. F. Eardley-Wilmot, R.A., F.R.S.	The Bronze Age.
12.	G. Warriner, Esq.	On Food and its uses.
13.	Maj.-Gen. E. H. Wilford, R.A.	The Defence of Canada.
14.	Charles L. Bloxam, F.C.S., Lecturer on Chemistry, Royal Military Academy	On Contrivances for kindling fire.

12. Some additions have been received to the Regimental Collection of Photographic likenesses, and also to the collection of views of Foreign Stations. For these contributions thanks are due.

13. *Model Room.*—Several additions, as stated in the following List, have been made to the Model Room.

The Committee are glad to report that an application which they made to the Secretary of State for War for Laboratory specimens to complete the valuable collection now in the Model Room has been favourably entertained, and consequently this most instructive branch of the Institution will be made as complete and satisfactory as they could wish.

The Committee have to express their grateful thanks to His Royal Highness the Patron and President, for the kind interest he has shewn in the matter, to which, they believe, the success which has attended their application is mainly due.

Presentations to Model Room.

Assortment of Flannel and Waterproof Paper Cartridge Bags for Smooth-bore and Rifled Ordnance	...	Royal Laboratory.
Cones of 68-pr. shot, after impact on Armour plates	3	Capt. T. A. J. Harrison, R.A.
Armstrong and Whitworth competitive shot and shell	9	Ordnance Select Committee.
French Shot and Shell fired during the Italian Campaign	2	Col. J. L. A. Simmons, C.B., R.E., through Major C. F. Young, R.A.
Bullet for the rifle in use with the army of the Netherlands.	1	Capt. W. R. Lluellyn, R.A.
Swedish Percussion Fuze, complete and in section	1	The Officers of the Foreign Tour of 1864, through Lieut. G. B. B. Hobart, R.H.A.
do Time do do	1	
do Friction Tubes	6	
do Cavalry pistol bullet	1	
Dutch rifle bullet	1	
Danish do (Minié)	1	
Specimens of Projectiles fired against Iron Plates		Special Committee on Iron.

14. *Drawing.*—A Drawing Class under Mr Aaron Penley, has met regularly and has been attended by a large number of Officers.

15. *Turning.*—A lathe has been put up in one of the upper rooms of the Institution (as being more convenient for Members than in the carpenter's shop), and is in working order.

In compliance with Rule IV. the following Officers retire from the Committee, and are not eligible for re-election.

Lieut.-Colonel Field,	Captain Majendie,
Captain C. B. Brackenbury,	Lieut. F. S. Stoney.

The following Members have also left the Garrison, and the vacancies thus occasioned have been filled up by the Committee, subject to the approval of the General Meeting :—

Colonel Travers,	by	Colonel Younghusband,
,, J. H. Smyth, C.B.	,,	Lieut.-Colonel Austen,
Lieut.-Colonel Gibbon, C.B.	,,	Colonel W. B. Gardner,
Surg.-Major J. M. S. Fogo,	,,	Surg.-Major Litle, A.B.
Captain Keate,	,,	Captain R. Sandham,
Lieut. G. B. Hobart,	,,	Lieut. J. M. Murray,

and Captain Bruce has been added to the Committee to complete the number.

Due notice having been given in accordance with Rule XVII., the following alterations were submitted by the Committee and carried :—

That the following Rule be inserted as Rule IV.

"Any Member who, whilst serving on full pay, shall cease to belong to the Royal Artillery Institution, either by resignation or otherwise, shall not again be eligible for admission, without paying all arrears of annual subscriptions, since the date of his last payment."

That Rule IV. and the remainder of the Rules be re-numbered consecutively to XVIII.

The following Resolution was passed :—

Proposed by Lieut.-Col. Field, seconded by Major Young, and carried unanimously,—

"Captain Bruce having resigned the Secretaryship of the Royal Artillery Institution on appointment as Assistant Inspector of Studies at the Royal Military Academy, the Committee wish to bring to the notice of the General Meeting their appreciation of the zeal and ability he has at all times displayed in conducting the business of the Institution, to which they consider its present flourishing state is mainly to be attributed."

The following Officers were elected, viz :—

Colonel Middleton, C.B.,	Captain Molony,
Major Lukin,	Lieut. Chambers,

to serve on Committee, in place of the undermentioned Officers withdrawn in accordance with Rule V.

Lieut.-Col. Field,	Capt. Majendie,
Capt. C. B. Brackenbury,	Lieut. Stoney.

The Committee for the current year will stand thus :—

PATRON AND PRESIDENT :

Field Marshal H.R.H. the Duke of Cambridge, K.G.

VICE PRESIDENTS :

The Commandant.
The Deputy-Adjutant-General.

MEMBERS :

The Assistant-Adjutant-General.
The Secretary Ordnance Select Committee.
The Brigade-Major.
The Director of Artillery Studies.

Colonel W. B. Gardner.
" Younghusband.
" Middleton, C.B.
Lieut.-Col. Austen.
Surg.-Major Litle, A.B.
Colonel S. E. Gordon.
Major C. H. Owen.
Captain E. J. Bruce.

Major Lukin.
Captain W. R. Lluellyn.
" R. Sandham.
" Molony.
Lieut. Chambers.
" J. M. Murray.
" E. Marshall.

Captain T. A. J. Harrison, *Secy. and Treasurer.*

(Signed) E. C. WARDE, Major-General,
Vice-President, in the Chair.

May 2, 1865.

Catalogue with appended notes, on the animals collected in North West America, by J. K. Lord, F.Z.S., and presented to the Royal Artillery Institution, by Captain Haig, R.A., late of the British North American Boundary Commission.

Lynx, canadensis.—(RAF.)

CANADA LYNX. Common on both the eastern and western slope of the Cascade Mountains and on the western side of the Rocky Mountains. Found also on Vancouver Island.

I never obtained more than one species, although I have seen skins in the Hudson's Bay Company Stores, that I imagined were v. *Maculatus* or Texas wild cat of AUD. and BACH, but I never succeeded in obtaining a perfect specimen, so as to compare the skull and teeth, yet I feel quite sure that two well marked species are common to this district.

Canis latrans.—(SAY.)

PRAIRIE WOLF.—CAYOTE. I have called this small grey wolf, *latrans.* It is found abundantly between the Cascades and Rocky Mountains, and on the west side of the Cascade and coast range. I am rather disposed to think it may be a distinct species, but having no means of comparing it with specimens from Texas and Mexico, I must leave it an open question. It has its young in burrows in April, and is beyond all question the progenitor of the Indian dog, and appears to be a connecting link between the true wolf and the fox; two other species are common, *Lupus griseus, Lupus occidentalis.*

Vulpes macrourus.—(BAIRD.)

PRAIRIE FOX.—LARGE-TAILED FOX. Found on both sides of the Cascade Mountains, and on the western slope of the Rocky Mountains, reaching an altitude of about 8000 feet above the sea level, has its young in burrows, usually from three to four, in April or May.

(var.) *decussatus.*

CROSS FOX. Not quite as plentiful, but in habits, and range, the same as v. *Macrourus.*

(var.)—*argentatus.*

SILVER FOX. In every particular the same as v. *decussatus.*

It is worthy of note that the fox is quite unknown on Vancouver Island, why, I am at a loss to imagine, as the wolf is rather common.

I quite agree with Professor Baird in making the red fox of Oregon and British Columbia a distinct species, and in considering the cross and silver foxes as varieties of the red. I have carefully examined large numbers of skins at the various trading posts of the Hudson's Bay Company, and find every intermediate tint of colour merging by regular gradations, from the red into the cross, and from the cross into the silver and black, rendering it often a difficult question even for the trader himself to decide, which of the varieties a skin really belonged to. The Indians also positively assert, that frequently cubs of the different varieties are found in the same litter.

Mustela americana.—(Turton.)

Pine Martin.—American Sable. Found on the east and west slopes of the Cascade Mountains, west slope of the Rocky Mountains, and on Vancouver Island.

I am quite satisfied in my own mind that there is but one species of martin common to the above specified districts, and though great differences exist in colour and size, when a large number of skins are compared from various localities, still their variations are simply attributable to local modifying causes. I have examined hundreds of skins at the trading stations of the Hudson's Bay Company, and it is curious that the martin taken at the south end, even of Vancouver Island, when compared with that from the north end, is invariably much lighter in colour, and has a thin wiry fur arising from climatal influence. It has also lately been most clearly proved, that the Asiatic sable mustela zibillina, and the American pine martin are one and the same species.

An immense trade is carried on in martin skins by the Hudson's Bay Company, and now by lots of outsiders. Some thousands of skins annually find their way from the various trading posts to Victoria, (Vancouver Island,) where they are repacked and shipped for England.

It requires long experience, great skill and perseverance, and a thorough knowledge of the animal's haunts and habits, to be a successful martin trapper. The Indians use steel traps when they can get them, but the trap generally used is a *fall* trap, a crafty and ingenious contrivance, so constructed, that the prowling little robber is tempted by a bit of rabbit or grouse, to venture into a kind of *den,* built up with stones, but having grabbed the bait he backs out and tugs it after him; this frees a heavy log that falls upon him, and breaks his back.

The winter fur is always the best, and the male fur is more valuable than the female. The male is called a *Stone Martin,* so named because the Indians usually leave a small portion of the generative organs attached to the peltry, as a mark of *sex.* The male commanding a higher price.

Taxidea americana.—(Baird.)

American Badger. Found on the east and west slopes of the Cascade Mountains, and west slope of the Rocky Mountains, more plentiful on the Sandy plains on both sides of the Columbia River than west of the Cascades. I obtained one remarkably fine specimen from the hills above Lake Osoyoos, it was shot by Colonel Hawkins, R.E. (Her Majesty's Commissioner), and the Colonel most kindly packed it in himself, for me to skin. On comparing this skin with a stuffed specimen from Labrador, I noticed several striking differences in the markings, but on comparing the skulls, no structural difference whatever is detectable, hence I feel quite safe in saying there is but one species common to this large slice of North America.

Sciurus richardsonii.—(Bach.)

Richardson's Squirrel. Plentiful between the east slope of the Cascades and west slope of the Rocky Mountains, lives in the tall pine trees, and feeds on the seeds, has a strange habit of throwing down large numbers of cones before descending to feast on the seeds. I have seldom seen it above an altitude of about 4000 ft. above the sea level. Builds a large nest of dry grass, I think for the purpose of protecting its young, generally choosing a young pine tree to build in; does not hibernate in winter. I saw them out lively and brisk at Colville, when the temperature was 15° below zero. Not found on the west side of the Cascades.

Pteromys (var.) *alpinus*.—(Rich.)

Rocky Mountain Flying Squirrel. This squirrel I have called variety *Alpinus* of Sir J. Richardson, and I have no doubt that it is the species brought by Dr Townsend from the Columbia River. In size it does not differ much if at all from *Pter Oregonensis* but the colour is much lighter, the hind and fore feet densely covered with hair, completely hiding the claws, flaps of the flying membrane yellow. Found on the east slope of the Cascades, and west slope of the Rocky Mountains.

Tamias quadrivittatus.—(Say.)

This active little squirrel is common on the east slope of the Cascades, and west slope of the Rocky Mountains. I never met with it on the west side of the Cascade Mountains, where *Tamius townsendii* (Bach.) is the common species. I saw it at an altitude of about 6000 ft. above sea level.

It is known as the ogre squirrel among the Indians, and they have a curious tradition accounting for the stripes upon its back, thus it runs:—

A horrible old ogress lived on the Rocky Mountains, called Tath-a-clea, she had an amiable weakness for anything nice, and enjoyed a baby savage for breakfast as we do a bloater; her whole aim and object was to catch these juvenile delicacies, and craftily adopted various means to coax them within reach of her claws. One day a little child, the son of a chief, had strayed too far from the lodge, and the ogress was just laying her claws on him, when the father and mother spied the danger of their dusky darling. Too late to save, they both prayed to the Great Spirit to spare their child, and rescue it from the ogress. The Great Spirit heard the prayer and changed the child into this tiny squirrel, and as it deftly slipped through her claws the marks for ever remained on its back.

Spermophilus townsendii.—(Bach.)

Townsend's Ground Squirrel. These small but handsome little squirrels are found in great numbers on the Sand Plains between the Dalls and the Spokan River, which river appears the boundary to its range towards the west slope of the Rocky Mountains. Its food must consist of wild sage and grass as nothing else grows there. How it obtains water I am at a loss to imagine. I have often seen it on dry sandy plains, where thirsty nature had not even dew to drink, miles and miles away from any spot where water was obtainable; they live in small holes dug in the sand, at the entrance to which they sit on their hind legs like a begging dog; on the least alarm utter a sharp whistle, and take a header into the burrow. Hibernates in winter.

Hesperomys leucopus.—(Leconte.)

White-footed Mouse. East and west of the Cascades, and on the west slope of the Rocky Mountains; some of the skins brought home were taken at Sumass Prairie on the Fraser River, and others at Fort Colville on the Columbia. It is scarcely possible to camp anywhere for a day or two, but this mouse infests the tents and stores; he eats holes in apparel, and on the Sumass prairie they devoured a great many of my most valuable specimens, before I was up to their predatory habits.

Arvicola townsendii.—(Bach.)

Oregon ground Mouse. This mouse is very common on the Sumass and Chilukweyuk Prairies, and on the open plains between the Cascades and Rocky Mountains. They cut regular trails through the long grass and use them until the trail is beaten like a road; make nests of long dry grass stalks in hollow places in the ground. When the Sumass prairie floods in the spring, many of these mice get drowned in attempting to escape to the high land. I have seen them swimming in all directions, striving for any bit of dry ground visible.

Erethizon epixanthus.—(Brand.)

Yellow-haired Porcupine. I collected only three specimens of this curious animal, and all three from the western slope of the Rocky Mountains. I have but little doubt that it exists on the Cascade range, although as far as I could learn it was never seen by any of our working parties.

I know but very little of its habits, it lives entirely in the dark gloomy pine forests, and feeds principally on the bark of the young pine trees, and its long sharp incisors, are instruments admirably adapted for chiseling it off. I suspect they burrow into the ground and hibernate during winter.

Lepus washingtonii.—(Baird.)

Red Hare. I met with this hare along the entire length of the Boundary Line, also at Fort Rupert, at the northern end of Vancouver Island. It lurks among the underbrush in the forest, hides under logs, and is but rarely seen in the day light, and when taken is snared in the night; the Indians trap the greater number in the winter, the snow enabling them to easily track the hare.

In the winter they become quite white, but in summer months they are a rich brown like our European hare. They subsist in the cold months almost entirely on the ends of young twigs, and the bark of trees; and the nibbled spots become a capital guide in the spring, as to the depth of snow, the height at which the bark is gouged off, shewing where the hare stood on the snow.

An immense number of these skins are annually traded by the Hudson's Bay Company.

Lepus artemisia.—(Bach.)

Sage Rabbit. I procured specimens of this beautiful little rabbit at the Dalls and at Cow Creek, the latter a small stream crossing the trail between Walla Walla and Colville; its favourite haunts are the narrow belts of scrub that fringe the banks of the streams, hiding in the day in crevices of the rocks or among the *talus* at the base of a cliff, failing these places of concealment it makes burrows in the sand banks; breeds early. I obtained a doe in March, heavy with young; and am disposed to think it is only found east of the Cascades.

Lagomys minimus.—(Lord, sp. nov.)

Sp. char. Differs from *Lepus* (*Lagomys*) *princeps* of Sir J. Richardson (F. B. A., i. p. 227, pl. 19) in being much smaller. Predominant colour of back dark grey, tinged faintly with umber-yellow, more vivid about the shoulders, but gradually shading off on the sides and belly to dirty white; feet white, washed over with yellowish brown; ears large, black inside, the outer rounded margin edged with white; eye very small and intensely black; whiskers long, and composed of about an equal number of white and black hairs.

Measurement: Head and body $6\frac{1}{2}$ inches; head 2 inches; nose to auditory opening $1\frac{1}{4}$ inch; height of ear from behind 1 inch.

The skull differs in being generally smaller; the cranial portion of the skull in its superior outline is much narrower and smoother. The nasal bones are shorter and broader, and rounded at their posterior articulation, instead of being deeply notched as in *L. princeps*. Distance from anterior molar to incisors much less; auditory bullæ much smaller. Incisors shorter and straighter, and very deeply grooved on the anterior surface. Molars smaller, but otherwise similar in form. Length of skull $1\frac{1}{4}$ inch.

General differences from *Lagomys princeps*—*First*, in being smaller, $1\frac{1}{2}$ inch shorter in total length; the ear, measured from behind, $\frac{1}{4}$ inch shorter; the colour generally darker, especially the lower third of the back.

Secondly, in the *structural* differences of the skull; for although these differences are not prominent or well defined, yet they are unquestionable specific variations.

Thirdly, in the habit of constructing a nest of hay for the winter sleep, and in living at a much greater altitude.

This *Lagomys*, which I propose making a new species, and calling, from its being so much less than any other, *Lagomys minimus*, lives on the summit of the Cascade Mountains, at an altitude above the sea-level of about 7000 feet. He chooses as his residence loose piles of rocks and stones. He is shy and wary, and on the slightest noise takes a header into a crevice. When everything is again still and quiet, he cautiously peeps out, and growing bold in the silence, climbs up on the top of a stone, and, sitting on his hind legs like a begging dog, gives a sharp shrill cry; and so curiously deceptive is it that I constantly imagined the sound was far distant when it has been close to my feet. It was in October, when I was on Ptarmigan Hill, a high mountain in the Cascade range; the snow was just beginning to fall, and all these little fellows were then busily employed in making large nests, in the crevices between the stones, of dry grass and leaves, evidently for their winter sleep, and perhaps storehouse. I should have made much more extensive observations, had not the prospect of coming snow driven me down.

Catalogue with appended notes by J. K. Lord, F.Z.S., on the Birds' Nests and Eggs collected by him, in North West America, and presented to the Royal Artillery Institution, by the British North American Boundary Commission.

Colaptes mexicanus.—(Baird.)

Redshafted Flicker. The eggs generally from ten to twelve are laid on the bare wood at the bottom of a deep hole bored in the dead branch of a pine tree, very difficult to obtain, being high up and the branch usually rotten. Taken at Colville in July.

Chordeiles popetue.—(Veil.)

Night Hawk—Bull Bat.—Lays two eggs on the bare ground, never more. Taken at Camp Kishenen, altitude above sea level 4150 feet.

Ceryle alcyon.—(Boir.)

Belted King Fisher. The place selected for nesting is generally a high sand bank (close to a river), into which the birds bore a long hole; the one from which these eggs were taken measured 7 ft. from the entrance to the end, where I found the eggs, twelve in number, laid on the bare earth. Taken in June from a gravel bank near the salmon falls on the upper Columbia River.

Tyrannus carolinensis.—(Baird.)

King Bird.—Bee Martin. Nest loosely constructed of grass and small bits of stick, and lined with root fibres. I have never seen this bird use hair in lining its nest. Generally built in a thick thorn bush; number of eggs laid usually five. Taken in June in the Colville valley.

Tyrannus verticalis.—(Say.)

Arkansas Fly-catcher, Yellow King Bird. Nest constructed of dry grass, and lined with root fibres and deer hair; usually built in the fork of a scrub oak, or cotton wood tree. Taken at the Dalls in May.

Turdus pallasii.—(Nuttall.)

Hermit Thrush. Nest very neatly put together; outside composed of green moss and lichen, exactly resembling the bark of the tree in which it is built; inside lined with hair and root fibre, lays five eggs. Taken at Syniakwateen in July.

Turdus migratorious.—(Linn.)

Robin. One of the earliest nesters in the north-west; nest tightly made of moss and lichen, and plastered inside with mud; built in the fork of a tree with very little attempt at concealment, five eggs usually laid. Taken at Colville in May.

Scialia arctica.—(Baird.)

Arctic Blue Bird. Nest constructed of feathers, grass, and hair, placed at the bottom of a hole, in a green cotton wood tree; the hole these eggs were taken from was 3 feet deep and about 15 feet from the ground. I obtained only one nest, as it is extremely difficult to find, and a work of labour to chop it out. Taken in the Colville valley in May. I do not know of any having been brought home before.

Geothlypis trichas.—(Cabanis.)

Maryland Yellow Throat. Nest constructed of dead leaves and grass, lined with hair and fine rootlets; built on the ground amongst the thick underbrush and domed over, a small hole being left for the bird to enter. Taken at Syniakwateen in June.

Ampelis cedrorum.—(Baird.)

Cedar Bird. Nest rather loosely put together; made of coarse grass stalks, the inside *invariably* lined with a black lichen *Lichen-jubatus.* (This lichen is used as food by the Indians), generally built in a thick thorn bush overhanging the water. The only places I found their nests was at Colville, on the banks of the Columbia, and at Syniakwateen, on the Pend-oriel river; five eggs the usual number laid. Taken in July.

Mimus carolinensis.—(Swainson.)

Cat Bird. Nest loosely put together and constructed of twigs, grass, and dead leaves, and lined with fine fibre; builds very near the ground in a thick thorn bush, or amongst the wild briars. Taken at Colville in June.

Zonotrichia leucophrys.—(Swainson.)

White-crowned Sparrow. Builds in a thick bush; nest lightly woven with moss and fibre, and lined with feathers and hair; rather a rare nest to find, the birds choosing secluded places in the dense forest; about five the usual number of eggs laid. Taken at Vancouver Island in July.

Sturnella neglecta—(Aud.)

Western Meadow Lark. Nest neatly made of grass stalks, and lined with fine roots. Usually placed on a sloping bank in a hollow in the ground, about five the usual number of eggs laid. Taken on the Spokan prairie, in May.

Icterus bullockii.—(Bon.)

Bullock's Oriole. Builds a hanging nest, very neatly made, often several in the same bush. I saw one tree on the Shasta plains literally covered with the nests of these orioles, it was a sight curious and pretty; the tree was an oak and growing perfectly alone and isolated, from even a bush, on the great sandy desert, near mount Shasta in Oregon; a tiny spring bubbled up near it through the sandy soil, and these birds I suppose from sheer want of a place to erect their homes, had taken possession of this tree. The dazzling livery of orange and black, shone out in bright relief, and contrasted prettily with the green leaves and grey garb of this lone tree in the wilderness; from five to six eggs are usually laid. Taken at the Dalls in July.

Corvus caurinus.—(Baird.)

Fish-crow of Oregon.—North-west Fish-crow. Retires from the coast into the interior to breed, constructs a very large nest of dead sticks in a low tree or a thorn bush, and domes it over like the magpie, the inside being smoothly plastered with mud; lays from five to six eggs. I believe these eggs were first brought home by myself. Taken on Sumass prairie on the banks of the Fraser River in June.

Pica hudsonica.—(Bonap.)

Magpie. Begins building very early. I took eggs from a nest near the Snake River in May before the snow had left; nest exactly like our own species, from ten to twelve eggs usually laid. Taken on the little Spokan River bank.

Tetrao obscurus.—(Rech.)

Dusky Grouse. This grouse selects a kind of covered or hollow place under a projecting rock for its nesting establishment. A pit is scratched in the earth and the eggs laid on the bare ground; they begin laying early in April, from nine to twelve eggs being usually the number sat on; the chicken leave the nest as soon as hatched, and follow the hen; she usually takes them on to a dusty hill side, near some mountain bourn, that comes dancing down the rocky ravine, tarrying here and there to rest in a tiny pool, a drinking font of natures own contriving. Taken in May near the Spokan Prairie.

Numenius longirostris.

Long-billed Curlew. Seldom lays more than two eggs, these are placed in a hollow on the open prairie amongst long grass, nothing is used in making a nest, not even dry grass. Taken on the Spokan Prairie in June.

List of several new species of Coleoptera from Vancouver Island and British Columbia, collected by J. K. Lord, F.Z.S., late naturalist to the British North American Boundary Commission, presented by him to the R.A. Institution, by permission of Colonel Hawkins, R.E., late Her Majesty's Commissioner.

Genus, *Carabus*.—(Linn).

Carabus bicolor (n.s).

Niger breviusculus subtilissime punctatus thorace stria media bene determinata lateribus subconvexis angulis posticis productis elytris cupreio lineis sex e pustulus elongatis nigris lateribus subconvexis.

Black, rather short, head and thorax very minutely punctured, the former with the usual impression on each side, in front. Thorax with an impressed distinctly marked middle line, sides slightly convex, hind angles produced extending over the fore border of the elytra. Elytra cupreous, each with three lines of elongated black pustules and with a submarginal line of minute impressions; sides slightly convex. Length of the body eight lines. This belongs to the group of *C. ligatus*, which it resembles in the sculpture of the elytra. Hab. Vancouver Island and Fort Colville.

Genus, *Calisthenes*.—(Fischer).

*Calisthenes pimelioides (n.s).

Nigra brevis lata obscura subtilissime punctata capitis lateribus retusis excavatis disco antico sublævi thorace lateribus subconvexis subretusis stria media tenui elytris lineis pustularibus lateribus valde rotundates.

Calosoma black, short, broad, thick, dull. Head and thorax very finely and thickly punctured. Head, in front, with an almost smooth disk, and a retuse and excavated border on each side. Thorax slightly convex and retuse along each side narrower hinderward with a slight impressed middle line. Elytra very convex on each side; each with about seventeen lines of minute pustules. Length of the body eight lines. It is somewhat allied to an undescribed Calisthenes from California, but quite distinct. Hab. same as preceding.

Fam., *Silphidæ*.—(Leach).
Genus, *Necrophorus*.—(Fab.)

*Necrophorus conversator (n.s).

Niger obscurus subtiliter punctatus capite nitente subtilissime punctato sulcis duobus postice connexis thorace marginibus latis subreflexis elytris maculis sex ochraceis.

Black, dull, thickly and minutely punctured. Head shining, very minutely punctured with two furrows which converge, and are connected hindward. Thorax with a broad and slightly elevated rim, transverse line in front and longitudinal distinctly impressed. Elytra with six ochraceous spots of which four form an uninterrupted band before the middle, and the other two are near the hind border. Abdomen extending much beyond the elytra, four segments uncovered. Length of the body nine lines.

It is quite distinct from the North American *N. hebes*, obscurus, Hallii, Melsheimeri, pygmæus, and Vetulinus. In the markings of the elytra it resembles *N. defodiens*, but the scutellum is much smaller. Hab. Fort Colville in the upper Columbia river, also found on the sand plains about Walla Walla.

Fam., *Atoniidæ.*—(MACLEAN.)
Genus, *Cremastocheilus.*—(KUOCH).

CREMASTOCHEILUS ARMATUS (N.S).

Niger aspere punctatus capite bicornutus thoracis angulis posticis valde productis Elytris litura basali pallida femoribus tibiisque valde dilatatis.

Black, dull, roughly punctured. Head deeply retuse in front, with an acute projection on each side in front of the eye. Thorax with the four angles smooth, much produced and very prominent, the hind angles especially so. Elytra broader than the thorax, and a little more than twice its length, each with a pale basal mark. Abdomen with a protuberance on each side at the tip apical segment vertical. Femora and tibiæ punctured and much dilated. Length of the body six lines.

It may be distinguished from *C. mexicanus* by the much more protuberant hind angles of the thorax and by the pale mark at the base of the elytra. HAB. sand plains about Walla Walla.

Fam., *Buprestidæ.*—(LEACH).
Genus, *Ancylochira.*—(ESCH).

*ANCYLOCHIRA ORNATA (n.s).

Aureos viridis capite thorace que confirtim punctatis stria longitudinali elytris punctato lineatis cupreo bi.-vittatis abdomine subtus fasciis auratis apice cupreo.

Ancylocheira, bright golden green. Head and thorax thickly punctured, with an impressed longitudinal line. Elytra with deeply impressed punctured lines, with a purplish tinge on each side in front, full four times the length of the thorax. Abdomen beneath, with a short gilded band on the fore border of each segment, tip cupreous. Length of the body nine lines.

The cupreous stripes in the elytra of this species distinguish it from *A. aurulenta* and from *A. decora.* HAB. taken both east and west of the Cascade Mountains, frequent on *Pinus ponderosa,* also found on Vancouver Island.

Genus, *Eliodes.*—(ESCH).

*ELIODES CONJUNCTA (n.s.)

Nigra sat obscura, H. convexicolli affinis thoracis lateribus minus rotundatis scutellos majori elytris angustioribus capite thoraceque subtilissime punctatis thorace binotata.

Black, rather dull, like *H. convexicollis* in structure. Head and thorax very minutely punctured. Thorax with a shallow discal on each side, hindward sides less convex than those of *H. convexicollis,* scutellum larger. Elytra narrower, their sides more linear. Length of the body thirteen lines. HAB. Common about Walla Walla, frequents the wild sage (Artemesia).

Five new species belonging to this genus were obtained by me on the Columbia plains.

**E. subtuberculata.*
**E. convexicollis.*
**E. binotata.*
**E. conjuncta.*
**E. latinscula.*

Fam, *Cerambycidæ.*—(Kirby).
Genus, *Eutrypanus.*—(Dejean).

*Eutrypanus princeps (n.s.)

Mas. et Fœm, Niger punctatus tomento cano et cervino varius antennis canis nigro annulatis thorace fascia vittisque duabus cenis guttis duabus anticis pallide cervinis elytris fusco et cervino variis fasciis quatuor dentatis incisis canis.

Mas.—Antennis corpore quadruplo longioribus.

Fæm.—Antennis corpore plus duplo longioribus oviductu corporis dimidis longiore.

Male and Female.—Black, roughly punctured, varied with hoary and with fawn-coloured tomentum. Antennæ hoary, with black rings. Thorax with the hoary hue forming a stripe on each side, and a slender curved band in front of which there are two pale fawn-coloured dots. Elytra with four irregular dentate and notched hoary bands, intermediate spaces partly brown or fawn colour. Length of the body ten lines.

Male—Antennæ four times the length of the body.

Female—Antennæ more than twice the length of the body, exclusive of the ovipositor. Ovipositor much more than half the length of the body.

Hab. The dense pine forests about Fort Colville. Seen only early in the spring.

CONTRIBUTIONS

TO THE

TECHNOLOGY OF FOREIGN RIFLED ORDNANCE.

(No. 1.)

BY BRIGADIER-GENERAL LEFROY, R.A., F.R.S.

1. The first introduction of rifled field and heavy artillery, has been attended with much reserve if not secrecy, in all armies; and details are sparingly given in military works of reference published on the Continent. For example, although the Prussians adopted their present breech-loading system in 1859, the *Handbuch* of 1860* is entirely silent on the subject. The French *système la Hitte,* was adopted in April 1859; but the *Aide Mémoire portatif de Campagne,* published 1864, is the first work the writer has seen which gives anything like full details of the gun and projectiles. The *Ordnance Manual* of the United States for 1861, gives a few bare details of one 11-pr. (3-inch), and one 36-pr. (4·5-inch), but alludes to nothing heavier. On the whole the sources of information on this subject are so scattered, that it cannot fail to be useful to bring together what may be collected from them as to the progress made upon the Continent, and elsewhere, in this great revolution of Artillery. It is proposed at present to take the countries *seriatim* as far as known, and to make such comparisons with our own artillery as may be suggested by the data as they present themselves. Any officers who may have recently travelled on the Continent will confer a favour by communicating their notes to the Secretary in aid of this object.

FRANCE.

2. The following are the particulars of the *canon de 4 rayé système la Hitte,* which is the present field gun of the French army: dimensions are given in both French and English measures. It may be useful to observe that the piece is of the calibre of the old brass 4-pr. rifled—hence called *canon de 4 rayé.* It also so happens that its projectile weighs 4 kilos. very nearly, but the denomination is not taken from this coincidence.

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* Handbuch für die Offiziere der Königlich Preussischen Artillerie. Berlin, 1860, p. 871.

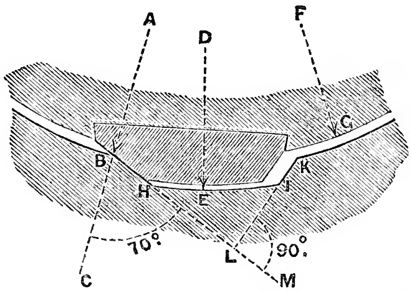
Table I.

Diameter of the bore	86·5 mm.	3·406 in.
Diameter across the grooves	92·1 "	3·626 "
Total length of bore	1400· "	55·120 "
Length of grooves of the bore	1270· "	50·000 "
Length of the *partie rétrécie,* answering to our locking groove	50 "	1·97 "
Length of chamber unrifled	130· "	5·118 "
Total length of gun, breech and swell of muzzle included	1600· "	62·990 "
Line of metal elevation	55′	
Distance from the tangent sight to the trunnion sight	690· "	27·165 "
Distance from the axis of trunnions to that of piece	0·	
Diameter of vent	5·6 "	0·22 "
Number of grooves	6·	6
Depth of grooves	2·80 "	0·110 "
Width of grooves at the bottom	17· "	0.669 "
Width of groove on the cylinder of the bore	25· "	0·984 "
Width of each bearing surface of groove	7· "	0·276 "
Width of the opposite surface	5· "	0·197 "
Angle made by the bearing surface (*flanc directeur*) with radius drawn to its salient angle	70°	
Angle of the two sides of grooves (*flancs*)	90°	
One turn of rifling in about 26 calibres, or	225·0 "	8·858 ft.
Windage of projectile (high gauge)	2·0 "	0·079 in.
Windage of the projections on the shot (*ailettes*)	0·9 "	0·035 "
Service charge	0·55 kil.	1 lb. 3·4 oz.
Weight of piece	330· "	6 cwt. 2 qr.
Preponderance of breech	44· "	97·05 lbs.

There is no doubt that some of the guns first made in 1857 exhibited considerable signs of wear after 200 rounds,—the fact is admitted: it is asserted that by subsequent improvement, more especially in the centering of the projectiles, they have attained as many as 2500 rounds without perceptible injury.

The annexed diagram shows the actual form of the grooves, and the manner in which they are traced.

Fig. 1.



$AB =$ radius of the bore drawn to the angle of a groove $= 1·703$ inches,

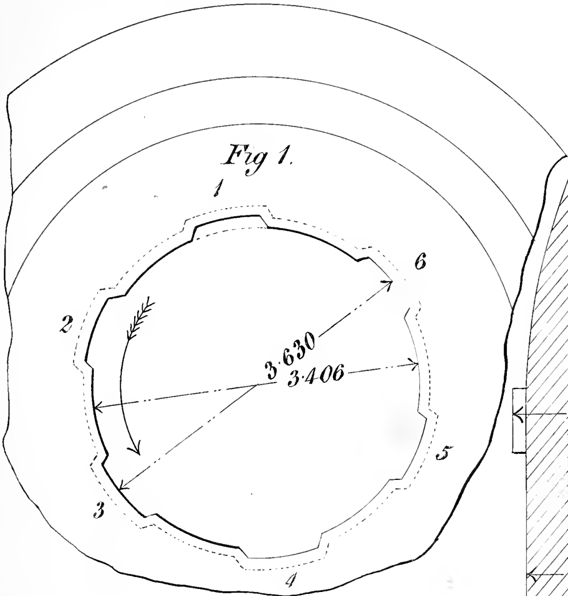
$BH =$ driving side of the groove drawn so that $HBC = 70°$,

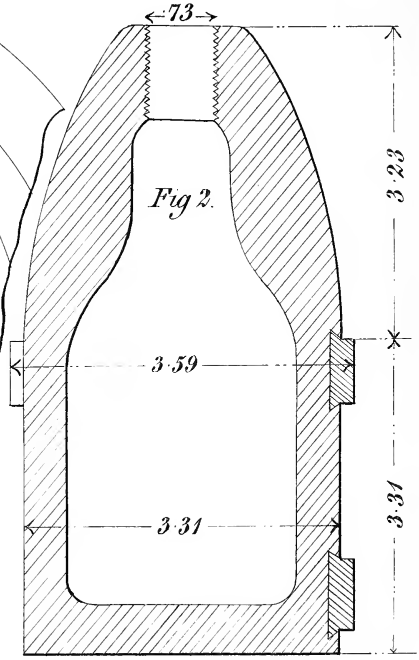
$HI =$ bottom of groove described with radius $1·703 + 0·110 = 1·813$, and $0·669$ wide,

$IK =$ loading side of groove drawn through I so that $KLM = 90°$.

FRENCH CANON DE 4 RAYÉ.

Muzzle of Gun — *Common Shell.*

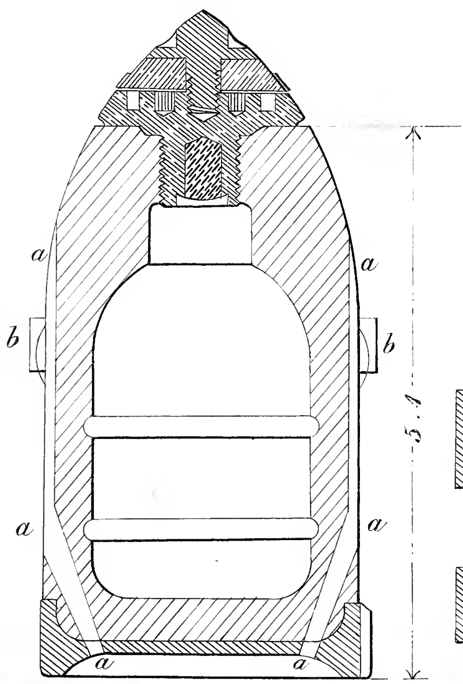




SWISS SHELL

and Time Fuze.

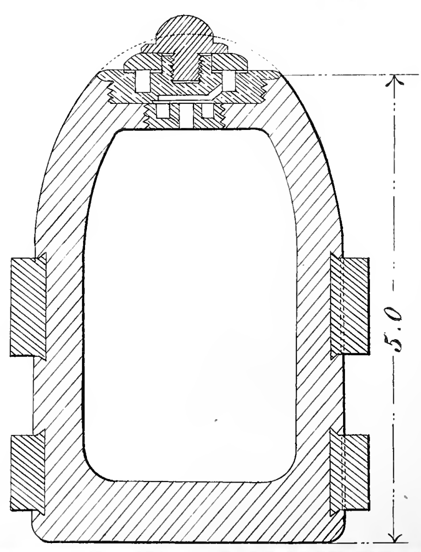
Fig 3.



WURTEMBERG SHELL

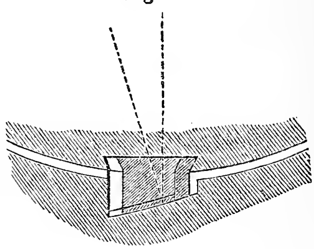
and Time Fuze.

Fig 4.



The shot in this figure is drawn as central: in point of fact, the face of the stud bears on the bottom of the groove: the windage under the body of the shot is 0·032, above it 0·066, which insures easy loading. General Didion, writing in February 1860,* claims to have been the first to propose, as far back as 1850, to centre a rifle shot in the bore of a gun by the pressure of eccentric planes on the bearing surface of the studs. He observes, "Further experiments were made at the School of Artillery la Fère in succeeding years, in which two buttons whose profile was not eccentric (this was the system adopted in 1858) took the place of the single *ailette.* Those buttons presented certain inconveniences and at the present time (February 1860) they are making further trial on the system of eccentric *ailettes*," we see the result in the above profile. The face of the stud it is true is still concentric, but the bevel of the driving edge, fulfils the part of its eccentric face (Fig. 2), and constitutes a part of the difference between the shells which failed in 1859 and those which succeeded in 1865. The bottom of the groove is struck from a centre about 0·31 of radius to the left of the centre of the bore. The breadth and depth are not stated, but have been enlarged to the scale of Fig. 1, shewing if they are truly proportioned in the original, a very much smaller stud than is now employed.

Fig. 2.



Gen. Didion's proposal of 1850.

There are three patterns of projectiles, viz. those of 1859, 1861 and 1863. The following details refer to the latter. The principal difference is in the size and profile of the studs;—but it must be understood that the different powers which have based their system of field artillery on that of the French, have by no means adhered closely to the form of projectile, see for example, Figs. 3 and 4 of the annexed Plate I., which are the common shells of the Swiss Federal and of the Wurtemburg artillery respectively.

TABLE II.

PRINCIPAL DETAILS OF THE COMMON SHELLS.

	mm.	in.
Diameter of shell (high gauge)	84·3	3·319
do (low gauge)	83·7	3·296
High gauge of studs or *ailettes*	91·2	3·591
Length of the cylindrical part	88·0	3·465
Total length (minimum)	160·0	6·299
Diameter of the zinc studs	15·5	0·610
Projection of the zinc studs	3·6	0·142
Interval between the two rows of studs, from centre to centre, sockets (*alvéoles*)	60·0	2·362
Centre of the posterior row of studs from the bottom of the shell	15·0	0·591
Thickness of metal in the body of the shell	12·85	0·506
Thickness of the bottom of the shell	12·75	0·502
Diameter of fuze-hole to bottom of thread	25·0	0·984
Weight of shell empty	3·66 kil.	8·08 lbs.
Mean normal weight, charge, and fuze complete	4·07 "	8·97 "
Weight of bursting charge	0·2 "	0·44 "

* Traité de Balistique, p. 425.

Table III.

PRINCIPAL DETAILS OF THE SHRAPNEL (*Obus à balles*).

Diameter of shell (high gauge)	84·3 mm.	3·319 in.
do (low gauge)	83·7 "	3·299 "
Length of cylindrical part	79·0 "	3·110 "
Total length	160·0 "	6·300 "
Thickness of metal in the middle of the shell	10·6 "	0·417 "
Thickness of the bottom	12·75 "	0·502 "
Number of leaden pistol balls (*pistolet de gendarmerie*), diameter 14·7 or ·578 in.	60	
Weight of bursting charge	0·07 kil.	0·13 lbs.
do melted sulphur	0·06 "	0·11 "
do sand	0·045 "	0·10 "
Weight of loaded shell	4·15 "	9·15 "

The fuze hole is of the same diameter as that of the common shells. The studs on the shell are similar in all respects. The bullets are fixed with melted sulphur.

Table IV.

DIMENSIONS OF CASE SHOT (*Boite à mitraille*).

Number of iron balls, No. 6 (diameter 1·02 in.)	41	
Number of layers of balls	6	
Weight of sulphur per shell	0·60 kil.	1·32 lbs.
Exterior diameter of case { minimum	83·5 mm.	3·288 in.
Exterior diameter of case { maximum	84·0 "	3·307 "
Interior diameter	79·5 "	3·130 "
Maximum height of case	152·0 "	5·984 "
Mean weight	5·92 kil.	13·05 lbs.
Diameter of bottom	84 mm.	3·307 in.
Thickness of bottom	5 "	0·197 "

This projectile is not provided with *ailettes*. The balls are fixed with melted sulphur. The case is made of zinc with top and bottom of the same material.

WEIGHT OF CARRIAGES.

	kilos.	cwt.	qrs.	lbs.
Carriage for rifled gun of 4 kilos. fully packed	1250	24	2	13
Ammunition wagon for do.	1300	25	2	11

4. We have been thus particular with the French field gun because it is the model of several other countries. For example, Switzerland, Holland, Wurtemburg, Spain, and Russia, although some of these have introduced modifications of it, as we shall see hereafter.

5. The French correct the constant *derivation* of the shot, or its tendency to deflect to the right, which is very considerable, owing to the quickness of the twist and the action of the *ailettes* on the air, by giving the tangent

scale an inclination to the left equal in angular value to $\frac{1}{10}$th the angle of elevation, they have consequently no deflection scale; but for the same reason, no means of applying an accurate correction for the variable effect of wind. The amount of the correction is due to the fact which has been observed that the *derivation* at any distance is one-tenth of the quantity by which the trajectory deviates from the prolongation of the axis of the piece, *ligne de tir* in French terminology, but for which we have no convenient term in English.

For 500 m. it is given as 1 m.	For 2000 m. it is given as 25 m.
1000 m. „ „ 5 „	3000 m. „ „ 80 „

6. The initial velocity of the shell is about 1066 ft. (325 m.) per second for the service charge of $0·55^k$ and the remaining velocities are nearly as follows:—

	Tangent scale.	Elevation.	Remaining velocity.
	mm.	° ′	ft.
At 500 metres or 547 yds.	14·0	1 10	932
1000 „ „ 1094 „	34·5	2 50	817
1500 „ „ 1640 „	61·2	5 5	722
2000 „ „ 2187 „	94·2	7 45	650

A comparison of these elevations with those which the Armstrong 12-pr. requires for the same ranges, viz. 0′ 37″, 2° 16′, 4° 0′, and 5° 49′ or thereabouts, shews a much more highly curved trajectory, which is so far a disadvantage. It has in fact been ascertained by measurement that the highest point of the curve of the 12-pr. on a range of 1000 yds. does not exceed 33 ft.; that of the French projectiles for the same distance is 38 ft.

7. The penetration of the shell of 4 *kilos.* with the service charge is stated to be as follows:—

Into brick at 71 yds., a wall of 47·2 inches thick.........	Penetrated it.
Into good masonry at 76 yds.	23·6 in.
Into oak 41·2 inches thick at 437 yds.	32·7 „
Into earth at 3500 yds.	67.0 „

The Armstrong 12-pr. segment shell has been fired at the same distances into very solid brickwork, namely, that of a Martello Tower 56 years old, and into a cubical mass of the soundest oak, giving respectively 21·2 in. and 27·2 in. of mean penetration. It is however necessary that guns should be fired into the same object if we wish to compare penetrations exactly: a shot will go through a 4 ft. wall by being enabled to knock out the bricks behind, when it will not penetrate nearly four feet into a 7 ft. wall. It may, however, be conceded that the strength of the French common shell adapts it better to penetrate hard substances than does the construction of the 12-pr. segment shell: no observations have been made of the penetration of the 12-pr. common shell, which is not generally introduced.

Penetration, we may observe, is the first quality of battering ordnance, but not the first quality of field artillery.

8. A gun made to what were then believed to be the dimensions of the French field gun, when tried in England in 1859, did not give satisfactory results in respect to range or precision. The projectiles appear to have been made with too great windage, the form of the studs differed materially from that which is described above, and the twist was too sharp, the particulars however possess a certain interest, as the superiority evinced by an Armstrong 6-pr. tried on the same occasion had a considerable effect in establishing the character of the Armstrong system. There were two sorts of shells fired, the one had round *ailettes*, the other elliptical ones, neither pattern bore any close resemblance to the present service French projectile, and the practice with the former was so bad that it need not be quoted. The practice with the shells which had elliptical *ailettes* was indifferent, but not extremely bad.

Table V.

Comparative practice of a brass gun of 6 cwt. 68 lbs., calibre 3·39 inches rifled in 6 grooves with 1 turn in 59 inches, against an Armstrong B.L. 6-pr. of 2 cwt. 56 lbs., calibre 2·25 inches, 28 grooves, twist 1 turn in 90 inches.

1859	Charge.	Elevation.	No. of rounds.	Observed ranges.			Mean difference of range.	Mean reduced deflection.
				Min.	Max.	Mean.		
	lb. oz. dr.							
French 8-pr. common shell 7 lbs. 10·5 oz.	1 3 3	P B	5	300	507	453	31·7	1·9
	—	P B	5	313	455	379	43·2	1·0
	—	5°	10	1408	1753	1635	70·8	4·7
	—	5°	10	1652	1959	1765	80·4	7·0
	—	10°	20	2588	2749	2660	38·0	17·0
Armstrong 6-pr segment shell 6 lbs. 2 oz.	0 12 0	P B	10	552	642	590	25·1	0·7
	—	5°	19	1747	1922	1820	44·0	2·6
	—	10°	20	2754	3059	2901	75·8	2·2

9. A much more satisfactory comparison has however been very recently made. At the instance of the O. S. Committee, Earl de Grey gave directions in April 1864 for the gun to be re-rifled, which was effected by boring out the former rifling, inserting a cylinder of gun metal, and re-boring it. A fresh supply of shells were made in the Royal Laboratory, and it was tried in March last, against an Armstrong B. L. 9-pr., which corresponds more closely with it in all respects than the 6-pr. used before. By oversight in the instructions, the 9-pr. charge of 1 lb. 2 oz. was used with the French gun, instead of its proper charge of 1 lb. 3·4 oz., a circumstance which has slightly reduced the ranges—but has probably had no sensible effect on the accuracy—the shells only differed 1 oz. in weight. The following Table contains the result.

Table VI.

Comparison between the French *canon de 4 rayé* and an Armstrong B.L. 9-pr., March 1865.

	French gun.	Armstrong 9-pr.
Calibre	3·406 inches.	3·00 inches.
Weight	6 cwt. 52 lbs.	6 cwt. 12 lbs.
Spiral	1 in. 26 cal.	1 in. 38 cal.
Length of bore	55·5 inches.	53·0 inches.
Grooves	6	38
Charge	1 lb. 2 oz.	1 lb. 2 oz.
Weight of shell	8 lbs. 13 oz.	8 lbs. 14 oz.

The French gun fired common shells, the Armstrong gun segment shells, in both cases plugged.

No. fired	Elevation.		Mean time of flight	Ranges. Min.	Max.	Mean.	Mean difference of range.	Mean reduced deflection.
	°	′	s	French gun.				
20	2	6	2·70	685	797	762	27·0	0·6
20	5	3	5·53	1404	1551	1495	31·0	1·7
20	10	2	9·95	2250	2453	2340	30·4	5·0
				Armstrong 9-pr.				
20	2	6	2·56	729	810	770	13·6	0·7
20	5	3	5·72	1555	1688	1628	23·8	1·3
20	10	2	10·27	2593	2751	2673	39·9	6·2

Both guns were then fired at targets 18 × 9 ft. at a distance of 1000 yds. The French put six shots through before graze and eight *en ricochet*. The 9-pr. put thirteen through before graze, and two *en ricochet*, on the whole only one more than its rival.

Lastly, they were fired against time. The French fired 20 rounds in $4^{m}\ 20^{s}$ being sponged each time. The breech loader which was not sponged, fired 20 rounds in $3^{m}\ 10^{s}$.

10. Thus it will be seen that the brass muzzle loader held its own remarkably well at all points against the breech loader, and on the whole they may be considered as very fairly matched. Since, however, the *canon de 4 rayé* would have to cope with the 12-pr. as well as the 9-pr. I subjoin the mean of 13 series, principally of 20 rounds each, fired on different occasions with the latter.

Averages for Armstrong B.L. 12-pr.

Elevation.	Range.	Mean diff. of range.	Mean reduced deflection.
2°	1087	17·2	0·6
5°	2086	19.5	1·3
10°	3410	36·5	2·9

There may be a question whether the Armstrong 9-pr. has any substantial advantage over the French *canon de 4 rayé,* but there can be scarcely any as to the relative efficiency as concerns range and accuracy of the Armstrong 12-pr., and this indeed the least that we could expect from its greater weight and less general mobility.

11. The French gun appears in the preceding comparisons as we have found it on trial. The following table is based on very extensive practice at La Fère, and doubtless gives a more just representation of its average accuracy.

TABLE VII.

Distance.		Elevation.	Mean error		Extreme errors or rectangle including all the shots.	
			In range.	In direction.	Length.	Width.
mètres.	yds.	° ′	yds.	yds.		
400	437	0 55	9·8	0·38	...	...
600	656	1 30	18·6	0·55	41·5	4·3
800	875	2 10	21·8	0·87	...	...
900	...	...	...	...	78·7	4·3
1000	1094	2 50	24·0	1·31	...	...
1200	1312	3 40	25·1	1·53	50·3	6·5
1500	1614	5 5	27·3	2·08	32·5	7·6
1800	1969	6 35	29·5	2·73	43·7	10·9
2000	2187	7 45	30·6	3·27	...	...
2100	...	...	...	...	55·8	9·8
2400	...	...	...	...	117·0	10·9
2500	2734	11 0	32·8	5·03	...	...
2700	...	...	...	...	131·2	17·5
3000	3281	15 10	37·2	7·00	76·5	29·5

The mean errors (*écarts moyens*) above appear to be the same thing as the mean error of range and mean reduced deflection of our tables. The *écarts maxima* are not given for the same mean ranges in all cases, but I have included the whole of them.

12. Lastly, we have the results of target practice at the Camp of Châlons in 1860.

The following table contains, First the number of hits on a target 2 mètres (6 ft. 6 inches) square, and the number in line but over or under not more than 30 mètres. Second, the number which struck targets representing a battalion in column of divisions, whether at half-distance or closed up. The practice was in both cases assimilated as much as possible to actual service, that is to say, the fire was sustained and rapid; the distances were not known to the batteries.

TIME AND PERCUSSION FUZES OF THE FRENCH. RIFLED CANNON.

1860. *Fuzées à 2 durées* 1863.

Fig 1.

Fig 2.

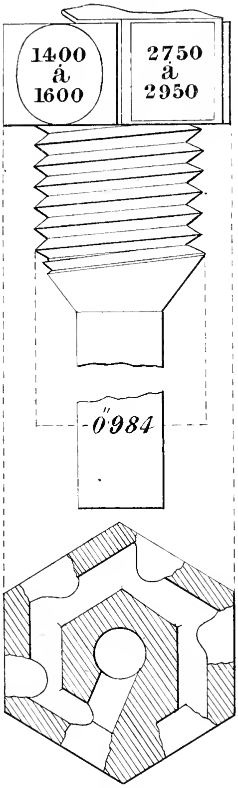
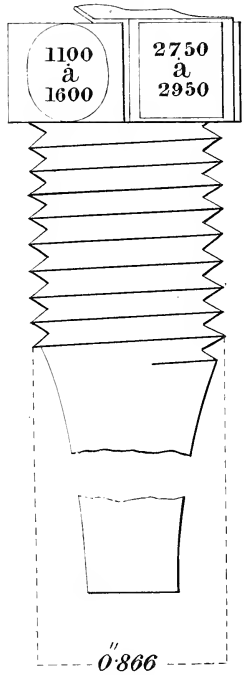
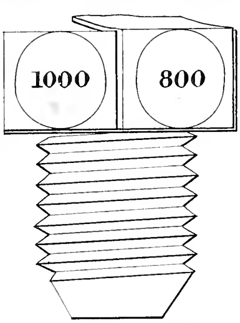


Fig 3.



Pattern of 1861 à 3 durées.

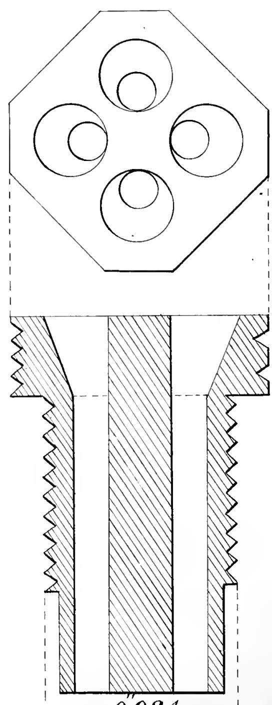
Fig 4.



Pattern of 1864 à 4 durées.

Fig 5.

Fig 6.



Percussion Fuze Pattern 1859.

Fig 7.

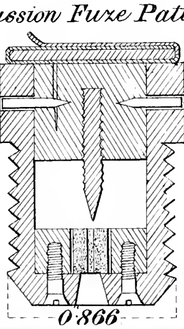


TABLE VIII.

Mètres.	Target 6·5 × 6·5 ft.				Column of divisions.	
	No. of rounds.	Struck target.	In line.	Within ± 33 yds.	No. of rounds.	Struck the battalion.
900	95	10	56	48	...	...
1000	84	10	54	52	...	...
1100	96	6	32	33	...	...
1200	96	2	32	48	...	...
1300	96	4	21	49	...	...
1400	324	17	154	135	...	...
1450	144	14	54	81	...	...
1500	...	...	...	...	144	87
1550	...	...	...	...	18	17
1600	...	...	...	...	72	35
1700	96	...	34	10	...	...
1750	96	...	22	13	...	...
1800	...	...	...	...	144	33
1950	...	...	...	...	...	...
2000	96	...	35	19	144	63
2050	144	...	50	54	...	...
2100	144	5	46	84	72	32
2700	...	...	...	...	48	25
Totals	1511	68	590	626	642	292

13. The normal projectile of the French system being the common shell* we are naturally led to the consideration of the fuzes employed, on which so much of the efficiency of any shell system depends. The accompanying Plate II. represents those in use, Fig. 1 is the time fuze for common shells, pattern of 1860, the history of which is as follows :—It was introduced in 1859 for the shells of the preceding year and was so arranged that the total time of burning was capable of six subdivisions depending upon which of the lighting holes in the head was opened. It will be observed that they all terminate in the same central channel, No. 1 communicates with it direct, No. 6 has the circumference of the head to burn before it reaches it. This fuze with six outlets (*évents*) ceased to be regulation in 1860, and was altered. Its length was increased from 1·5 to 2·75 inches by screwing on a piece of tube, of the six *évents* four were closed with a leather disc and painted over: two only remained open, one of them closed with a leather disc, and a label of red paper with the figure 1500 on it. The other closed

* Each limber box carries

Common shells	26
Shrapnels	3
Case	3
	32

They are packed, filled, and fuzed, with the fuze downwards, and such adjustment as they are capable of is given without removing the fuze. Two case are carried in an axletree box with their cartridges.

in a manner easily distinguishable from the first, and bearing a white paper label marked 3000. As these two figures 1500–3000 gave but a very imperfect idea of the bursting distances, they were altered in 1863 to those which appear in Plate, viz. $\frac{1400}{1600}$ and $\frac{2750}{2950}$ respectively. There is another pattern (Fig. 2) of 1863, adapted for the present fuze hole, but otherwise like the last. The fuze is always set for the extreme distance, and when the distance is less than 2750 mètres both openings are uncovered. Thus in effect but one length of fuze is used with the common shell for all distances up to 3000 yards. The fuzes used with the shrapnel are different, and have three or four available lengths. Fig. 3 is the fuze of 1859 with three of the original openings left, marked respectively for 800, 1000, and 1200 mètres: Fig. 4, pattern of 1864, is of a different arrangement: it has four parallel channels, calculated for distances of 500–800–1000 and 1200 mètres. As with common shells, the fuze is always set for the longest distance, and a second opening is made for distances under 1200 mètres.

14. The French percussion fuze is represented in Fig. 7, and is much the same as our own in principle and mode of action. The striker is suspended on two pins, but is also supported by a strip of metal forming a removable head exterior to the body, which can be pulled away by means of a small projecting end of the strip which will be noticed in the plate. When it is desired to render the fuze more sensitive, one of the suspension pins can be taken out by getting the blade of a knife under the head. The detonating composition is identical with that of the French friction tubes, namely

Chlorate of potash........................	1
Sulphuret of antimony	2

15. The duties of the detachment are distributed as follows:—

No. 1 *R* sponges and rams home,
,, 2 *L* loads, uncaps and sets the fuze,
,, 3 ,, points, serves the vent and pricks the cartridge,
,, 4 ,, assists No. 3, primes, and fires,
,, 5 *R* is the artificer, delivers ammunition to No. 2,
,, 6 *L* assists No. 2.

We have here the whole duties of a gun detachment distributed among six instead of eight men: for the duties of No. 9 in our system (attending the ammunition wagon) not being provided for above, that number cannot be brought into comparison. This releases eighteen men per battery, and as one driver per gun at least is also saved, twenty-four men per battery less are required under the French system than under our own, other things equal; the difference is probably greater than this, as the reduced number of horses and carriages would call for fewer shoeing-smiths and other artificers, but it is difficult to make a direct comparison where the organizations differ so much.

16. The following appears to be the usual composition of rifled field batteries.

	de 4 de Campagne.	de 4 de Montagne.	de 12.
Guns	6	6	6
Gun carriages	8	9	8
Ammunition wagons	12	36 boxes	18
Small arm do	6	18	0
Store wagons	2	0	2
Field forges	2	1	2
Spare wheels	8	0	8
Sets of shafts (*limonières*)	0	12	0
Pack saddles, gun and carriage	0	24	0
„ ammunition and store.	0	33	0

The *personnel* on the footing of active service is as follows:—

	de 4 de Campagne.	de 12.
Mounted men	118	144
Dismounted men	80	90
Riding horses	24	24
Draught horses	140	180

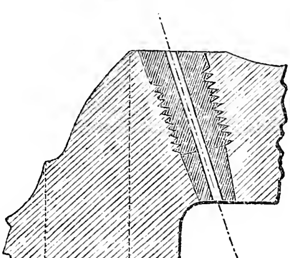
Canon de 4 rayé de Montagne.

17. The gun for mountain service is identical in calibre and mode of rifling with the gun for general field service, the only difference being in length, weight, and external dimensions.

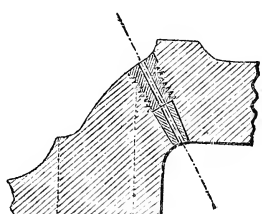
Calibre	86·5 mm.	3·406 in.
Length of bore	805· „	31·7 „
Length of grooving	715· „	28·1 „
Total length over all	960· „	37·8 „
Diameter of base ring	173· „	6·8 „
Diameter of muzzle	150· „	5·9 „
Length of trunnions	60· „	2·4 „
Width between their shoulders	175· „	7·0 „
Total weight	100· kil.	220·6 lbs.
Breech preponderance	15· „	33·1 „
Grooves &c., see Table VI.		
Charge	0·30	10·6 oz.

There is a slight peculiarity in the bushing of the mountain gun, the upper screwed portion of the bush being of iron, whereas it is of copper in the field gun: both are represented below.

Field service canon de 4.



Mountain service canon de 4.



Position of vent, and form of bush.

18. The projectiles are the same as those used for field service, namely :—

	Weight empty.		As fired.	
Common shell.........	3·66 kil.	8·08 lbs.	4·00 kil.	8·82 lbs.
Shrapnel (1858)........	2·75 ,,	6·06 ,,	4·21 ,,	9·28 ,,
,, (1864)......	2·60 ,,	5·73 ,,	4·72 ,,	10·41 ,,
Case shot			4·72 ,,	10·41 ,,

Thus the gun is 25 times the weight (m) of its ordinary projectiles (common shell), and the charge about $\frac{1}{12}$th, giving an initial velocity (V) of 225 m. or 738 ft., the weight of the carriage with 29·5 in. wheels is 206 lbs.; the total weight of gun and carriage (M) 427 lbs., and we have for the velocity of recoil (v),

$$v = \frac{m}{M} V = 14{\cdot}0 \text{ ft.}$$

This high value indicates a very sharp recoil, which is borne out by the following table.

Actual recoil of the mountain gun.

	Elevation.		
	0°	5°	15°
	ft.	ft.	ft.
On heavy wet soil	7·8	8·8	7·4
On good turf not dry	11·7	...	...
On medium earth such as the drill ground at Vincennes	19·2	15·6	...

19. The construction of the carriage permits a depression of 8° and an elevation of 15°, which commands a range of 2000 yds. The following table gives the particulars of practice with common shells.

Table IX.

Practice of French rifled canon de 4 rayé de Montagne.

Distance.		Angle of elevation.		Angle of descent.		Derivation.	Highest point of trajectory.	Time of flight.	Mean errors.		Striking velocity.
									Range.	Direction.	
mètres.	yds.	°	′	°	′	yds.	yds.	s.	yds.	yds.	ft.
200	219	0	45	0	55	0·5	0·9	0·9	...	...	703
300	328	1	15	1	25	0·8	2·2	1·3	...	...	689
400	438	1	45	2	5	1·3	4·4	1·8	6·6	0·4	672
500	547	2	20	2	50	2·2	6·5	2·3	...	...	656
600	656	2	55	3	35	3·3	10·9	2·9	12·0	0·8	640
700	765	3	30	4	35	4·7	15·3	3·4	...	...	623
800	875	4	5	5	25	6·3	19·7	4·0	14·2	1·1	607
900	984	4	45	6	35	8·3	26·2	4·6	...	...	591
1000	1094	5	30	7	40	10·6	33·9	5·0	17·5	1·3	574
1200	1203	7	15	10	10	16·7	54·8	6·2	19·7	2·2	545
1500	1640	10	40	14	30	29·2	100·6	8·3	21·9	3·3	505
1800	1969	13	35	19	25	...	...	10·6	24·0	6·5	466
2000	2187	16	20	22	50	63·4	200·1	12·5	26·2	12·0	440

It will be noticed that the error of range is considerably less at every distance than it is with the field gun, an effect which is due to the lower velocity and higher angles of descent. The error of direction is greater, but still very moderate considering the small size of the piece. A similar uniformity of practice with small charges and comparatively large angles is familiar at Shoeburyness.

20. One of our own brass mountain 3-prs. of $2\frac{1}{2}$ cwt. has been recently bored up to the calibre of the French mountain gun and similarly rifled, except that the number of grooves was reduced from 6 to 3, and the weight reduced by the process of boring up from 254 lbs. to 225 lbs. The practice, which is contained in the following table, is excellent. The recoil was violent but easily controlled by lashing the wheels: the loading very easy.

Table X.

21. Practice of an English mountain service 3-pr. bored up from 2·″88 to 3·″406 and rifled with 3 grooves resembling those of the *canon de 4 rayé de Montagne.* June 1865.

	lbs.	oz.
Weight of piece	225	0
Charge	0	10
Weight of shell empty	7	14
Bursting charge	0	9
Length of bore	34 in.	

Charge.	No. of rounds.	Elevation.	Ranges observed. min.	max.	mean.	Mean difference of range.	Mean reduced deflection.
oz		°	yds.	yds.	yds.	yds.	yds.
10	10	2	559	627	591	20·6	0·47
"	10	5	933	1100	989	48·2	1·22
"	10	7	1131	1362	1230	49·6	2·18
"	10	10	1509	1605	1552	21·9	2·62
Continuation with reduced charges.							
8	10	2	365	411	391	13·0	0·52
"	10	5	651	748	699	25·9	1·28
"	10	7	800	937	882	34·9	1·26
"	10	10	1194	1328	1264	28·7	2·1
"	5	18	1746	1981	1854	69·4	3·1
"	5	30	2188	2334	2234	52·0	15·0
6	10	10	881	1004	913	20·1	1·00
4	5	$18\frac{1}{2}$	952	1059	999	34·0	1·30
"	5	30	1200	1338	1255	43·0	5·52
2	10	30	677	779	739	25·5	2·2

French 25-pr. or *canon de 12 rayé de Campagne.*

22. In addition to the two light pieces described in the preceding pages, the French as early as 1859 began to rifle some of the 12-pr. Napoleon shell guns, the *canons obusier* of 12 *c* which were introduced in 1853, and they are now a recognized part of their rifled field artillery. They correspond to

our Armstrong B.L. 20-prs.; the weight of the projectile is 25 lbs., as was that of the Armstrong gun when it was first introduced. The gun weighs 53 times the weight of the loaded shell, and the charge is a little over one-twelfth. The Armstrong B.L. 20-pr. for land service weighs 94 times the present projectile, and it weighed 75 times the original projectile at the time when the recoil, with a charge of one-eighth, was found so violent and so destructive to the carriage, as to lead to a reduction in the rating of the gun. The recoil of the French gun must therefore be very violent also. This is further evident from the following comparison :—

	French canon de 12 rayé.	Armstrong B.L. 20-pr. land service.	
Weight of gun	1345·0 lbs.	1830·0 lbs.	
Carriage and wheels	1277·0 „	1684·0 „	
Charge	2·2 „	(1) 3·125	(2) 2·5
Projectile	25·4 „	25·0	21·5
Initial velocity of shell	1066·0 ft.	1142·0 ft.	969·0 ft.
Calculated shock of recoil per second	10·8 „	8·1 „	6·9 „

The velocities in the last line are found by the formula,

$$\text{Velocity of recoil} = \text{initial velocity of shot} \frac{\text{mass of shot}}{\text{mass of gun and carriage.}}$$

The actual recoil of the piece is as follows :

	Elevation.			
	0°	5°	10°	15°
	ft.	ft.	ft.	ft.
On heavy wet soil	6·5	6·9	6·5	6·2
On good turf, not dry	12·5	„	„	„
On medium earth	13·5	10·0	„	„
On hard dry turf	19·5		14·8	

23. The following table contains the principal constructive details of the *canon de* 12 *rayé.*

TABLE XI.

Weight of piece	610·0 kil.	12 cwt. 1·5 lbs.
Breech preponderance	70·0 „	1 „ 42·4 „
Service charge	1·0 „	0 „ 2·2 „
Diameter of bore	121·3 mm.	4·776 in.
Diameter across the grooves	128·3 „	5·051 „
Length of grooves	1705·0 „	67·1 „
Length of bore unrifled	110·0 „	4·3 „
Total length of bore	1815·0 „	71·5 „
Total length of gun over all	2066·0 „	81·3 „
Diameter at the base ring	316·0 „	12·25 „

Width between trunnions	268·0 mm.	10·3 in.
Number of grooves	6 "	6 "
Depth of grooves	3·5 "	0·138 "
Width of groove at the bottom	25·0 "	0·98 "
Angle of the driving side	70°	70°
Angle of the loading side	90°	90°
Twist 1 turn in calibres	24·7	24·7
Greatest windage over body of shot	2·9 "	0·114 "
Windage over studs	1·0 "	0·039 "

24. There are three patterns of common shell, but they differ in nothing essential except the size of the fuze hole, which was increased in 1861 from 0·866 inch to 0·984 inch (22 to 25 mm.) measured to the bottom of the thread, but is still 0·866 as we measure: the depth of the thread is 1·5 mm. or 0·059 inch; the same change was applied two years later to the shells of the *canon de* 4. The shells of both natures which have the smaller fuze hole are marked *A.M.* (*ancien modèle*) in red paint on the bottom. They are supplied to the arsenals in the rough from the foundries, with holes for the studs left in the cast and with the fuze hole tapped. They are there gauged, and studded with hammered zinc.

Table XII.

PRINCIPAL DETAILS OF THE 25-pr. COMMON SHELLS.

Mean gauge over body	118·0 mm.	4·646 in.
Mean thickness of wall	18·25 "	0·72 "
Mean thickness of bottom	19·0 "	0·75 "
Length of cylindrical part	131·0 "	5·15 "
Length of ogival part	100·0 "	3·94 "
Total length	231·0 "	9·09 "
Diameter of the holes for the studs	22·6 "	0·89 "
Depth	3·4 "	0·13 "
Diameter of studs	22·0 "	0·87 "
Thickness	8·0 "	0·31 "
Projection	4·6 "	0·18 "
Distance of first and last stud from centre to centre	94·0 "	3·70 "
Mean weight of empty shell	10·825 kil.	23·66 lbs.
Mean weight filled and fuzed	11·5 "	25·36 "
Bursting charge	0·5 "	1·10 "

There is no shrapnel (*obus à balles*) for this calibre, but a common case is supplied, containing 98 wrought-iron shot of No. 6 size, or 1·0 inch gauge, in 7 tiers.

The exterior is of sheet zinc, top and bottom of zinc castings, the shot are fixed by melted sulphur after being previously greased. Length complete about 7·7 inches, weight 24·75 lbs. It is effective up to 300 or 400 mètres.

Table XIV.

25. Range, elevation, and other particulars of practice with the rifled *canon de* 12; charge 2·2 lbs.; shell 25 lbs.

Distance.		Angle of elevation.		Angle of descent.		Time of flight.	Deriva-tion.	Highest point of trajectory.	Mean errors of		Striking velocity.
									Range.	Direc-tion.	
mètres.	yds.	°	′	°	′	sec.	yds.	yds.	yds.	yds.	ft.
200	219	0	25	0	25	0·8	0·4	1·1	...	...	974
300	328	0	40	1	0	1·2	0·6	2·2	...	...	958
400	438	1	0	1	15	1·6	0·9	3·4	8·3	0·25	942
500	547	1	20	1	30	1·9	1·1	4·9	...	...	925
600	656	1	40	2	15	2·3	1·4	7·1	...	...	909
700	765	2	5	2	30	2·7	2·1	9·8	31·7	1·00	892
800	875	2	30	3	15	3·1	28	13·1	...	...	876
900	984	2	55	3	30	3·5	39	16·7	...	...	860
1000	1094	3	20	4	20	3·9	5 5	20·8	10·2	1·54	843
1100	1203	3	50	5	10	4·4	7·1	24·0	...	...	827
1200	1312	4	25	5	30	4·8	8·8	29·5	...	...	810
1300	1422	5	0	6	20	5·2	10·7	39·4	14·2*	1·89	794
1400	1531	5	30	7	15	5·6	12·5	42·6	...	...	777
1500	1640	6	0	8	5	6·0	14·6	50·3	...	...	761
1600	1750	6	35	9	0	6·4	16·7	59·0	...	...	746
1700	1860	7	5	9	30	6·9	18·6	70·0	29·0	1·90	732
1800	1969	7	40	10	25	7·4	20·8	82·0	...	...	717
1900	2078	8	15	11	20	7·9	23·6	94·0	...	...	702
2000	2187	9	0	12	20	8·4	27·3	108·3	...	...	689
2050	...	...		...		...	...	...	120·5	0·87	...
2100	2297	9	30	13	20	8·9	31·3	121·	...	...	676
2200	2404	10	5	14	20	9·4	35·3	135·6	...	...	663
2300	2515	10	50	15	20	10·0	40·3	150·9	...	...	652
2400	2625	11	35	16	20	10·6	44·8	169·5	107·2	2·03	636
2500	2734	12	20	17	20	11·2	49·0	185·9	...	...	623
2600	2843	13	0	18	25	11·8	54·7	204·5	...	...	610
2700	2953	13	50	20	0	12·4	60·0	226·4	133·4	6·12	597
2800	3062	14	35	21	20	13·0	65·6	247·1	...	...	584
2900	3172	15	25	23	0	13·6	71·1	273·4	...	...	571
3000	3281	16	0	24	20	14·0	77·6	299·6	...	...	558
3400	3718	20	0	...		...	...	...	...	...	
4100	4484	30	0	...		...	...	...	...	...	

* Printed 1·30 in the *Aide Mémoire*, probably an error for 13·0 mètres.

26. The following are given as the times which may be reasonably allowed for the 25-pr. in coming into action on good ground, from column of march, the gunners supposed to be seated on the limber and wagon.

	m.	sec.
From the word "action front," to "load,"	0	27
From "load," to "fire,"	0	50
From "load," to the tenth round.................	6	26

A round may be fired on the average every 38 or 39 seconds, the gun being run up and laid properly every time. The following was the result of practice at the camp of Châlons in 1860, at targets representing a battalion in column of divisions, partly at half-distance, partly close.

TABLE XV.

Distance.		Rounds.	Per centage that struck.
m.	yds.		
1250	1367	54	·63
1550	1695	120	·67
1900	2078	42	·66
1950	2132	84	·50
2000	2187	120	·66
2700	2953	48	·46
		468	61·5

The Armstrong L.S. 20-pr. has been less used than any other of the breech-loading guns, and the means of comparing it with the *canon de* 12 *rayé* are more scanty. The following practice, however, may be taken as a fair example.

TABLE XVI.

Date.	No. of rounds fired.	Nature of projectile.	Corrected elevation.	Mean time of flight.	Ranges. min.	Ranges. max.	Ranges. mean.	Mean difference of range.	Mean reduced deflection.
			° ′	sec.	yds.	yds.	yds.	yds.	yds.
1862, Jan. 16	10	Solid shot	2 7	2·90	802	907	862	30·1	0·4
" " 15	20	"	5 3	6·30	1722	1906	1832	45·0	1·9
" " 16	10	"	10 2	11·50	2982	3223	3103	74·8	1·7
1861, Dec. 13	10	Common shell	0 28	not observ.	223	252	239	6·5	0·1
" "	9	"	2 5	2·94	823	984	898	40·1	0·6
" "	10	"	5 3	6·09	1782	1864	1820	25·7	1·2
" "	10	"	7 2	8·29	2348	2445	2401	29·8	3·4
1862, Jan. 13	10	"	10 1	11·50	3160	3325	3234	35·9	1·9
1861, Dec. 18	10	Segment shell	0 28	not observ.	222	252	237	6·8	0·1
" "	10	"	2 5	2·79	861	889	878	7·4	0·5
" "	10	"	5 3	6·14	1755	1912	1872	26·1	1·3
" "	10	"	7 2	8·31	2334	2463	2418	39·6	1·6
1862, Jan. 3	10	"	10 1	11·26	3227	3346	3284	34·8	1·8

The *écarts moyens* of the French gun in Table XIV. are extremely irregular, and evidently cannot be regarded as average values. Such as they are it would appear that the gun is in point of range, more accurate than the 20-pr. up to nearly 2000 yds., but inferior in accuracy of direction. At 3000 yds. its inferiority in both respects is decided.

27. The following *resumé* of the principal particulars relating to the several guns is added for convenience of reference; some details having been

given for the mountain gun and the 25-pr. which were omitted in treating of the field gun.

TABLE XVII.

	Canon de 12 rayé.	Canon de 4 rayé de Campagne.	Canon de 4 rayé de Montagne.
Calibre	4·776 in.	3·406 in.	3·406 in.
Weight	12 cwt. 1·5 lb.	6 cwt. 56 lbs.	221 lbs.
Length of bore	71·5 in.	55·1 in.	31·7 in.
Shell as fired	25 lbs. 6 oz.	9 lbs.	9 lbs.
Charge	2 lbs. 3·4 oz.	1 lb. 3·4 oz.	10·6 oz.
Initial velocity	1066 ft.	1066 ft.	738 ft.
Common shell, per box	17	26	7
Shrapnel shells ,,	—	3	1
Case ,,	1	3	1
Number of boxes per gun with one wagon	4	4	6*
Diameter of wheels	4 ft. 10·7 in.	4 ft. 8·3 in.	3 ft. 1·6 in.
Track of wheels	5 ft.	4 ft. 8·3 in.	2 ft. 5·5 in.
Weights of wheels, each	225 lbs.	165·5 lbs.	125·5 lbs.
,, gun carriage, without wheels	7 cwt. 43 lbs.	4 cwt. 64 lbs.	154 lbs.
,, limber, packed, with wheels	14 cwt. 9 lbs.	10 cwt.	—
,, gun carriage and limber, packed complete	38 cwt. 16 lbs.	25 cwt. 6 lbs.†	4 cwt. 30 lbs.
,, ammunition wagon and limber, packed complete	36 cwt. 35 lbs.	25 cwt. 89 lbs.†	—

27. The *Aide-Mémoire portatif de Campagne* of 1864, from which the preceding data are chiefly derived, contains full instructions on the use and employment of the guns referred to under all circumstances: characterized by that clearness, conciseness, and practical character which distinguishes the military manuals of the French; but it would be beside the purpose of this paper to quote largely from them. The work itself, notwithstanding its primary reference to a special material, may be cordially recommended as containing in a very small compass a great deal of matter of general interest to the artilleryman.

* 36 boxes for 6 guns, which with 64 in reserve, carry 150 rounds per gun.

† These weights differ a little from those at p. 346, which were taken from a different authority.

ERRATUM.

Table I. p. 344, *for* "1 turn of rifling in 8·858 feet," *read* "1 turn of rifling in 88·58 inches or 7·38 feet."

DESCRIPTION OF THREE GUNS FOUND IN THE FORT OF FUTTEHGURH ON ITS CAPTURE BY LORD CLYDE IN 1858.

BY LIEUTENANT H. W. L. HIME, R.A.

When Lord Clyde drove the mutineers from the fort of Futtehgurh, they left behind them a number of their guns. Since that time some of these have been melted down in the agency of the fort and the iron applied to various purposes in the construction of gun carriages. A few still remain, and while quartered at Futtehgurh, I took the dimensions of the three most remarkable, with the assistance of Captain M. Currie, R.A., gun carriage agent, and Mr Revie, foreman of the agency.

The first gun is a Bengal Artillery 6-pr., which appears to have been abandoned as completely unserviceable, the trunnions and cascable having been previously carefully knocked off. The rebels, however, so repaired it as to admit of its being again mounted on a carriage and fired.

The second gun is a built-up wrought-iron gun, entirely of native manufacture.

The third piece of ordnance consists of two wrought-iron guns, of native manufacture, fastened together by bands.

No. 1 Gun. As I have before said, this is a Bengal Artillery 6-pr. The trunnions and cascable have been knocked off in the most perfect manner, but no attempt appears to have been made to spike the gun, and the vent is still in good condition. On examination we found it was loaded, as were also Nos. 2 and 3. In order to discover the nature of the charge the gun was placed under a monkey which succeeded in breaking it across the chase, but the metal of the 1st reinforce resisted all our efforts; and we were unwilling to try the usual method of discharging as only a few days before a piece, which had remained loaded since the mutiny, had burst and killed a bystander.

On taking possession of this gun the mutineers began operations by boring a hole in the spot where the cascable had been knocked off, about 2·5″ long and ·75″ in diameter. Into this was driven a tightly fitting wrought-iron rod about 6·5″ long, with a knob at the end. This formed a temporary cascable, *c, c′*.

The next step was to form trunnions. For this purpose two bars of wrought-iron *t, t′*, were bent over and under the gun immediately behind the position of the original trunnions (*e, e′*) and fastened in their places by pins *d, d*. The bars are 1″ thick by 2″ and 2·25″ broad. The trunnions so formed are consequently 2″ thick by 2″ and 2·25″ broad: and the length of bars originally was such as to admit of the trunnions being about 6″ long. A section through *ff′* would exactly resemble the section at *mn* of No. 2 (γ), with this exception that the ends of the two bars forming the trunnions for

No. 2 are partially welded together as well as fastened with an iron pin, while the ends of the same bars in No. 1 are only secured by being pinned. It is evident that trunnions fixed on the gun in such an imperfect manner could not withstand the shock of even one discharge, and to prevent the gun being driven back out of the trunnions by the force of recoil, the mutineers constructed a sort of collar (β), *ab*, *a′b′*, of two wrought-iron bars, 1″ thick by 1·25″ broad, which was placed against the breech of the gun, the cascable passing through the space *h*. The two bars forming the collar were fastened together by pins *k*, *k*, *k′*, *k′*. This collar was connected with the trunnions by means of two iron rods, *g*, *g′*, *g″*, the front ends of which terminated in rings, *m*, *m′*, *m″*, which fitted on the trunnions, while the other ends of the rods were passed through holes in the collar and were secured to it by nuts, *n*, *n*, *n′*, *n′*, tapped with screws. The gun appears to have been frequently fired with this apparatus, as the collar was considerably bent when I examined it.

No. 2 Gun. This gun consists of an internal cylinder, *d*, *d*, *d′*, *d′*, of wrought-iron, strengthened by wrought-iron rings, *b*, *b*, *b′*, *b′*, shrunk or hammered on. The trunnions are formed of two bars of wrought-iron bent over and under the gun, *g*, *g*, *g′*, *g′*, the ends being rudely welded together and fastened by pins, *p*, *p*, *p′*, *p″*. In (γ), the inner circle represents the bore, the space between the inner and second circles the internal cylinder, the space between the second and third the strengthening rings, and the space between the third and outer circles the trunnion bars. There are two cow-like eyes and a nose, belonging no doubt to some Hindoo god, carved on the muzzle. The average breadth of the rings is 3″, as shown in (α). This gun, like No. 1, was loaded. We succeeded in working out a ball of irregular shape, such as was used by the rebels for case, by probing the charge with a pole placed in the bore. There were marks about the gun which showed it had once been covered with a thin coating of brass. As to the age of the gun we could form no conclusion.

No. 3 Gun. This piece of ordnance consists of two small guns of wrought-iron* strapped together by bands of iron. The trunnions are fastened on in a similar way to those of Nos. 1 and 2. The sections require no explanation. These guns had been evidently at one time covered with a coating of brass about ·25″ thick. It was probably melted off and sold during the mutiny. The brass seems to have been used solely for the sake of appearances, and not to strengthen the gun.

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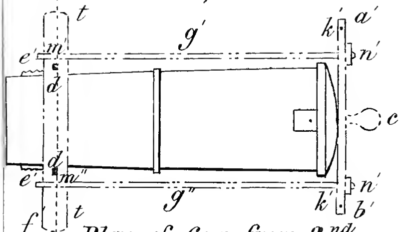
* I never heard of cast-iron ordnance made by natives of India. Mr H. Wilson, Bengal Civil Service, told me however that when Jung Bahadoor's force drove the rebels from Gorruckpore and occupied the place in 1858, a number of cores were found, apparently for the purpose of casting guns.

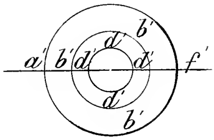
(γ)



Plan of Gun from 2nd Reinforce to Cascable

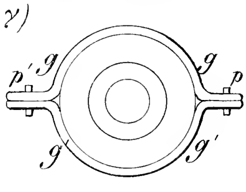
(β)

The Muzzle.



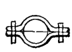
(γ)

Section at m n.



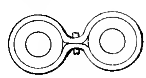
(γ)

Section at c d.



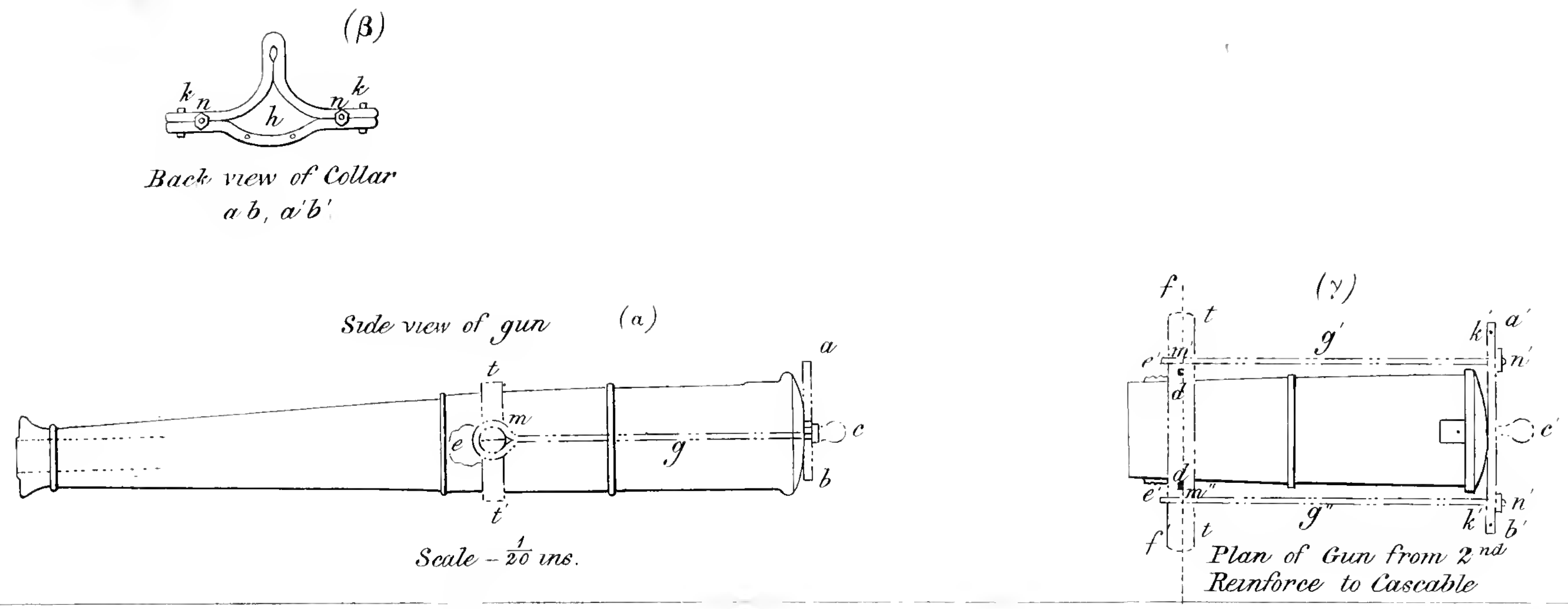
(δ)

Section at e f.

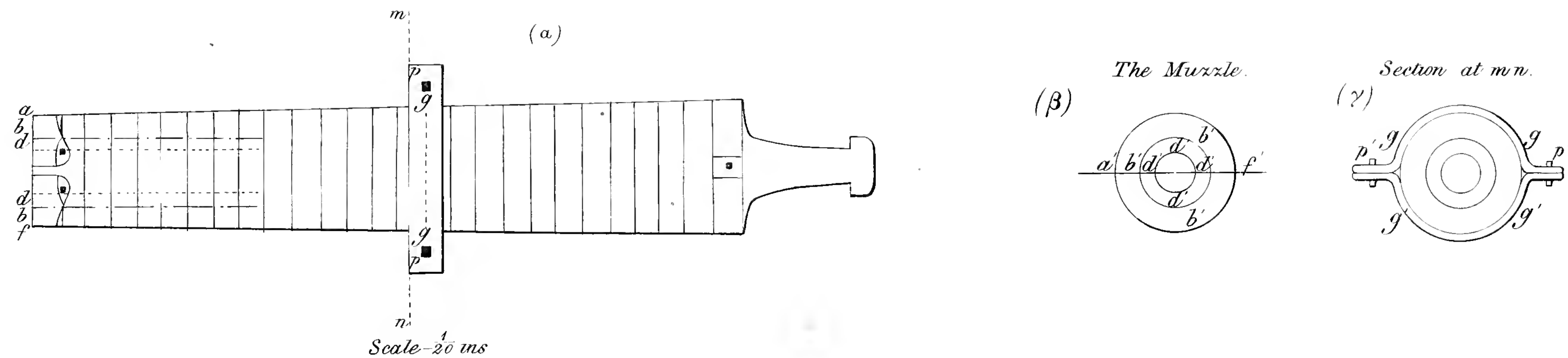


Lithographed at the Royal Artillery Institution

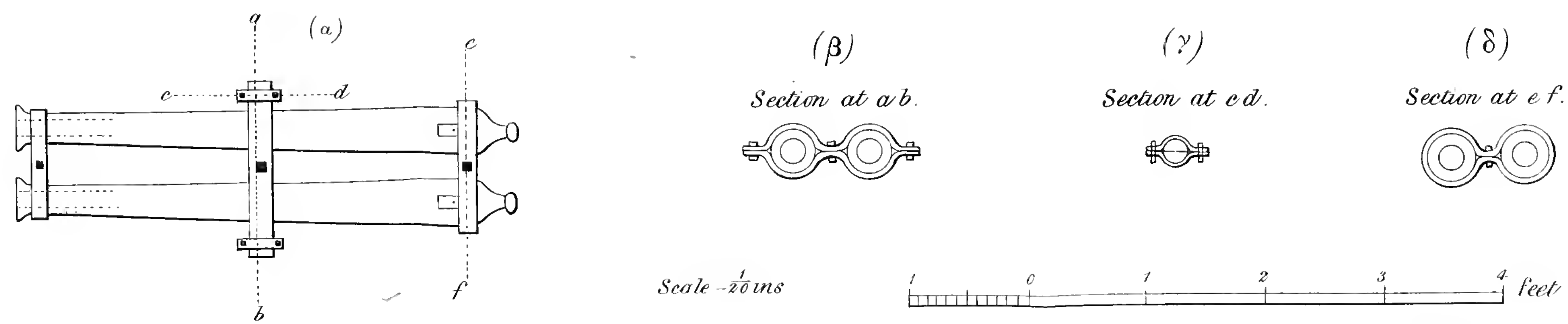
No. 1



No 2.



No 3.



Lithographed at the Royal Artillery Institution

ACCOUNT

OF

THE FINAL ATTACK AND CAPTURE OF RICHMOND BY THE FEDERAL AMERICAN ARMY, COMMANDED BY GENERAL GRANT.

BY MAJOR H. A. SMYTH, R.A.

COMMUNICATED BY THE DEPUTY-ADJUTANT-GENERAL, R.A.

MONTREAL,
April 30, 1865.

SIR,

I have the honor to forward the following observations on the recent operations of the American armies, for transmission to the Dept.-Adjt.-General, to be submitted, if he shall think fit, to the notice of the Commander-in-Chief: I forwarded to him, during my leave of absence, some observations of an earlier date, and do not yet know whether they were of value; but in this instance I think it probable that, as I was the only foreign officer present during the series of these the decisive operations of the war, a condensed account of my experience may have interest. I had the privilege of intimate acquaintance with General Meade, commanding the army of the Potomac, and many of the dispatches were read, and most matters openly discussed, in my hearing.

The force concentrated against Richmond on the 27th March consisted of the army of the Potomac, General Meade, comprising 4 corps, each of about 22,000 men with 40 guns; the army of the James, General Orde, of 2 corps of about the same strength; and the cavalry corps, General Sheridan, of about 12,000 mounted men with some batteries of horse artillery; making a total of more than 140,000 men, the whole under the immediate superintendence of the Commander of the Forces, General Grant. The force opposing this was variously reckoned at from 40,000 to 60,000 men; General Grant inclining to the lower and General Meade giving the highest estimate. This estimate was derived from a record which had been continuously kept for many months by officers of the information bureau, in which all variations in the names, numbers and position of each corps, division, and brigade of the enemy were noted down as ascertained by observation and by reports from spies, deserters, and prisoners; which record, by comparison and correction from time to time, attained very great accuracy, and, in the examination of any fresh informant, was usually consulted as a test of his reliability.

The position of the federal forces was fortified for a front of about 33 miles, 15 miles of it running generally north and south on the east side of Richmond and Petersburg, and 18 miles of it passing round the south side of Petersburg, and thence generally south-west, with the object of eventually arriving at the Plank-road and the railroad, running into Petersburg from the south-west and west, which constituted, since the partial destruction of the Richmond canal by Sheridan, the principal channel of supply for the confederate position and capital. Fortification was continued round the flanks and rear of the federal position, and united it very securely to the James river running through its middle, and constituting its base of supply.

The confederate lines were, in general terms, equal and opposite to the federal, though perhaps of slightly stronger profile; they had the advantage, being interior, of somewhat shorter lines of communication, but it was almost neutralized by a railroad constructed by the federals along most of their position. Regular siege approaches directed from several places against the confederate lines had been brought to a stand-still; and beyond the right of the lines an active force of undetermined strength had, from time to time, checked any direct efforts of the federals to extend their left.

The plan of campaign laid down for the federals was simply to extend their existing front, until the confederates should either be unable to correspond and thereby continue to cover their channels of supply, or be liable, from being too much extended, to be easily broken in the centre. The confederates appear to have resisted this extension with all the means at their command, but to have been finally stretched beyond endurance, and thus utterly broken.

On the night of the 27th March, General Orde was withdrawn with one of his corps from the extreme federal right, and moved, out of sight of the enemy, to the rear of the left, ready on the afternoon of the 28th to take up the defence of that part of the lines about to be vacated by the 2nd and 5th corps.

Long before dawn on the 29th, the 5th corps marched out towards the left rear of the position, having on its left the whole of the cavalry much extended, thus covering the left of the principal movement which was designed to be more directly towards the original left. Slightly connected with the 5th, the 2nd corps marched about dawn in the last-named principal direction, having in front one of its brigades in skirmishing order, its remaining 8 brigades following in one long column along a narrow road, and forming line of battle to their right in succession as they arrived on uncovered ground.

The right of this line was within supporting distance, and almost in continuation of the original fortified position; and during its establishment the 5th corps came round from its circuit on the left, and placing one of its divisions in line on the left on the 2nd corps, retained the other two divisions in support of the extreme left and to ensure the communication with the cavalry, which was collecting itself on roads of some importance at 4 or 5 miles to the left rear. This much (the occupation by the infantry of 4 or 5 miles in the desired direction) was accomplished shortly after noon, without opposition, the few confederate videttes seen through the woods retiring hastily, and losing but one or two prisoners.

It may be desirable here to call attention to the method followed by the troops in taking position on this occasion, as on almost all others that I was witness to. As soon as a brigade was halted in its place, without other word than perhaps company command, the arms were piled and the men broke themselves immediately into working parties to intrench. Of each little squad of 12 or 15 men, a proportion betook themselves to felling trees, a second proportion to arranging them in the line of intended parapet, a third to carrying them, (or other wood, especially fence-rails where procurable), up to the disposal of the second, and a fourth to throwing up earth to the front of the logs with their picket shovels. These latter work with all their might till out of breath, when other men relieve them at the shovelling, and so on, so that each man gets one or more turns at it before the completion of the work, and, in the very light soil of Virginia, a constant stream of earth is kept flying into the required place. In this manner I saw a breastwork, perfectly efficient against musketry fire, thrown up along the entire front of a brigade, in forty minutes; much emulation going on all the time amongst the various squads and regiments. If time allowed, the men next proceeded to "slash" the woods in front of the position, then to assist advanced sentries and picquets in forming rifle pits, and only then to prepare their meals. No doubt the line which I saw thus occupied would have become a formidable fortification by night, but the General told me that he expected to move them some distance forward before dark, and that neither he nor they would grudge the work in the mean time.

The trace of these works is not generally laid down by authority farther than the actual disposition of the troops in line goes, but the men themselves have a keen eye for such principles of advantage as command and flanking fire; in fact, only too much so, as a small show of flanking fire opposed to them, renders them, I was told, altogether unwilling to advance.

The proportion of intrenching tools regularly supplied does not appear to exceed one of each kind to every ten men, independent of the regular pioneers of regiments; but this number is indefinitely increased by the enterprise of the individuals. Besides the pioneers of the regiments, there is with each corps, for general works, a corps of pioneers, and another of engineers.

To return to the operations. The above force rested awhile behind its intrenchments, awaiting attack. The surrounding country was undulating, with but occasional clearings in the woods; the woods however were not difficult save where here and there a swamp, or more frequently a water course, offered fair opportunity for obstruction and defence. During the afternoon, nothing offering, the line was moved cautiously forward, the left in particular getting near to the desired Boydton Plank-road; in which neighbourhood a vivid resistance was met with, but was quickly overpowered by the numbers and confidence of the 5th corps. The confederates appear to have been unable to shew half the numbers, at this point, which were brought against them, but they defended their retreat fiercely; and though the federal officers reported them as less determined than during the last year's campaign in the Wilderness, they caused a loss to the 5th corps, in less than an hour's fighting, of nearly 1000 men, including one or two hundred prisoners; suffering in about the same numbers themselves. They had little or no artillery up; the federal artillery, though unable, from the nature of the country, to take up good positions, acted with much effect, thrusting itself forward in spite of musketry fire, and frequently getting an opportunity to throw in canister at effective range.

I may here remark that these tactics were much used throughout by the federal artillery, emboldened probably by the continual retreat of the enemy; and thereby, though they suffered unusual casualties, they inflicted more than unusual loss on the enemy. The federals preferred, for general use, batteries of brass 12-pr. Napoleon guns, bringing but few rifled 10-prs. with them; and although in the original armament the number of batteries had been equally divided between the two natures, they generally retained for this campaign but one-third rifled to two-thirds Napoleon.

During the night rain set in, and continuing through most of the 30th, rendered the roads very impracticable; little advance of moment was made save that the 5th corps effected a lodgment on the Boydton Plank-road, and ascertained that there were strong works on it ahead of them. The army, during the 30th and part of the 31st, had consolidated its position and had corduroyed the worst part of its roads, when, late on the 31st, news arrived from Sheridan that the cavalry, in sweeping round on the left in conformity with the movement of the rest of the army, had been assailed and cut in two with much loss, by cavalry and infantry combined, and had been forced to retreat on his former position of the night of the 29th. Still later, more urgent dispatches came in, relating the strong force of the confederate attack, and declaring that it included troops from Johnston's army in North Carolina, besides those of the army of Virginia proper. Now, doubts began to find utterance by Generals as to whether the "extension" strategy had not been carried too far; the line of works ahead and the left uncovered by the cavalry suggested the liability of the army to another of those heavy checks frequently received in former times; but General Grant lost no time in maintaining the forward policy by the use of the immense numbers at his command. The 5th corps was ordered to the left rear to join the cavalry that night (General Grant proposed to send a division only, but General Meade persuaded him to send the whole corps, an alteration which probably told much on the speediness of the following series of events); the 2nd corps occupying part of the vacated position of the 5th, and leaving the right of its own to be occupied by General Orde's corps, which was by this time in fortified connection with it from the left of the old position. And next day, the 1st April, the tide flowed again with the numbers.

Sheridan with his own cavalry (now about 11,000) and the corps from the army of the Potomac (about 21,000) came upon the confederate force (afterwards ascertained to have consisted of 5000 infantry and 4000 cavalry) slightly entrenched at Five Forks, the road-centre from which they had driven him the day before: attacking their front with his cavalry (dismounted as usual) and one division of infantry, and turning their left with the other two divisions, he, after a short and hot engagement, took the greater part of the infantry prisoners together with one or two field batteries. The cavalry were very effective in picking up prisoners, pursuing mounted *when organized resistance was at an end.*

This action opened the road towards the south side railroad, but it had not the effect of turning Lee's right, as commonly reported by the newspapers: his main position, a day's march distant, remained untouched, though his communication was so far endangered as to necessitate either a retreat or a re-establishment of the balance of force in this direction. I have been the more particular in stating the occurrences of this action and their consequences, as the former go far to modify the novel opinions expressed to me by federal cavalry officers, both before and after, that "their cavalry was a self-supporting institution," and was, besides being good cavalry, as efficient on foot as most infantry; and the latter correct a very generally received report (founded, indeed, on the very arrogating published dispatches of Sheridan) that the dash of Sheridan coupled with the irresistible nature of his cavalry suddenly turned Lee's right, and, not to mention tearing up the S. S. railroad, rolled him up in such confusion on his centre into Petersburg that he was glad to get out of it the back way during the night. In truth, eventually the centre, never the right, was broken, and that in a more old-fashioned way.

During the same day the left of the line met considerable resistance in its efforts to advance up the Boydton Plank-road, and was at one time fiercely repulsed, but bringing up its numbers succeeded in establishing itself in front of the works above mentioned, with the loss on either side of nearly 1000 men *hors de combat*. The dense woods had made the fighting obstinate, and had given an opportunity to those so disposed to get to the rear; a cordon of mounted men under the Provost Marshal was drawn along the rear of the line of battle, and intercepted and brought up at the close of the day a very respectable force of stragglers; these men did not appear to be ashamed of themselves, but were a little sulky. At night it was determined to deliver an assault along the whole line before the next dawn.

The 9th and the 6th corps, in front of Petersburg proper, were to attack first, General Orde's and the 2nd corps following suit consequent on the other's success. General Wright, an officer of the regular engineers, who commanded the 6th corps, and who was fond of dealing with earthworks, telegraphed, in announcing his readiness, that he would "put his corps in solid,* that he would bet that in fifteen minutes after the word *go* they would be in the enemy's works, and that then he would make the fur fly." The tone of this message was looked upon as an earnest of success; and the execution of his promise was *the* feat of the campaign, and decided the fate of the confederate army.

I may here remark that much of the strength of the regular lines on both sides, which I had noticed in the previous November, was done away with by the destruction of the "slashed" wood along nearly all their front. This had been used for fuel during the winter, in spite of the efforts of the Generals to the contrary, and though there was plenty of wood available a little farther off; the *abatis* also were somewhat disorganized; moreover the line opposite the 6th corps was not yet completed from some recent alterations, the ditches being in parts very shallow, and the parapets only half-height, and an inundation which had covered much of the front had run out. The works in front of the 9th corps were complete, with the exception of the "slashing," and were also nearer to the inner line of supporting works.

About two hours before daylight these two corps rushed to the assault, sweeping in the enemy's picquets with them. The 9th corps on the right had a little trouble with some *chevaux-de-frise* which in some places had

* General Grant had been averse to the solid formation for this attack, but General Meade had prevailed on him to permit it.

replaced the *abatis*, but it was so lightly constructed that they easily broke up the line of it into open column, and passed through, leaving on the ground a number of casualties, and, getting at once on to the main line of works, stuck there, unable to get farther, but maintained themselves till daylight and throughout the succeeding day, against many fierce onslaughts of the defenders to drive them off, partly on the outer slopes, partly amongst the traverses, blindages, and multifarious burrowings which had been plentifully constructed by the garrison, within all the more important points, for protection against the besieger's artillery. Neither side could prevail, and the loss was heavy.

The 6th corps, receiving but one fire from the defenders' guns, checked their speed for nothing till within the works; the meagre garrison got away from observation with little loss, and the assailants, having driven them into their inner line, (which at this point left the outer, and trended northward towards the Appomattox river), formed line of battle to the left, and proceeded to sweep out the works all the way down to the enemy's right, some 12 miles distant; at the same time tearing up portions of the S. S. railroad, being the first federals who reached it. There was nothing having the slightest chance of resisting them, and the 2nd and Orde's corps coming up to the lines told off for them to take, found the garrisons already away, under the menace of the approaching 6th, and trying to escape towards the north. It was thought at one time that Sheridan might get forward on the left and cut them off; but they succeeded, by hard marching and by Sheridan's having to fight much of his way through the woods, in getting across the Appomattox to their main body northward.

Now the 6th faced about towards Petersburg again, and, (Orde's corps having joined the left of the 9th, whose right touched the Appomattox below the town), placed itself on Orde's left and completed the hemming in of the place to the river above. It is worthy of notice that during the absence of the 6th, some reinforcements arriving from the confederate rear had re-occupied two of their detached works between the inner and the outer lines; these had no flanking defence and were of small extent; but they were of good profile, and the defenders were mostly armed with repeating rifles; General Orde's corps re-took them only at the loss of a number of men larger than that of the garrisons.

The whole confederate position, including Richmond, was naturally evacuated during the night; General Weitzel entering the latter place (from the extreme right of the federal position) at 8.15 a.m. on the 3rd April, without finding any enemy, and triumphantly telegraphing that "he had taken Richmond," including so many guns, stores, &c. The fighting for the federal army was now over, and it bent its energies at once to the pursuit. Well for its success that it did not fall in with the general American expectation of triumphing in the city of Richmond; the confederate army would then have easily got itself and its trains away to better strategic points in the south.

It being known that General Lee's army was somewhere to the westward of Richmond and Petersburg, and consequently north of the federal army; and that it must necessarily strive to get to the south-west, or west of the latter, (that is either to Danville or to Lynchburg, the only two points of advantage left to it), the federals had only to move due west to be sure of always cutting off, by a shorter line, Lee's line of retreat.

Accordingly the troops, leaving the 9th corps to rest in Petersburg, and to garrison it as a base of supplies, moved westward in the order in which they happened to find themselves, the cavalry reaching far ahead and feeling for all roads leading to the south.

They marched from before daylight till far into the night, sometimes all on one road, sometimes on parallel ones, with the artillery generally well up to the front, but the roads in rear cut and blocked up by the enormous trains of supply and other wagons; the expense train extending, when on one road, 18 miles, and the main train still more. On the night of the 4th Sheridan struck and brought to a standstill some portion of the enemy, near Jetersville; the infantry, though just in from a 14 hours march, were at his request hurried towards him during the night, but failed to reach him owing to one of his own divisions which had mistaken its way, blockading the roads: they joined him on the 5th, and everything was made ready for the attack which he was expecting; the enemy, however, did not come on, but bore away to their right to try again for the south farther on.

The 5th April having been thus mostly expended in preparing for action, it was the afternoon of the 6th before the infantry, skilfully disposed by General Meade came up with the enemy again, near Sailor's Run, in such shape that whilst the cavalry barred their passage to the west, the 6th corps assailed them from the south, and the second from the east, the unfordable Appomattox (over which they had two bridges) running along their rear on the north. The result was that the entire rear guard, though fighting obstinately, was either killed or taken, together with much artillery and wagon train. General Sheridan's dispatch on this action, as on previous ones, appeared to claim the whole success for himself, whereas the fighting was done principally by the two corps (having together 25,000 actually in the fight) under General Meade's orders, the picking up of prisoners by all, including the cavalry (now about 7000 strong).

This was perhaps the only occasion of the campaign when the artillery might find satisfactory positions; the ground being comparatively open and extensive they were enabled to concentrate so much fire on the principal body of infantry as to force them gradually, and in spite of themselves, into a neighbouring ravine for cover; the outlet of the ravine was difficult, and the federals, running up to the brink of it, easily made the whole of them prisoners.

The confederate army could not raise its head anywhere without receiving a repetition of this sort of treatment at the hands of the numerous, confident, and well-handled legions that beset its path; and it could not sufficiently outmarch the federals to get across their front to the south; consequently, when, on the 8th April, a similar affair seemed to be imminent on a larger scale (the 5th and Orde's corps being then present), near Appomattox Court House, everybody in the federal army, except some few non-combatants, was glad that General Grant's overtures made the surrender of the enemy and the end of their slaughter, distress, and unavailing devotion, probable.

The terms of surrender were correctly reported by the press; in addition the men were allowed to take home with them, for their spring ploughing, any horses their own property; this was by the good-will of General Grant, who however had refused to allow it to form an article in the terms.

The whole of the next day was spent by the confederate army in collecting their remaining ordnance, arms, &c. for giving over, and in calling in to the benefit of the parole such of the stragglers as could be reached: in this way 11,000 men actually present at the first summons became 25,000 who took the parole; the arms were 11,000, and the guns more than 100.

As soon as terms were agreed on, parts of the federal army commenced to retrace their steps towards its base of supplies; which were conveyed to it with much difficulty, even though the S. S. railroad, of peculiar gauge, was being altered to suit the northern rolling stock, at the rate of 16 miles a day. Of the supplies it possessed on the spot some was immediately sent in to the confederate army, which had subsisted generally for the last seven days on two days full rations of bread, and a little more of meat, and such trifles as they could pick up. Both armies were worn by long marching, little food, and want of sleep, but the confederates far the most so; now, in the almost unnatural quiet, all rested, and a feeling of fraternization began to arise between the two armies. It was only when I left the fighting men and came northward amongst the politicians that I heard bitterness and boasting, and longing for cowardly revenge.

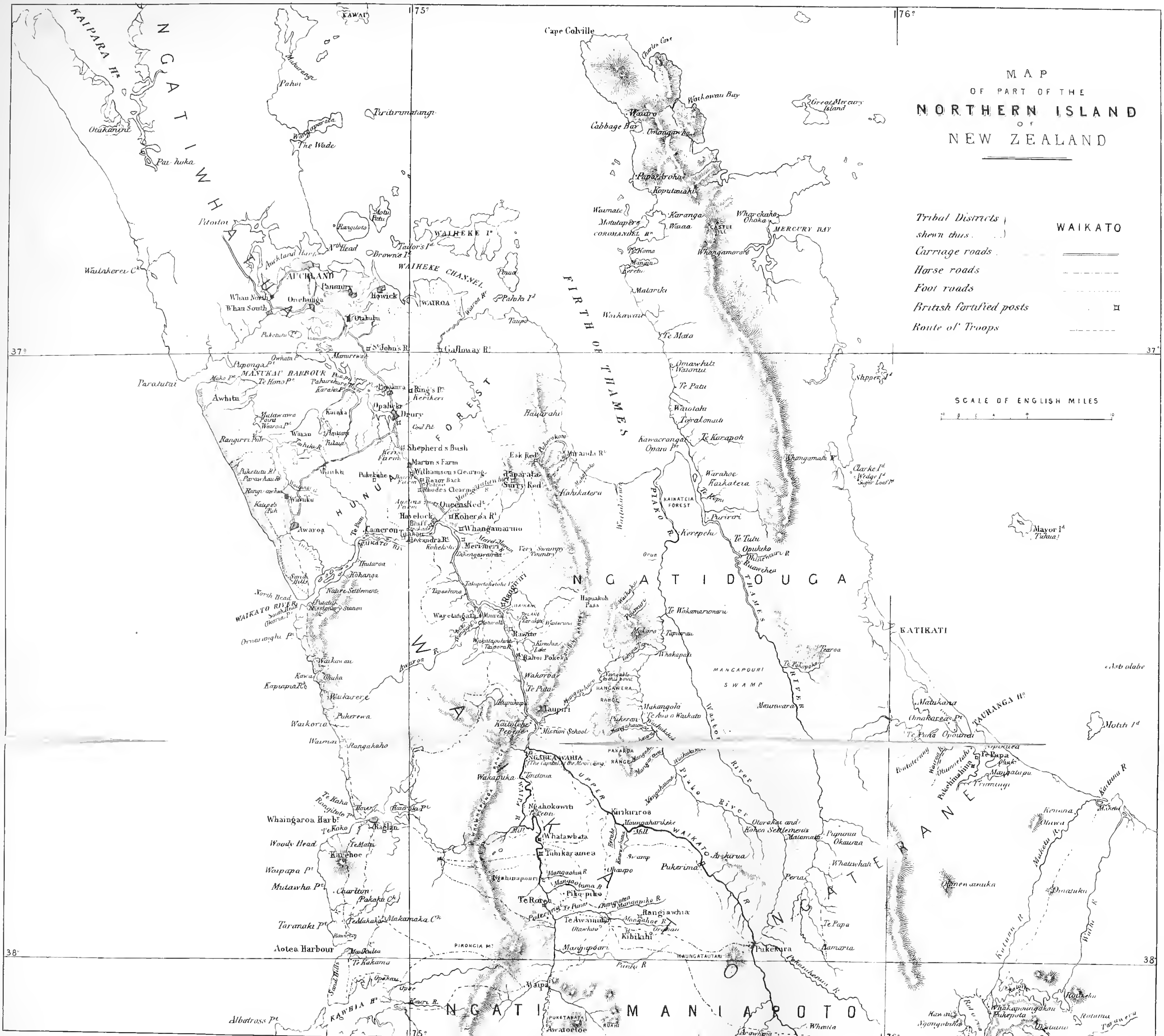
General Lee, in friendly conversation after the surrender with General Meade, mentioned three instructive facts, which I will briefly recount. He said that the south had never been able to shew so fine or so confident an army since the disastrous day of Gettysburg; that at the opening of the present campaign he had had but 40,000 men, (as he paroled 25,000 and as nearly 25,000 more had already passed prisoners through the hands of the Provost Marshal, and as he must have lost at least 10,000 killed and wounded, it is probable that he meant 40,000 present in the ranks, and that 20,000 more must have been sick, team-drivers, artificers, &c.); and moreover, that he had desired to withdraw the army from Richmond towards the south-west ever since last autumn, but that the political authorities would not consent.

Various particulars of the American military system in the field struck me as very interesting; but as this account of the actual operations has become so long, I will reserve notice of them to a future communication.

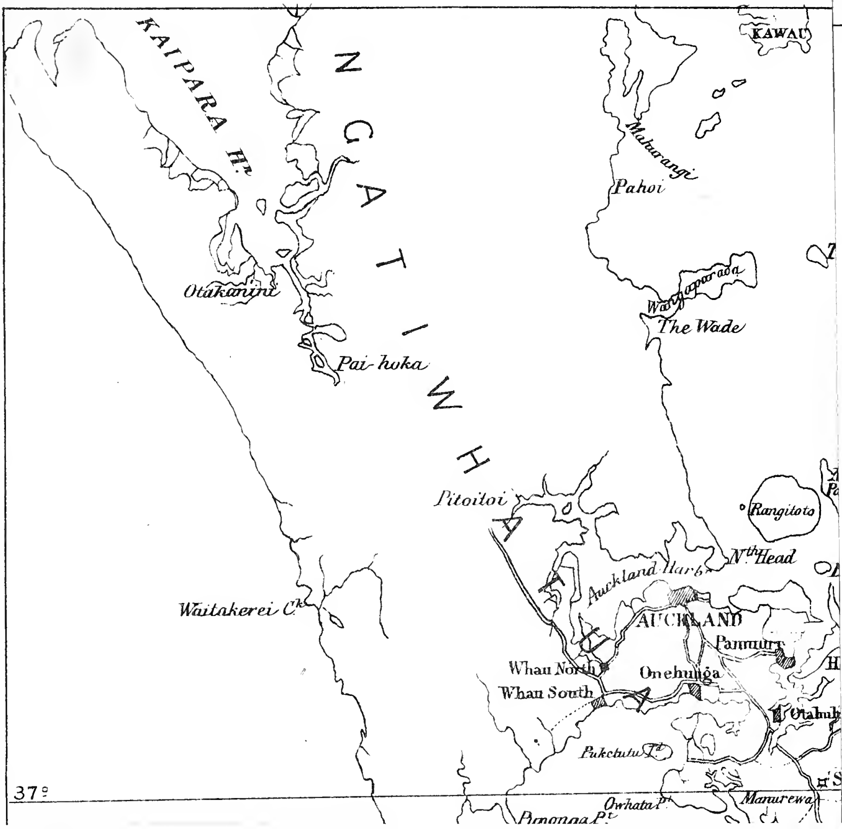
I have the honor to be,

Your most obedient Servant,

H. SMYTH, Major,
Royal Artillery.



Lithographed at the TOPOGRAPHICAL DEPOT of the WAR OFFICE
under the Superintendence of Major A. C. Cooke R.E.
COLONEL SIR HENRY JAMES R.E. F.R.S. &c. DIRECTOR



KAIPARA Hr.
N G A T I W H A T U A
KAWAU
Mahurangi
Pahoi
Otakanini
Wangaparaoa
The Wade
Pai-hoka
Pitoitoi
Rangitoto
Nth Head
Auckland Harb.
Waitakerei Ck.
AUCKLAND
Panmure
Whau North
Onehunga
Whau South
Otahuhu
Pukctutu Id.
37°
Owhata Pt.
Manurewa

REMARKS

ON

THE OPERATIONS OF THE ROYAL ARTILLERY DURING THE CAMPAIGNS, IN NEW ZEALAND, IN 1861, AND 1863-1864.

BY LIEUT. A. F. PICKARD, V.C., R.H.A.

On the 4th March 1861 Captain Mercer's battery of the 4th Brigade, Royal Artillery arrived in Auckland harbour from Woolwich, in the troop-ship "Norwood," after a passage of 99 days. The ship could not be brought alongside the pier, so the guns, stores, &c., had to be lowered into cargo boats which were unloaded on the pier.

The battery horses had not yet arrived from Sydney (N.S.W.), and the harness was not unpacked; the ordinary civilian cart-harness could not be fitted to the gun-carriages; so, as the different parts of the carriages were brought on shore, they were packed on carts, taken up to the barracks, and mounted as soon as possible.

In four days the six 12-pr. Armstrong's belonging to the battery, and two 10-in. and two 8-in. mortars (which had also arrived in the "Norwood"), were ready for service.

On the 12th March, Captain Mercer and Lieut. Pickard, with three 12-pr. Armstrong's and four mortars, were ordered to Taranaki, a settlement on the west coast of New Zealand, where Sir T. Pratt, K.C.B., in command of about 2000 men and a few guns, was still engaged in operations against the natives.

The ordnance, &c. had again to be taken to pieces and conveyed in carts to the Manukau harbour (six miles from Auckland) on the west coast. At the Manukau, the carts were driven into the water alongside cargo boats, into which they were unloaded, and everything was taken to the Colonial steam sloop "Victoria," which was to convey the half-battery to Taranaki.

On the 13th March, the "Victoria" anchored off the mouth of the river Waitara, in Taranaki. The guns, stores, &c. having been lowered into surf boats, were disembarked on the left bank of the river, and were taken up by hand or in carts to the camp which was about a mile distant; bullock-poles were then fitted to the carriages.

On the 15th March, the guns and mortars, drawn by six bullocks each, started at 6 a.m. The 10-in. mortars travelled in carts.

In about three hours the guns arrived at a redoubt occupied by the 40th Regiment about 800 yards from the native position, called Te Arei. This position consisted of lines of rifle pits, communicating with one another, cut along the crests of hills and ridges which extended in a semi-circular form for a distance of about a mile from right to left. Behind the position was a dense bush or forest. On its right was the river Waitara, and in all directions was high and thick fern, which was most difficult to walk through.

A position for the guns was taken up near the redoubt, about 800 yards from the rifle-pits; and orders were received to "keep down the fire of the natives," who being scattered about in the different pits* were firing at the troops engaged in pushing forward a double sap, the head of which was about 100 yards from the centre of the position.

The shells from the Armstrong's were fired either with concussion fuzes to pierce and burst in the pits, or with time fuzes fixed to burst the shells short and high, so that the pieces might search the different entrenchments. During the three days that the Armstrong's were in action, about 100 rounds were fired from them.

The mortars were occasionally used, and the small 5½-in. coehorns, in an advanced parallel, were particularly useful.

It was while laying one of these small mortars that Lieut. MacNaghten, R.A., who had served throughout the entire campaign at Taranaki, was killed on the 17th March, and the following day Serjeant Christie, R.A. was wounded near the same spot.

A 24-pr. howitzer and a 9-pr. gun were also in charge of the Royal Artillery, but were seldom used after Captain Mercer's arrival. An attempt was made to burn the bush and fern with carcasses, but it did not succeed.

After the cessation of hostilities, Captain Mercer and other officers carefully examined the native position; and as doubts had been raised as to whether the shells burst when fired with concussion fuzes into earth, several were dug out, and it was found that in every case the shell had burst after entering from 6 to 8 feet, though the displacement of earth underground was very small owing to the small amount of powder in the burster.

The artillery laboured under great disadvantages. They were firing up the side of a hill; they were ignorant of the shape of the Maori rifle-pits and could not tell what damage was done after each round. The firing was directed at a position more than a mile in length, and the direction was continually being changed from one part to another. Not more than the head and shoulders of any hostile natives were visible during the time the guns were in action, and a group of more than two or three natives together was never seen. No breaching was required.

In the beginning of May 1861, the three Armstrong's being ordered back to Auckland were again taken to pieces at the mouth of the Waitara river, and were conveyed in surf-boats to H.M.S. "Fawn" which took them to the Manukau harbour. The drivers of this half-battery had accompanied it to Taranaki, but not being required with the guns (as there were no horses, and bullock driving is a trade of itself), were employed in assisting the engineers in gabion-making for the sap.

At Manukau harbour the half-battery was disembarked, put together, and

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* The pits were from 5 to 7 feet deep, about 3 feet wide, and provided with steps to fire from. The excavated earth was thrown *behind* the pits, and at every 8 or 10 yards a traverse was left of nearly the same width as the ditch.

drawn to Auckland by the horses of the battery which had lately arrived from Sydney, in charge of Captain Watson, and Vet.-Surgeon Anderson, R.A., and which were being rapidly trained and broken in to draught. Most of the horses having been lately driven in from out-stations in New South Wales were very wild, and gave much trouble in training.

From this time until December 1862, the battery was employed in paving the stables and stable yard, in assisting to make the great south road into the interior of the country, and, as military train, in conveying provisions to the troops employed on the road.

As it would have been very expensive to hire civilian carts to carry scoria stone from the quarries for paving the stables, &c., the limbers of the smooth-bored ordnance were stripped, and harness boxes were secured on them. The metal was then conveyed in them from the quarries to the stables by the battery horses. During the road-making these limbers were again employed, a cart body being secured on them instead of harness-boxes. There was a tilting arrangement of the axletree-bed, by means of which stones, earth, &c., which were required at different parts of the road could be easily upset at any point in a short time. These carts were not found to answer well on hilly roads, as the weight came too much on the back of the cart when going up hill, thus causing the horses to jib; but they were afterwards used for carrying baggage, &c., and answered much better, as the heavier boxes could be put well forward in the cart, and lashed to keep them in their places.

A crab-capstan was made use of on the line of road for clearing away stumps and trunks of trees.

When the transport-work and road-making were finished, the men and horses returned to Auckland, and were constantly exercised at drill and in marching order over the rough country roads, which shook the carriages considerably.

The O. P. fuze boxes used occasionally to break open while going over rough ground, and the time fuzes, which were also O. P. and of white metal, were found to suffer from rust.

Once during a field day, a vent-piece was blown out, and the cause was discovered to have been a badly made cartridge, the serge of which had been caught between the vent-piece and the bore. Once also, a vent-piece was blown out at drill. No reason could be discovered for this but carelessness on the part of No. 2 at the gun. The man was punished, and the circumstance never occurred again, either at drill, during practice, or on service.

In December 1862, the battery went for practice to a range of about 1760 yards on land, and about 4 miles from Auckland.

Having been informed by officers who had been engaged in the former New Zealand wars, that great difficulty was always experienced by the artillery in breaching the pahs or fortified places occupied by the natives, Captain Mercer had sections of pahs made according to the descriptions furnished by officers who had seen the pahs themselves. Plans of pahs taken in former years were also obtained from the Officer Commanding Royal Engineers. From these plans and descriptions two sections were constructed; one of which, similar to the pahs constructed in the northern part of the island, consisted of two rows of young trees or strong spars about 18 inches in diameter placed upright side by side from 8 to 10 feet high in the clear, the rows being about 3 ft. apart.

The other description of pah consisted of strong spars about 18 inches in diameter placed upright in the ground about 8 feet apart; cross bars connected them, and on these were hung smaller spars from 4 to 6 inches in diameter; these were placed close to one another, and their ends were kept about a foot above the ground. No nails were used but, as is customary with the natives, flax secured everything. The line of stockading was again double. The natives used to fire out of pits dug out behind the second row, and made deep enough for them to fire under the stockades.

These latter pahs were used by the southern natives in the war of 1860–61 and, on one occasion, one 8 in. gun and two 24-pr. howitzers, besides a 9-pr. gun, failed to make a practicable breach in a pah, formed as above stated, after two hours firing, at a distance of 200 yards.

The battery of six 12-pr. Armstrong's took up a position 900 yards from the stockade and after rather more than an hour's firing made a breach, in the section constructed after the northern fashion, large enough to allow a section of men to go through abreast.

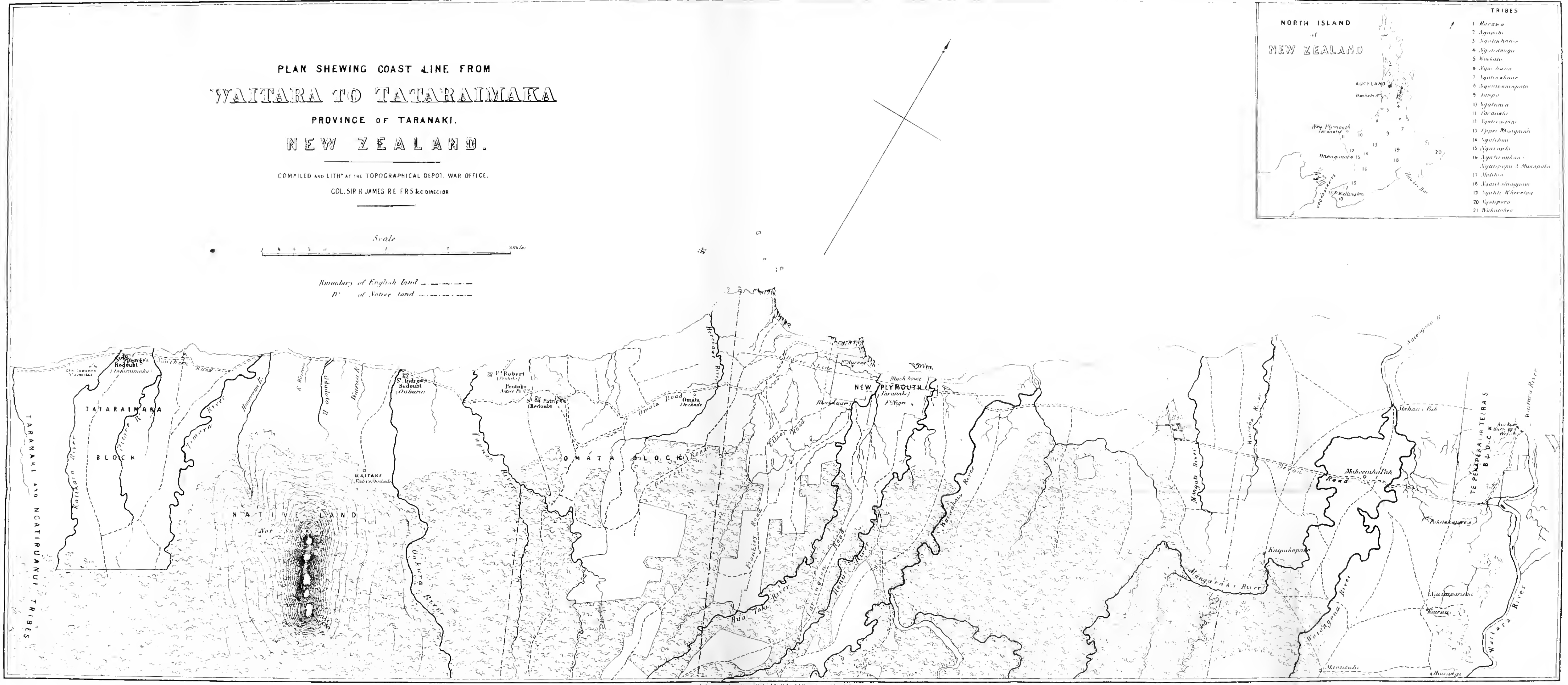
The southern description of pah was more difficult to breach as it *gave* more to the shell on bursting; and the debris, supported by the flax, was most difficult to clear away. With both descriptions of pahs salvoes were found most effective; all the guns being laid on the same part of the stockade, until the posts which seemed to afford most support were destroyed.

The great accuracy with which these guns could be fired, and the tearing damage done by the shells on bursting, contributed greatly to effect a breach in the latter description of pah. About two hours were employed in making a practicable breach, and concussion fuzes were chiefly used.

The trails used by the battery were old 9-pr. trails which had been altered for the Armstrong's. Three of them broke during the practice; one while firing at a distance of 900 yards, and the other two at 1800 yards from the target; the range being nearly level in both cases. The point of fracture was immediately under the elevating screw bed. On the return of the battery to Auckland the trails were repaired and strengthened, and were used in the campaign of 1863–4 without further damage, though several rounds were fired from some of the guns and at high elevations.

In March 1863, Captain Mercer received directions to mount 100 gunners and drivers of his battery and to drill them to act as cavalry. Each man was armed with a regulation cavalry sword and either a carbine (cavalry pattern) or a Dean and Adams' revolver. These arms were supplied by the Colonial Government. One troop had hunting saddles and light bridles, which were also supplied by the colony.

As hostilities were expected to break out shortly at Taranaki, Captain Mercer was ordered to take his squadron down there by sea; and also to take four Armstrong 12-prs. with harness in case they might be required. At this time only four officers were with the battery, viz. Captain Mercer, Lieut. Pickard, Asst.-Surgeon Temple, and Vet.-Surgeon Anderson. The other officers had been previously promoted or exchanged and their reliefs had not yet arrived, but Lieut. Rait arrived soon after the order was given for the formation of the squadron of cavalry.


PLAN SHEWING COAST LINE FROM
WAITARA TO TATARAIMAKA
PROVINCE OF TARANAKI,
NEW ZEALAND.
COMPILED AND LITH^D AT THE TOPOGRAPHICAL DEPOT, WAR OFFICE,
COL. SIR H JAMES R.E. F.R.S. &c DIRECTOR
Scale
3 miles
Boundary of English land
D° of Native land
NORTH ISLAND
of
NEW ZEALAND
AUCKLAND
New Plymouth
Wellington
Hawkes Bay
TRIBES
1 Rarawa
3 Ngatiwhatua
5 Waikato
9 Taupo
11 Taranaki
13 Upper Whanganui
17 Muaupoko
19 Ngati Wheretau
20 Ngatipuru
21 Wakatohea
TATARAIMAKA BLOCK
TARANAKI AND NGATIRUANUI TRIBES
NATIVE LAND
KAITAKE
OMATA BLOCK
Omata Road
Omata Stockade
S^t Andrews Redoubt
F^t Robert
S^t Patricks Redoubt
Oakura River
NEW PLYMOUTH
Block house
F^t Niger
Waiwakaiho River
Mangaraki River
Waiongana River
Mahoetahi Pah
Road
Waitara River
TE PEKAPEKA OR TEIRA'S BLOCK
Kaipakopako
Huatoki River

Fifty men and horses went, about the 18th of March 1863, from Auckland to the Manukau harbour to embark for Taranaki, under Lieut. Pickard. On arrival at the beach it was found necessary to drive the horses into the water, slings having previously been placed on them; boats then towed them to the ship, which was about 500 yards from land, and the horses were hoisted on board and stowed away in the hold or on deck.

On arrival at New Plymouth in Taranaki—where there is no harbour, but only an open roadstead with generally a high surf running—the ship anchored about $\frac{3}{4}$ mile from the beach, and the horses were hoisted overboard and towed on shore by men in surf boats, two horses being taken by each boat. Some of the horses were very unmanageable in the water. A mare was drowned, having got under the boat and then, while swimming away, been carried off by a strong current.

The second troop and the guns followed about a week afterwards, and the squadron was drilled as much as possible in riding, carbine, pistol, and sword drill.

The horses were picketed in a field until sheds were built to protect them during the rainy season which began about this time.

The disputed land at Tartaraimaka was peacefully occupied by the troops in April 1863, but an ambush of natives having soon afterwards waylaid and shot down a detachment of the 57th Regiment and two officers who were going to New Plymouth, hostilities commenced, and the mounted artillery were continually employed, as patrols during the night, and as orderlies during the day, between New Plymouth and the various posts in the province of Taranaki.

These duties were most arduous, as the winter season had now begun, and incessant rains falling made the roads so slippery that horses fell continually; while in some parts the mud was so deep that the horses sunk in it and strained themselves badly. The field in which the horses were picketed also became so deep in mud that it was almost impossible to groom them properly.

On the 4th June 1863, after a night march of 15 miles over a difficult country, a force of about 600 men accompanied by three 12-pr. Armstrong guns, the whole being under the command of Lieut.-General Cameron, proceeded to attack a position taken up by the natives on the left bank of the Katikara river near the sea coast and about 15 miles south of New Plymouth.

As soon as it was light, the three guns were brought into action about 800 yards from the Maori entrenchments, and covered the advance of the 57th Regiment with such success, that hardly a native could show himself to fire until the 57th were quite close to the principal work, when the guns ceased firing and the entrenchments were stormed and taken.

The bodies of the natives showed that the effects of the shell firing had been very great. The principal entrenchment was made on an entirely new plan to any before constructed by the Maories. No palisading was used, but a low indented parapet surrounded a few huts in which they lived. The Maories fired from a traversed ditch in front of the parapet, and a few fired over the parapet itself.

The position taken up for the guns was most favourable for artillery fire, but the ground was very soft, owing to the recent rains; and the fern, being as high as the gun-wheels, impeded the working of the guns. Blocks of hard wood were always carried on the footboards, to put under the point of the trails (when there was time to do so) to prevent them sinking deep into the soft ground every time the guns were discharged.

After the action the guns returned to New Plymouth. The artillery were not mounted on this occasion as it was expected that the ground would be impracticable for cavalry. The roads were very slippery and muddy from the rain, and there were three fords to cross and several steep ascents and descents on the way to Tartaraimaka and back, but no accident occurred except the breaking of a bullock-pole on coming into action. A spare bullock-pole was carried under each gun; also several planks to assist in crossing ditches &c.

About the end of June 1863, Captain Mercer received instructions to take up a position to shell some native entrenchments at Kaitake, which was on the lower ranges of Mount Egmont and about seven miles from New Plymouth.

Four 12-prs. were accordingly brought into action, after much trouble and hard work, at about 2000 yards from Kaitake. No advantageous position could be taken up nearer to the natives, whose entrenchments were on the summits of two adjoining hills, and were protected by palisadings. Several wharés or huts were behind the palisadings, but no natives were seen. About 50 rounds were fired with time and concussion fuzes. The shells burst wherever they were required, but the distance was too great to observe the extent of damage done.

Captain Mercer, wishing to use the shells as carcasses against the huts, tried the experiment of putting pieces of portfire composition and loose powder into the shell instead of the concussion fuze and burster. The time fuze was then screwed in; but as the shells were not seen to burst, and as no report was heard, the experiment was concluded to be a failure.

On the 1st July, the Armstrong's were sent back to Auckland by sea in the same manner as before, and kept in readiness for an expedition against the Waikato tribes. The mounted artillery followed in a few days, and was reduced from 100 to 50 men. The gunners returned to their guns, and the drivers continued to act as cavalry, under Lieut. Rait, R.A. The other horses of the battery and all the harness were given over to the commissariat transport corps, who moved the guns when necessary with either horses or bullocks.

In the beginning of July 1863, General Cameron crossed the Maungatawhiri creek, which was the boundary between the European and native land in Waikato district. A position was taken up by some infantry on the heights overlooking the creeks and surrounding country, and an action took place a few days afterwards in which the natives were defeated.

Artillery was not used, none having yet crossed the creek. Orders for their crossing, however, were received soon afterwards at Queen's redoubt, where the Head Quarters were now stationed; and two 12-pr. Armstrong's were marched to the creek (about two miles from Queen's redoubt), the carriages taken to pieces, put in flat-bottomed boats and, the opposite bank being soft and marshy, were rowed down the stream until hard ground was discovered.

The spot selected for a landing place was a sort of headland near a bend of the creek, about 80 feet high and very steep. The guns were hauled up to the top of this, piecemeal, with tackle; and although they met with very rough usage in being thus hauled up, no damage was done to them.

Three round spars about 5 feet long and 3 inches in diameter were carried with each subdivision, and were most useful in all cases when the guns had to be taken to pieces. One of these spars inserted in the muzzle, another in the breech, and the third lashed across the trunnions, enabled a few gunners to carry the guns wherever they were required, particularly when they had to be mounted inside redoubts, the entrances to which were generally so narrow that the guns had to be taken to pieces in order to be mounted inside. Handspikes were found to be not of sufficient strength to bear the weight of the guns.

The gunners were now employed in assisting to build the redoubts and in otherwise fortifying the position on the Koheroa heights.

About the end of July a night march was made to some native settlements about 15 miles from Koheroa, where a large body of natives were reported to be located. The track was not well known, and no wheeled conveyances had ever before travelled on it. Two 12-pr. Armstrong's, drawn by bullocks and carrying several fascines and planks for bridge making purposes, accompanied the force, which started at about 9.30 p.m. The night was very dark and the track so narrow and slippery that, when about three miles from camp, one gun upset down the side of a steep ridge; it was, after some difficulty, brought up again on the track and, one wheel having been broken, the gun was left behind with an escort, and as soon as a second wheel was brought from camp* the gun returned to Koheroa. In several places the bullocks had to be taken out and the guns drawn by hand. The other gun continued with the column, which, finding the natives had left their settlements and retired to the bush, returned to Koheroa the following day.

In the beginning of August 1863, another position having been taken up at Whangamarino about six miles south of Koheroa, the gunners were employed in making the track to it practicable for artillery. When that was finished, the two 12-pr. Armstrong's were brought up and put in position near a stockade which was built for the troops on a height overlooking the Whangamarino and Waikato rivers.

Beyond the former river was a swamp, impassable at this time of the year, and the natives had collected in large numbers at the other extremity of the swamp, and had built entrenchments to oppose the further progress of the troops.

The distance from the guns to the native entrenchments at Mere-mere was about 2000 yards.

It was found necessary that the attack on these works should be made from the river, and while a steamer and boats were being built for this purpose, the artillery were ordered to annoy the natives as much as possible by firing at any large bodies of them that appeared, and at the canoes which brought their provisions down the river. Another 12-pr. Armstrong was

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* The only way of getting a spare wheel along the track was found to be, by running it along on a tent pole which was passed through the nave.

sent to Whangamarino, and the three guns were placed in a small battery having platforms made of large trees sawn in half, with the convex surface sunk in the ground.

Two Armstrong 40-prs. were sent over from Sydney (N.S.W.), and were sent to Whangamarino to be mounted. The latter was a service of great labour and difficulty, as the guns had to be dragged piecemeal up to the top of the eminence on which the stockade was built, and then mounted.

The guns at Whangamarino then annoyed the Maoris at Mere-mere as much as possible. It was found that the best way to damage canoes at great distances was to fire shells with concussion fuzes, to strike rather short of the canoes; the shell burst on striking the water, and the pieces ricocheted forward among the canoes. It was found also that by firing with time fuzes fixed to burst at the extreme range of the fuze, the pieces of the shells all went over 2600 yards if the gun was laid with about half a degree more elevation than the actual range required. The shells thus fired burst high in the air, and the pieces being propelled forward and downward, went to a great distance.

Three gun-boats were constructed in Auckland from cargo-boats, they were plated with iron and capable of carrying a 12-pr. Armstrong and small mortar in each. Two iron-plated steamers were also constructed, and about the end of October 1863, everything being ready for a move, a force was taken up the Waikato past the Mere-mere position in the steamers and gun-boats, and landed at Takapou about five miles in rear of Mere-mere. Arrangements were then made for attacking the Maories in front and rear simultaneously. On the day before the attack was to take place, however, the natives were seen to be evacuating their position in great numbers, having with infinite labour dragged their canoes during the night from the Waikato river, overland, to the swamp. They left behind them three or four old carronades or ship guns which they had fired with little or no effect at the steamers and gun-boats as they passed their position.

After Mere-mere had been occupied by the troops the three 12-pr. guns were sent back to Queen's redoubt (crossing the Maungatawhiri piecemeal as before), and on the 18th November, two of them were again taken to pieces and towed in boats to Mere-mere. The sheers used for embarking and disembarking, were trunks of trees cut down near the spot.

Foreseeing the impossibility of conveying ammunition wagons with the small number of transport animals that accompanied the force, Captain Mercer had caused extra ammunition boxes to be made, to fit and travel on the footboard of each limber, and to contain 24 extra rounds of ammunition per gun with cartridges, and time and concussion fuzes complete.

On the morning of the 20th November, 1863, the two Armstrong 12-prs. drawn by bullocks, and a 6-pr. naval field gun drawn by sailors, accompanied the force under General Cameron which left Mere-mere at 7 o'clock a.m. for Rangiriri, about 12 miles south of Mere-mere. Eight bullocks drew each gun, and the weight they had to draw was much increased by eight scaling ladders and the extra ammunition-box, besides several planks being carried on the guns.

The track led through several swamps and gullies and over some narrow ridges, where the bullocks had to be taken out and the gunners to draw the guns by hand. When half-way to Rangiriri, thirty of the gunners were supplied with Dean and Adams' revolvers (the use of which they were well acquainted with from having been armed with revolvers while acting as cavalry), and Capt. Mercer was told that in case there was any serious difficulty met with in the projected storming of the Maori entrenchments at Rangiriri, his men would be called upon to assist in the assault. Owing to the difficult nature of the ground it was 3 p.m. before the force arrived at Rangiriri. The guns were brought into action about 600 yards from the centre of the Maori works, on a rising ground behind which the limbers were placed nearly out of fire. The Maories began firing directly the guns came into action, but without effect, except a few shots striking the wheels and gun-carriages.

The object of the artillery fire was to engage the attention of the natives, while the steamers, which had arrived opposite Rangiriri about the same time as the force under General Cameron, proceeded to disembark troops in rear of the works. The disembarkation took a considerable time. The natives did not show at all, but continued firing as long as the guns did.

When the assault was ordered the rapidity of fire was increased; shells had been prepared in expectation of the assault, and the guns were loaded as fast as they were fired. The shells burst beautifully, and prevented the Maories taking any aim at the advancing troops, but when, from the near approach of the storming party to the works, the shelling was stopped, the soldiers suffered severely.

Half the position was quickly taken, and the Maories who escaped rushed some to the Waikare Lake, where they were shot down by the 40th Regiment which had landed in rear of the work, and some to a few canoes in the swamp, but two shells from the Armstrong's bursting among the latter, they ran back to their entrenchments and joined others who had remained in the works.

The last gun Captain Mercer looked over had been laid on a canoe supposed to be about 2000 yards off, crossing the Waikare Lake and full of fugitives. The canoe was smashed by the shell and swamped.

About an hour after the first assault had been made, a message was brought from General Cameron to Captain Mercer asking for some shells to be sent down to be thrown by hand among the Maories. Captain Mercer sent back an answer to say that Armstrong shell were unsuited for this purpose, and he had no common shell.

Soon after this an aide-de-camp brought an order for Captain Mercer to bring down his men to drive out the Maories, who were still resisting. Captain Mercer accordingly led his men to the assault, which failed, as others had previously done, owing chiefly to the men not being able to get to a hand-to-hand fight with the natives. Captain Mercer was mortally wounded, Sergeant-Major Hamilton was shot in two places, and four other non-commissioned officers and men were killed or wounded while trying to get into the work.

Driver Culverwell, who was Captain Mercer's servant, seeing his master shot down, ran to his assistance and was mortally wounded while doing so.

The gunners were then employed in filling up a narrow passage leading to the principal Maori work from which much loss had been inflicted on the troops, and which, while open, prevented assistance being given to the wounded who had passed the entrance.

Some $5\frac{1}{2}$-in. common shell were obtained from the gun-boats and thrown among the natives by Serjeant McKay, and Gunner F. Green, R.A. The fuzes were of rather ancient date (1806-7), and great risk was run by the above-mentioned men, as the fuzes had to be lighted while the shells were in their hands, and then the shells themselves had to be thrown up over a high parapet. No accident occurred, and the shells, by setting fire to the huts and bursting among the natives, did much damage.

At about midnight the gunners went back to their guns (which in the meanwhile had been guarded by the rest of the artillery and a company of infantry) and the following morning, the natives being surrounded and having no outlet of escape except into the swamp, surrendered unconditionally. This was one of the hardest day's work the artillery ever underwent in New Zealand.

There was no palisading about the Rangiriri entrenchments. The main obstacle was a high thick perpendicular parapet, built as all parapets are in New Zealand, with layers of fern intermingled with the soil, and thus no berm nor exterior slope is required.

Some of the Armstrong shells were fired to pierce the parapet, as it was expected that the natives would fight from behind them, but it was soon found that the parapet was only intended as an obstacle, the firing being from the ditches in front of it. The fuzes were therefore fixed to burst the shells short, by which means the pieces went forwards and downwards into the pits, the guns being on high ground. Small mortars or howitzers would have been very useful, especially the latter if a breach had been required, but the Armstrong's had answered so well at the previous fight at Katikara, that it was expected that they would be also sufficient at Rangiriri.

When a long range or great precision is required, the Armstrong shell is most effective, but it would fail if used as a substitute for a howitzer shell in breaching field parapets, and in ricochet fire at short distances.

Captain Mercer having died from the effect of his wound, the command of the artillery devolved on Brevet-Major Strover, of the 12th Brigade, R.A.

The guns remained at Rangiriri about six weeks after this time, and the men were employed in assisting the engineers to make redoubts, landing-places, &c., and afterwards in making a road through a swamp on the right bank of the Waikato.

About the end of December four small mortars and another 12-pr. Armstrong gun having arrived at Rangiriri, they and the two 12-prs. before mentioned were taken to pieces, and embarked on board flat-bottomed boats which conveyed them to a station called Rahuipokeka, about eight miles further up the river. Here they were disembarked, and afterwards taken up in a steamer to Ngaruawahia, about fifteen miles further up the Waikato at the junction of that river with the Waipa. Very little damage or loss of stores occurred in these constant shiftings, but great care had to be taken to avoid it.

The other three 12-pr. Armstrong's of the battery were given into store in October 1863 (by order), and were afterwards served out to the Royal Navy for service in the gun-boats.

At Ngaruawahia the gunners were employed in building bridges over creeks, and in foraging parties.

The mounted artillery under Lieutenant Rait, R.A. were also sent to Ngaruawahia, where they were continually employed in reconnoitring, foraging, and as orderlies.

As the ammunition supplied for the $4\frac{2}{5}$-in. mortars was of very old date, it was replaced by 12-pr. howitzer ammunition, the wooden bottoms of the shells being knocked off for this purpose.

Lieut. Carré, R.A. having arrived in New Zealand, joined at Ngaruawahia about the beginning of January.

About 24th January 1864, the guns being required up the Waipa river, and the track being impracticable for artillery, the guns and mortars were again taken to pieces and were sent up the river in a steamer. The gunners marched, and at Whata-whata, about twelve miles from Ngaruawahia, the guns were landed and put together again.

On the 27th January, the three 12-prs. drawn by six bullocks each, accompanied an expedition which was ordered to Te Rore (about twelve miles south of Whata-whata). This march took two days, from daylight till night of each day. A great deal of small-arm ammunition carried on pack ponies was in charge of the Royal Artillery. The difficulties which the guns met with on this march, were narrow paths, and roads hurriedly made by the engineers where any steep ascents and descents had been met with. The bullock-drivers were not very good, and often the guns were in imminent danger of being upset down places from which it would have taken hours to extricate them; and from the paucity of transport no spare wheel could be carried.

The temporary bridges over creeks had also to be made in a great haste, and of any materials that could be got on the spot. Sometimes the guns had to be taken over these bridges, and up and down the more difficult ascents and descents by hand, thus entailing extra labour on the gunners and fatigue-parties assisting them. There was, of course, no transport for men's necessaries; every man carried his own blanket, carbine,* and change of clothes. At about 9 p.m. on the second day's march, the guns arrived at a creek about thirty feet wide, with soft low banks, and it was necessary to cross it as soon as possible. A large canoe was procured, and the gunners, assisted by a detachment of sailors, took the guns to pieces in the dark, and, the canoe being placed as a bridge, the guns were taken across piecemeal, put together on the opposite side, and taken on about three miles further to the camp.

On both these nights and for a short time afterwards the troops bivouacked, as there was no transport available for tents. One limber-box was slightly damaged during the march, but no further damage was done to the guns and nothing was lost. The round spars previously mentioned were invaluable in moving the guns about.

On the 27th January 1864, Colonel Williams, R.A., arrived to take command of the Royal Artillery in New Zealand. "I" Battery of the 4th Brigade, R.A. equipped with six of the latest pattern 12-pr. Armstrong's under Colonel Barstow, arrived at the same time.

Six 6-pr. Armstrong's also arrived at this time and were consigned to the Principal Military Storekeeper in New Zealand.

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* Every gunner in the battery had been supplied with a carbine by the Colonial Government.

Col. Williams arrived at Te Rore, where the head quarters of the army were posted, on the night of the 28th January 1864, and appointed Lieut. Pickard acting-adjutant.

About four miles from Te Rore, inland from the Waipa river, was a strong Maori position called Paterangi. A post was established about 1500 yds. from this pah, and two 12-prs. were sent there under Captain Betty and Lieut. Carré. The guns were occasionally fired and with good effect.

Colonel Barstow with half of "I" Battery, was ordered from Auckland to Ngaruawahia, in charge of three 6-prs., and three N.P. 12-pr. Armstrong's. No horses were handed over to the battery, and every gunner and driver was armed with a carbine or rifle, and learnt gun-drill.

About 20th February, Colonel Barstow left Ngaruawahia, having been ordered to join the head quarters at Te Rore with the three 6-pr. guns; the 12-prs. remained at Ngaruawahia in charge of Lieut Toogood, R.A.

On the 21st February, a night march was made to Rangiawhia (about eight miles in rear of Paterangi), and the 6-pr. guns drawn by two horses each, accompanied the expedition.

An engagement took place on the 22nd February, at Rangiawhia, in which the natives' entrenchments were assaulted and taken by the 50th Regiment, whose advance was covered by the firing of the two 6-pr. Armstrong's, manned by detachments of "I" Battery. The practice was very good, but the uneven ground, the height of the fern, and the difficulty of getting a view of the natives in their pits, were great obstacles to rapid firing.

Just after the assault on the Maori entrenchments at Rangiawhia had succeeded, and while the natives were dispersing in all directions, they were charged by the mounted corps of Royal Artillery, under Lieut. Rait, R.A., and good service was done, though the difficulties of the ground were very great. One driver and one horse were killed, and three or four men and horses, including Lieut. Rait's horse, were wounded during the charge. The high fern was found most difficult for cavalry to act in. It concealed holes, pits, and other inequalities of ground, and by tilting up the scabbards, swords used often to be dropped. The latter objection was removed, however, by detaching the scabbards from the slings of the sword-belt and fastening them to the saddle instead. The carbine was worn in a bucket in front of the right leg until required for use. The pistol was worn buckled round the waist in a leathern case, and a small strap fastened to the trigger guard attached the pistol to the body.

The uniform worn by all the troops was a blue serge "jumper" or short frock with shoulder-straps. The drivers were supplied with long boots and hunting-spurs.

The three 12-prs. of "C" Battery were afterwards forwarded to Te Awamutu (two miles from Rangiawhia) from Te Rore, and one was placed in each redoubt built there.

Six 12-pr. Armstrong's were bought by the New Zealand government from the colony of Victoria, and were in charge of the Principal Military Storekeeper at Auckland. Two of these were drawn out of store by the Royal Artillery in January 1864, and sent down with detachments of "C" Battery under Lieut. Greer, R.A. to Tauranga, on the east coast of New Zealand, to join the force stationed there under Colonel Carey, 2nd battalion, 18th Regiment.

As soon as the natives at Paterangi heard of the night march and engagement at Rangiawhia, they abandoned all their entrenchments and retired to Maungatautari, on the Waikato river, where they again commenced building strong entrenchments on a range of hills well adapted for the purpose.

Their mode of fortification was something similar to that adopted at Rangiriri, but obstacles were now placed in front of the ditches and pits from which they fired, and these pits communicated with the interior of the pah by means of covered ways leading under the parapets. The obstacles were strong post and rail fences, and behind these, on the edge of the counterscarp, were palisadings of brushwood, poles, &c. all tied together and presenting an object difficult to breach with artillery, and well calculated to stop a sudden rush. The loopholes from which the natives fired were at the foot of the palisades; the works were enclosed but communicated with one another by covered ways. The works at Maungatautari were reported to be more formidable than any yet constructed, and a strong battery of guns was sent for to Auckland.

By the end of March 1864, the following pieces were collected at Pukerimu (which is about four miles from Maungatautari), and manned by detachments from the three batteries in New Zealand; many of the men having never had anything to do with smooth-bored ordnance, required continual instructions and drill, to enable them to perform the different duties properly.

Two 10-in. mortars,
Two 8-in. „ on travelling beds,
Two $5\frac{1}{2}$-in. „
Two $4\frac{2}{5}$-in. „
Two 32-pr. howitzers,
Two 24-pr. howitzers,
And three N.P. 12-pr. Armstrong's.

Each gun was supplied with about 200 rounds of ammunition.

Captain William Smith arrived in New Zealand about this time, and relieved Bt.-Major Strover, who had previously been promoted, in charge of No. 3 Battery, 12th Brigade, R.A.

The other three new pattern 12-pr. Armstrong's of "I" Battery had been sent, about the beginning of March 1864, to Taranaki, under Captain Martin, R.A. Before his arrival, Lieut. Larcom, R.A. had commanded the artillery in the Taranaki district; he had under his command, a detachment of No. 3 Battery, 12th Brigade, and was in charge of several smooth-bored pieces of ordnance, guns, mortars, and howitzers.

While employed on a reconnoitring expedition under Colonel Warre, C.B., commanding troops at Taranaki, Lieut. Larcom had been severely wounded. He was, at the time, in command of a 24-pr. howitzer and two small mortars which were in action near a pah which was being reconnoitred. The howitzer was short of men, and Lieut. Larcom was himself assisting as a number at the gun when he was wounded.

After Captain Martin's arrival at Taranaki, the 12-pr. Armstrong's were used with good effect on several occasions while accompanying expeditions into the country; but the rough and rugged nature of the country made the labour very great, and the tracks often led through places admirably adapted for ambuscades, and the natives on one occasion, attacked the guns while on the line of march but were driven out of their hiding places without doing any serious damage.

In the Waikato country great difficulties were now experienced in getting the ordnance, already mentioned, to Pukerimu; and the different varieties of ammunition and stores, which were entirely new to most of the men (more particularly the drivers), were very confusing.

The two 24-pr. howitzers which had been a long time in the country were each of different manufacture; the wheels of one would not fit the other, and in the constant removals from one station to another, by water transport, this was very inconvenient.

In the beginning of April 1864, the position for the breaching batteries having been chosen and all being ready for the guns to move forward, a reconnoitring party discovered that the Maungatautari position with all its entrenchments had been suddenly abandoned by the natives. This was partly owing to a severe defeat which the Ngatimaniopoto tribe had met with at Orakau, near Rangiawhia. Brigadier-General Carey, who commanded at the latter post after General Cameron had removed the head quarters to Pukerimu, discovered that the Maories had built a pah near Rangiawhia. He surrounded the pah suddenly one night, and after two assaults had failed, sapped up to it. Three 6-pr. guns (Armstrong's) were at Rangiawhia, and three 12-prs. of "C" Battery, under Captain Betty, R.A., were also available but were not required. A 6-pr. was, however, sent up the sap and was employed in breaching the palisadings on the counterscarp.

Howitzers or mortars would have been most useful at Orakau, but they were all at Pukerimu, and the intervening country was impracticable for artillery. 100 hand grenades were put in boxes, and sent on pack ponies to Orakau, and were very serviceable.

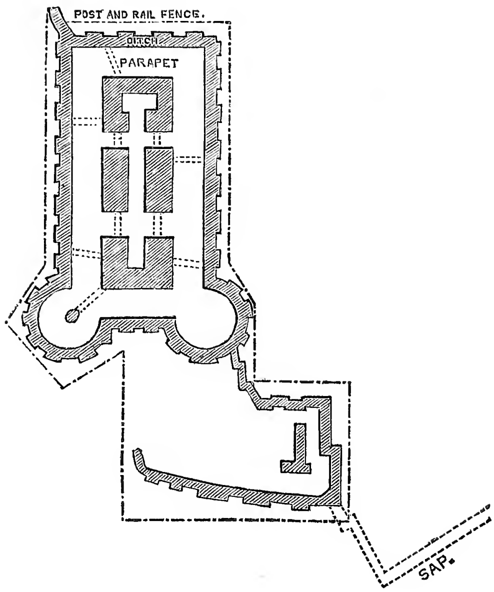
Serjeant Angus McKay of "C" Battery, whose behaviour at Rangiriri has already been mentioned, threw the hand grenades at great personal risk to himself from the sap into the pah, where they did much execution. For this service Serjeant McKay was publicly thanked by General Carey after the pah was taken, and highly spoken of in his despatch afterwards. When the sap was within a few yards of the ditch, the Maories suddenly rushed out of the pah and breaking through a part of the circle of troops which was less strongly guarded than the rest, they made their way, though with the loss of about half their number, to the swamps, creeks, and ravines with which the country abounds. They were followed by the mounted corps of artillery drivers, under Lieut. Rait, R.A. and also by the colonial cavalry, but the difficulties of the country for cavalry operations prevented much damage being done. Veterinary Surgeon Blake's horse was shot, and a few other casualties took place in the troop.

About the end of April orders were received to remove all the ordnance from Pukerimu (except the 12-pr. Armstrong's and small mortars) to Auckland, from whence they were to be sent to Taranaki where operations were now to be carried on. There were already several small mortars at Taranaki which was the reason those at Pukerimu were left there. The work entailed on the artillery in shifting the ordnance, ammunition, and *matériel* was now very great, and the greatest precautions had to be taken to avoid loss of stores and the mixture of one description of ammunition with another.

While on the way to Auckland intelligence was received from Tauranga, a settlement on the east coast, the effect of which was, that the guns

ORAKAU PAH.

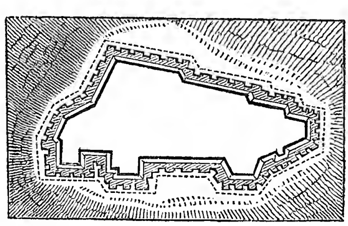
(Taken 2nd April, 1864).

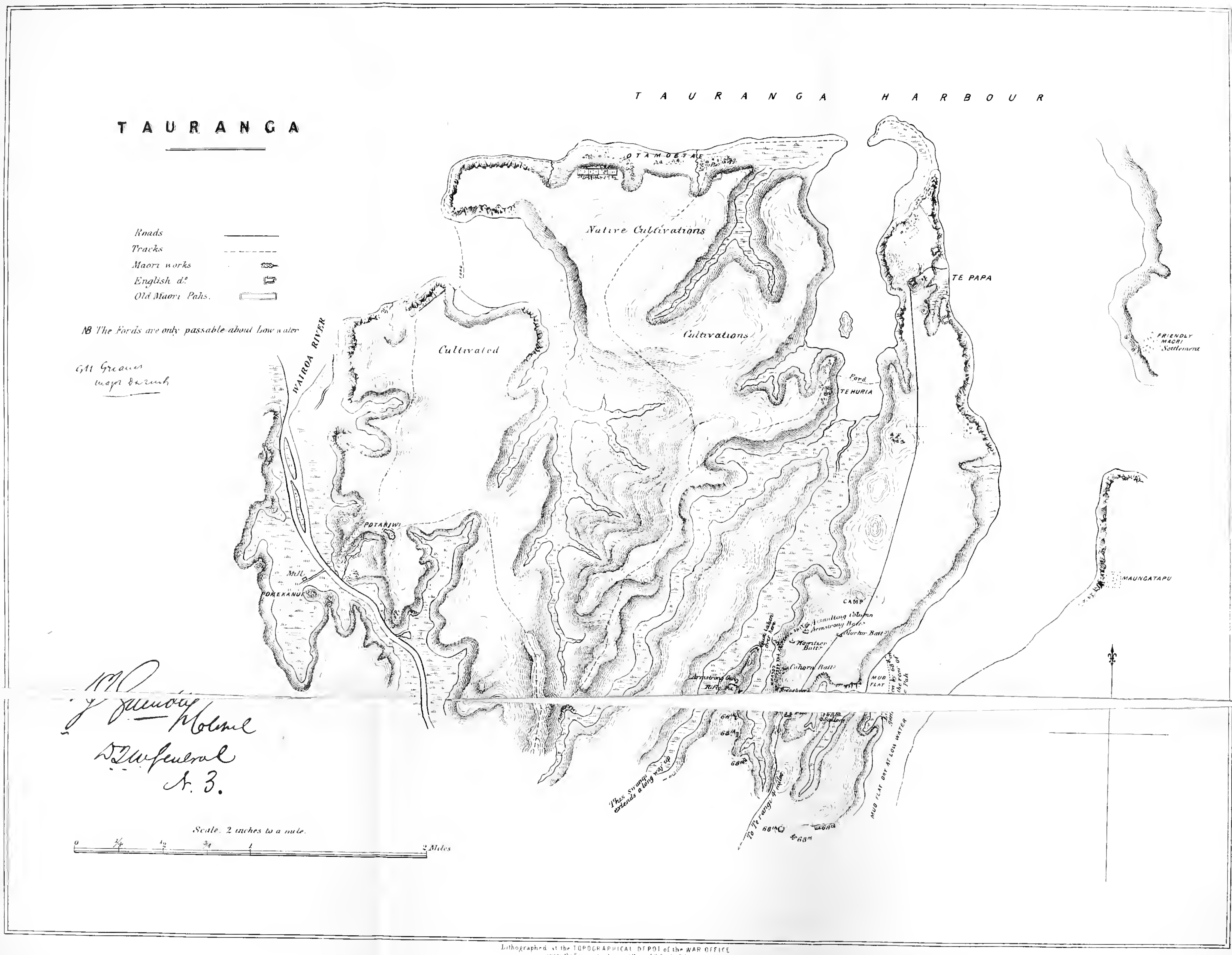


N.B. The dotted lines shew the communication between the interior and the ditch, under the parapet.

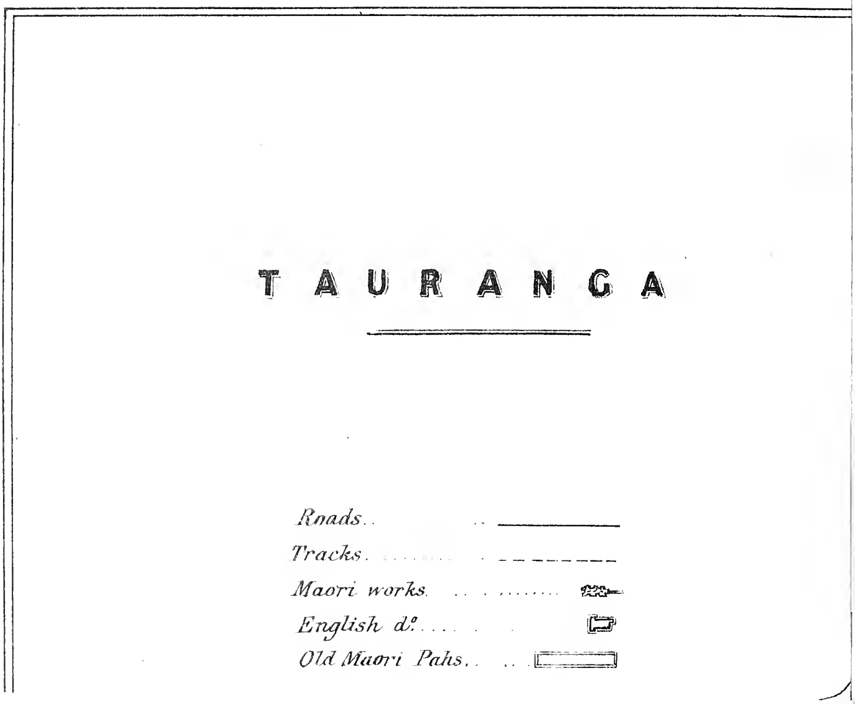
MAUNGATAUTARI PAH.

(page 383).





Lithographed at the TOPOGRAPHICAL DEPOT of the WAR OFFICE
under the Superintendence of Major A.C. Cooke R.E.
COLONEL SIR HENRY JAMES, R.E. F.R.S. &c Director
1864


TAURANGA
Roads
Tracks
Maori works
English d°.
Old Maori Pahs

intended for Taranaki were ordered to be sent to Tauranga as quickly as possible. Small mortars would also be required, but these having, for the reason already mentioned, been left in the Waikato district, some very old pattern mortars were drawn out of the military store in Auckland for use in the Tauranga district. These mortars had been cast in Sydney under the directions of Captain Gother Mann, late of the Bombay Horse Artillery, but now Governor of the convict establishment at Cockatoo Island (N.S.W.) They were cast in 1846 for the war that was then going on in New Zealand, where a light species of ordnance, capable of projecting shell with precision at short distances was required. The mortars were about half the length of the service $5\frac{1}{2}$-in. mortar, so that half the circumference of the shell projected beyond the muzzle of the mortar. There was a small chamber for the powder, and the diameter of the muzzle was sufficient to allow of the $5\frac{1}{2}$-in. shell being used, and thus one species of ammunition was sufficient for the 24-pr. howitzers and small mortars. The bed was of iron and was fastened on a flat platform of wood about two inches thick. The mortar itself was light enough for one man to carry with ease. The bed and platform were rather heavier than necessary, and service-beds were afterwards substituted for them.

It was supposed that, as the fuze projected considerably beyond the muzzle of the mortar, the flame of the charge, when ignited, would not reach the fuze composition, and therefore it would be necessary to ignite the fuze with a portfire before firing the mortar. This, however, proved not to be the case. It was found that the fuze never failed to ignite on the mortar being fired, and the shells were very accurate up to 400 yards, fired at 45° of elevation.

As fast as the guns arrived in Auckland from the Waikato district, they were sent down to Tauranga by sea, and by the 28th April 1864, the following pieces of ordnance with about 200 rounds of ammunition per piece, and manned by detachments from each of the three batteries in New Zealand, were ready for action :—

Two 8-in. mortars,
Two 24-pr. howitzers,
Two 12-pr. Armstrong's,
Two $4\frac{2}{5}$-in. mortars,
Four $5\frac{1}{2}$-in. mortars (Captain Mann's pattern) and three 6-pr. Armstrong's.*

On the 27th April a pah was reconnoitred which had been built by the natives about three miles from the camp at Tauranga and, being placed on the boundary between the European and native land where the Maories formerly had placed a toll-gate, it was known by the name of the "*gate pah.*" It was built of an oblong form on high ground, and the enclosed ground was about 100 yards long by 15 wide. The front face of the work extended down on right and left to swamps which flanked the position.

On the 28th April, positions were chosen in which to place the batteries intended to breach the parapet, &c. Both mortar and howitzer batteries were obliged to be placed so that the fire from them would be almost *direct* as, owing to the nature of the ground, enfilade fire was impossible to be obtained.

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* The 6-prs. had only about 100 rounds per gun.

As it was feared that the natives would abandon their position if they saw the batteries being made, these latter were constructed during the night of the 28th and morning of the 29th April, while the 68th Regiment was sent round by a swamp on the right flank of the pah, to surround the position in the rear, and prevent all escape in that direction. There was little or no transport to be got for conveying ammunition, &c.

A few pack ponies, the two 8-in mortar carts and, late in the day, three or four transport carts were all the transport that could be obtained, and a great portion of the ammunition was sent up from Tauranga to the "gate pah" (about 2½ miles) in wheelbarrows, with fatigue parties of artillery and infantry. The batteries were constructed after dark, and by daylight on the morning of the following day, 29th April, the undermentioned batteries were ready to open fire.

Two 8-in. mortars in a breastwork 800 yards from the pah under Lieut. Greer, R.A.

Two 24-pr. howitzers in a breastwork 600 yards from the pah under Captain William Smith, R.A.

Six small mortars behind a parapet about 300 yards from the pah, under Lieut. Grubb, R.A.; and two 6-pr. Armstrong's were kept ready to be taken to any place where they might be afterwards required.

There was also a heavy battery of Armstrong's consisting of one 110-pr. and two 40-prs., manned by the Royal Navy, under direction of Commodore Sir W. Wiseman, C.B., R.N. This battery was about 700 yards from the pah. The batteries opened fire soon after daybreak, but the natives hardly returned a shot. The 8-in. shells seemed from the battery to fall in the centre of the pah.

The fire of the howitzers and heavy Armstrong's was directed on the left corner of the pah where a breach was to be made; and the mortars threw shells into the pah and adjacent rifle pits. About noon it was discovered that the swamp on the left of the native position was passable by a 6-pr. Armstrong if taken across piecemeal. This was done under Lieut. Donnithorne, R.A., and after great difficulty the gun was brought into action on a hill beyond the swamp, which looked on to the left flank of the entrenchments. As soon as the gun was seen from the pah, the natives in the left flank of the works who had been occasionally firing at the battery of small mortars, left their position and went to the right flank where they could not be touched by the fire of the 6-pr. A small howitzer would have been most useful here, and a $4\frac{2}{5}$-inch mortar being carried across the swamp threw several shells into the pah which was now enfiladed. By this time a large breach had been made in the parapet and in the double fence which was in front of it, as shown in the description of the works at Maungatautari, &c. The parapet was about five feet high and five feet thick, and was half sunken. From the hill on which the gun and mortar were placed, it was seen that most of the shells from the 8-in. mortars were going a few yards over the pah, which was much narrower than was expected. On a message being sent to the battery this was rectified, and the shells subsequently all fell into the work.

The assault was now ordered. Very little had been seen or heard of the natives during the day, and it was not until the storming party, composed of equal numbers of the 43rd Regiment and Royal Navy, had arrived within a few yards of the breach, that the Maories opened a heavy fire. Then, however, they did so with such precision and rapidity, and from such well concealed places, that the men in the assaulting party could not see the Maories whose fire was destroying their officers and leading files. The storming party was eventually repulsed. After dusk a breastwork was thrown up about 100 yards from the pah, and two small mortars taken into it, which, under direction of Captain William Smith, R.A., threw shells into the pah during the night.

At daybreak on the morning of the 30th April it was found that the natives had evacuated the pah during the night, leaving several wounded behind them—they had gone away in small parties at a time, over swamps &c., but lost many men from the fire of the 68th Regiment who were surrounding the rear of the position, and who were spread over a large extent of ground. On examining the pah afterwards it was found that the breach was perfectly practicable, but the natives had fired from underground pits almost completely covered by roofs of flax and earth, &c., &c., and into these pits entrance was most difficult. They had also fired from traversed pits in front of the parapet, between the latter and the palisading.

Boxer's fuzes answered admirably; not one was observed to fail in bursting the shell at the required place, when properly bored. The mortars of Captain Gother Mann's making, answered very well, the platforms, however, were rotten from being so long in store.

The 10-in. mortars and 32-pr. howitzers arrived at Tauranga by sea from Auckland a few days after the engagement at the "gate pah." There was great difficulty and trouble in landing them and their ammunition, and conveying them afterwards from the beach to the artillery park.

Several expeditions were afterwards made to different native settlements in the Tauranga district, and they were generally accompanied by a 6-pr. Armstrong, drawn by one or two horses.

These 6-prs. are too narrow between the wheels, which are too low for the very rough ground over which they had to travel. Their limbers do not carry sufficient ammunition. They were continually upset on the line of march, and once, on coming into the action in rough ground, the limber upset while being reversed.

The natives having left this part of the country, the artillery were re-embarked about the end of May, and all the ordnance, ammunition, &c. was taken back to Auckland, except the Armstrong guns and small mortars, which remained under Lieut. Grubb, R.A., with detachments from "C" and "I" Batteries of the 4th Brigade.

The last occasion on which artillery were used in action during the campaign was at the engagement at Te Ranga, a few miles inland from Tauranga and the "gate pah." One 6-pr. Armstrong was used with great effect under Lieut. Grubb, R.A., manned by a detachment of "I" Battery, 4th Brigade. Several rounds were fired during the attack and at the retreating Maories afterwards, and the practice was highly spoken of by Colonel Greer, 68th Regiment, who commanded the troops on this occasion.

The Armstrong field guns were always most effective where a long range or great precision was required, and they are therefore in every way an admirable substitute for, and improvement on, the old 9-pr. brass smooth-bored gun. The great number of times that the Armstrong's were taken to pieces, and the continual rough usage which they met with in embarking and disembarking and in crossing rough country, without sustaining any damage, shows that they are not liable to get out of order from being of too delicate manufacture. They can be loaded and fired very quickly with time and concussion fuzes with *well-drilled detachments.*

In "C" Battery, 4th Brigade, a certain number of fuzes were put aside for drill purposes, and no shell was allowed to be brought up from the limber to the gun, whether at standing gun drill or in the drill-field without the fuzes being screwed in and fixed as would be required on service. If the detachments are not well drilled and constantly practised in screwing and unscrewing the time fuzes into the shells, there is a liability to confusion when the men are under fire, particularly on cold frosty mornings, or in the dark, or coming into action in a hurry and unexpectedly. The thread of the time fuze cannot be got to fit at once into the nozzle of the shell; the man fixing the fuzes forgets in the confusion and smoke, which way he has to turn the nut which fastens and unfastens the collar; he is puzzled about the right direction to move the key when he tightens the time fuze in its place, and a careless No. 1 omits to tighten the nut sufficiently when the fuze is set, thus causing premature explosions occasionally.

Should the E pattern brass time fuze be continued in the service, some of these difficulties might be removed, by having the body of the fuze fitted with a spring something similar to that on the spring-spike; the fuze could then be fixed tightly into the nozzle of the shell as the spring-spike fits into the vent of a piece of ordnance, and half the difficulties of screwing would thus be done away with. There would still remain the collar and nut to be adjusted. It would probably be impossible to extract the fuze when once fixed, but that would be a small object when the greater rapidity of fire that could be obtained is considered, especially the first rounds on coming into action.

But although the Armstrong field gun has been proved to be an admirable substitute for the 9-pr. smooth-bored gun, yet it can in no way replace the 24-pr. howitzers which for obvious reasons were associated with 9-pr. batteries before the introduction of rifled ordnance.

When a moderately thick earthern field parapet requires to be breached by field guns, as at the "gate-pah" engagement;—when shells require to be thrown by hand amongst assailants or defenders of earthworks as at Rangiriri; when ricochet fire at very short distances is required, as at Orakau;—the Armstrong field shell will always fail to be as effective as a common shell from a 24-pr. howitzer. Therefore the same arguments which held good for associating 24-pr. howitzers with 9-pr. guns in the old smooth-bored batteries, still apply to the necessity for associating an improvement on the 24-pr. howitzer with the 12-pr. Armstrong.

It is hardly necessary to remark that on all occasions and whatever might be the various duties that the men were called upon to undertake, their conduct was most praiseworthy, and the duties were performed cheerfully and well, whether acting as artillery, cavalry, infantry, military train, or in assisting the royal engineers, in building redoubts or bridges, or in making roads in the interior of the country.

REPORT

OF THE

ORDNANCE SELECT COMMITTEE,

ON THE

TRIAL OF THE 7″ WROUGHT-IRON GUNS RIFLED ON VARIOUS SYSTEMS.

No. 3575. Dated 21st December, 1864.

[Communicated by direction of the Secretary of State for War].

1. The competitive trial between the 7-in. 149 cwt. guns rifled for testing the systems advocated by Commander Scott, R.N., Mr Lancaster, Mr Jeffery, and Mr Britten, in comparison with one another, and with that which is said to have been adopted in the French service, have now been carried out so far as to justify the Committee in reporting the results, for the information of the Secretary of State for War.

These guns were ordered on *Minutes* 8056–7–8, and 9161, at the request of the above-named gentlemen, who were rivals in the cast-iron rifled gun competition, reported on *Minute* 8365. Report 2685.

The difference between the systems of Messrs Jeffery and Britten, consisted substantially in the method of attaching lead to the base of the projectiles, and one gun only was prepared for these two gentlemen. The French gun was added at the request of the Committee.

2. The Committee, warned by experience of the former competition, determined on this occasion to limit the trial strictly to the rifling of the guns, and they therefore endeavoured to eliminate all other sources of difference, and themselves fixed a uniform weight, and form, and windage of shot, and also the charges of powder.

Mr Lancaster's shot are slightly shorter than the others, because the Committee had previously determined that the term "7-in. gun" should mean a gun down which a 7-in. spherical shot could be rolled, and under that definition the internal sectional area of an oval bored gun must necessarily be larger than that of a grooved gun of the same nominal calibre.

The Committee would gladly have confined the competition to the same amount of twist, but it was clear that the expanding projectiles of Messrs Jeffery and Britten would be unfairly treated if fired from a gun with as sharp a spiral as would suit the other competitors, and, moreover, the French system is that of an increasing twist, whilst that of the others is uniform. They therefore allowed each competitor full latitude in this respect.

Description of the Guns.

3. The guns are muzzle-loading. They have solid steel tubes three inches thick, a solid forged breech piece, and external strengthening coils. Their weight averages 149 cwt. and the length of bore is 10 ft. 6 in. Cammell's steel is used in Scott's, Lancaster's, and the Jeffery and Britten guns, and Firth's steel in the other. They are vented 5·75 in. from the end of the bore, this being the position to give the greatest initial velocity with a charge of 20 lbs.

Commander Scott's gun is rifled in five grooves, which are shallower on the loading side than on the driving side. The surface of the ribs on the shot and the bottom of the grooves in the gun are struck with the same radius, by which, in combination with the curves he has chosen for the driving side, Commander Scott hopes to attain a perfect centering for his shot. The rifling has a spiral of one turn in 294 in.

Mr Lancaster's gun is oval bored, the major-axis being 7·60 in., and minor-axis, 7·00 in. The rifling makes one turn in 360 inches.

The gun provided for Messrs Jeffery and Britten has thirteen grooves, each 0·10″ in depth and $\frac{1}{26}$ of the circumference in width, or 0·846 in. The rifling makes one turn in 805 inches.

The French gun is rifled in three grooves 0·25″ deep and 2·02″ wide. The rifling begins in a straight line, and increases gradually until it leaves the bore with an inclination of one turn in 259 inches.

Description of Carriages, &c.

4. The guns were mounted on wooden garrison carriages with traversing platforms, working at first on raised racers, but the spindles of the rollers proving too weak, the platforms were subsequently placed upon the ground. The platforms were inclined at an angle of 4° 36′ to 5° and no compressors were used.

5. *Description of Projectiles.*

1st supply (solid shot)	weight, 110 lbs. ± 2 lbs.		
	windage	over body,	0·05″ ± 0·02″.
		over studs,	0·03″ ± 0·01″.
2nd supply (shot hollowed at base)	weight, 100 lbs. ± 2 lbs.		
	windage	over body,	0·08″ ± 0·02″.
		over studs,	0·05″ ± 0·01″.

These latter shot were of the same length as the first supply, but reduced in weight by boring out at the base.

3rd supply (solid shot)	weight, 100 lbs. ± 2 lbs.		
	windage	over body,	0·08″ ± 0·02″.
		over studs,	0·05″ ± 0·01″.

The first supply were ordered with a smaller windage than that which the Committee consider it necessary to allow for service shot, in order that the very best shooting qualities of the guns might be developed.

Those of Commander Scott had simply five iron ribs with two very small copper studs inserted in the driving face of each. The total bearing length was about 9·2 in. The entire surface of the cylindrical part of the shot was planed. Mr Lancaster's shot were also turned, over the cylindrical part, and had four small brass studs on the loading quadrant.

Jeffery's and Britten's shot call for no particular description, both of them were leaded at the base and had wooden bottoms. Mr Jeffery added a band of greased flannel round the leaded part of his shot.

The projectiles on the French system had three large zinc half studs in front, supported by an iron back, and three smaller ones behind.

The second and third supplies were made with the service windage; and, with a view to placing the competition with these projectiles as nearly as possible on the footing of actual service, one half of the third supply was painted with two coats of paint, and the remainder allowed to rust by exposure to weather. For the same reason, a proportion of the second supply was carted a distance of 200 miles.

6. Besides the differences between the three supplies, as to weight and windage, described above, which were common to all the competitors, there were as regards Commander Scott's and the French projectiles, special differences which require particular notice. In the second and third supplies made for Commander Scott the iron ribs were faced with strips of zinc inserted in grooves planed in the body of the shot, and further supported by two tenons let into the iron rib; whilst in the French projectiles of the second supply a stronger mode of fastening the studs was adopted, giving support to the back studs against the first violent shock of the gunpowder, and in the third supply the arrangement of the studs was altogether altered, on a plan suggested by Major Palliser; the metal was changed from zinc to gun-metal; the smaller stud was placed in front, and the larger one behind; both were attached in a different manner.

Description of Cartridges.

7. The powder used was A_4; the cartridges were made up to a uniform diameter of 6·5 in. During the first 30 rounds, lubricators were used, which were 6·3 in. diameter, leaving therefore an air-space close to the base of the shot, which caused all the guns to indent in that part of the bore; from that time forward no lubricators were used, but the felt wad was retained, and an ordinary grummet wad placed behind the felt, so as more completely to fill up the air-space. Subsequent examination of the bore showed no further increase of the indent.

Dry sponging was used for the first 45 rounds, and would apparently have sufficed for keeping the guns clean, but the loading of Lancaster's gun with the second supply of shot was so difficult that a wet sponge had to be used with that gun, and it was then used with the others also, so that all might be on the same footing.

General Results.

Lead coated expanded Projectiles.

8. A very short experience showed that the systems of Messrs Jeffery and Britten were unsuited for heavy charges, large pieces of lead were blown off the shot, and the shooting was so wild as to throw these systems entirely out of the competition. They will not be referred to in this report, but the details of firing will appear in the Appendix.

Endurance.

9. About 350 rounds have now been fired from each gun. This is insufficient to test the endurance of guns such as these, but it is sufficient to indicate that with steel-lined guns there need be no fear of the breaking down of the grooving by the abrasion of the ribs or studs in either of these systems; at all events when in Commander Scott's system soft bearings are used.

The peculiar eating away of the centre of the end of the powder chamber may be due to the softness of the core of the steel lining, or the conical form given originally to these chambers, but, whatever the cause may be, it seems common to the three guns; and, although the defect has developed itself most plainly in Commander Scott's gun, the Committee do not think it is attributable to any peculiarity in his mode of rifling.

The Committee can see no reason at present for placing one gun before the other in point of endurance.

Easiness of Loading.

10. The French gun was certainly the easiest to load; but there is nothing to complain of in this respect in Commander Scott's gun. Mr Lancaster's shot were all got home with more or less difficulty, and in some cases a metal rammer had to be used.

Liability of the Projectiles to injury from rough usage.

11. None of these descriptions of shot are liable to injury from knocking about: but the Lancaster should take the first place in this respect; Commander Scott's first plan the second place; the French shot on Palliser's system the third, and Commander Scott's second plan the last.

Recoil.

12. There seems no practical difference between the guns in this respect.

In the early part of the trial the Scott gun had the greatest recoil, but on an exchange of carriages with the French gun, their places in this respect were reversed.

Initial Velocity.

13. The initial velocity of elongated projectiles discharged from guns of equal length and calibre depends upon the charge of powder, the weight of the shot, and the peculiarities of the grooving. In these experiments it was intended to eliminate, as much as possible, all differences between the competitors, except those of grooving, and, as before stated, the Committee themselves fixed the weight of projectiles, and also of the powder charge; they allowed ± 2 lbs. as the limits of weight to the manufacturer of the projectiles, and it appears that Commander Scott's projectiles, although well within the manufacturing limits, are yet generally lighter than those of the other competitors. This slight difference need not be considered when discussing the ranges attained, but the Committee have thought it right to reduce the observed initial velocities to that which would have been shown in projectiles of exactly 110 lbs. and 100 lbs. weight respectively. The gun rifled on the French system has somewhat decidedly the lowest velocities, and Mr Lancaster's, on the whole, the highest. He is in every instance superior in this respect to Commander Scott, but is exceeded once by Mr Jeffery and once by Mr Britten.

The following table contains the result in full :—

TABLE I.

Systems.	As observed.			Reduced to equal weights 110 lbs. and 100 lbs.			With round shot.	
	Charges.			Charges.			Charges.	
	25 lbs.	20 lbs.	12 lbs.	25 lbs.	20 lbs.	12 lbs.	20 lbs.	12 lbs.
	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.
Nominal weight of projectiles 110 lbs.								
Britten	1582	1508	1300	1581	1504	1295	—	—
Jeffery	1596	1510	1286	1598	1508	1286	—	—
Lancaster	1610	1496	1278	1618	1504	1283	—	—
Scott	1594	1502	1277	1583	1493	1270	—	—
French	1529	1444	1254	1526	1441	1252	—	—
Nominal weight of projectiles 100 lbs.								
Lancaster	1686	1557	1355	1687	1558	1356	1983	1666
Scott	1632	1548	1352	1625	1541	1346	2162	1827
French	1603	1545	1319	1609	1552	1325	2081	1718

Range and Accuracy.

14. In considering the order of merit, as to range and accuracy, the Committee are inclined to rely chiefly upon the results recorded with the 3rd supply of projectiles, because there is no doubt that the 1st and 2nd supply of French projectiles were not studded on the best principles, and placed the gun (which is the thing to be tried) at a great disadvantage. The same remark applies to the 2nd supply of Commander Scott's projectiles, reduced to 100 lbs. in weight, by boring out from the rear. Some of these broke up in the gun, from the weakening of the hollow projectile by the grooves in which Commander Scott had placed his zinc ribs, and several others were found on recovery to be more or less damaged from the same cause. On the other hand, it must not be overlooked that

the reduction of weight placed Mr Lancaster at a disadvantage in respect to the length of bearing of his shot, which was reduced from 8 to 7 in.

15. The Committee having determined to give the detailed records in an appendix, are anxious not to confuse the body of the report by the introduction of more figures than are necessary; they, therefore, record, in the first of the following tables, only the mean range, the mean deviation from that mean range, and the reduced deflection. This last term has always been used in tables of this nature, but it is not self-explanatory, and it is as well to state that it means the mean lateral deviation from the mean line of fire. The Committee wish also to explain that the table headed "general means" represents no actual result, but it is introduced to collect into one line the aggregate results of the practice with the three charges of powder at the three elevations.

Table II.

Practice for Range and Accuracy. 3rd Supply of Projectiles. 100 lbs.

No. of rounds fired.	Nature of gun.	Elevation.	Charge.	Mean range.	Mean deviation from mean range.	Mean reduced deflection.
		°	lbs.	yds.	yds.	yds.
11	Scott	2	12	1157	36·9	1·7
10	"	"	20	1416	29·8	1·2
10	"	"	25	1560	70·7	3·2
10	"	5	12	2201	62·2	3·2
10	"	"	20	2635	30·6	2·6
10	"	"	25	2793	59·6	3·7
10	"	10	12	3712	44·4	10·8
10	"	"	20	4239	34·1	23·8
10	"	"	25	4450	59·8	10·3
				9)24,163	9)428·1	9)60·5
			Means	2685	47·6	6·7
11	Lancaster ...	2	12	1173	50·5	8·7
10	" ...	"	20	1416	21·2	3·3
10	" ...	"	25	1520	34·4	1·5
10	" ...	5	12	2236	60·4	4·2
10	" ...	"	20	2640	17·7	4·8
10	" ...	"	25	2784	36·9	2·6
10	" ...	10	12	3977	50·4	18·6
10	" ...	"	20	4498	35·9	17·5
10	" ...	"	25	4613	36·9	10·4
				9)24,857	9)344·3	9)66·6
			Means	2762	38·3	7·4
11	French	2	12	1143	11·5	0·5
10	"	"	20	1384	29·1	0·8
10	"	"	25	1446	19·9	2·0
5	"	5	12	2285	46·2	1·5
10	"	"	20	2538	23·1	2·9
10	"	"	25	2716	35·9	2·6
5	"	10	12	3909	21·8	7·2
10	"	"	20	4350	31·7	5·7
10	"	"	25	4566	25·6	9·1
				9)24,337	9)244·8	9)32·3
			Means	2704	27·2	3·6

General Means.

Nature of gun.	Mean range.	Mean deviation from mean range.	Mean reduced deflection.
	yds.	yds.	yds.
Scott	2685	47·6	6·7
Lancaster	2762	38·3	7·4
French	2704	27·2	3·6

Cost of Rifling.

16 There is no difference worth mentioning in the cost of rifling on these three systems.

Cost of Projectiles.

17. The Superintendent Royal Laboratory states that the cost of projectiles weighing 100 lbs. would be respectively:

	£	s.	d.	
Scott's 1st system	442	14	0	per 1000
„ 2nd „	727	1	1	„
Lancaster's	450	11	7	„
French, on original plan	570	6	9	„
„ on Palliser's plan	534	8	0	„

Value as Shell Guns.

18. There seems no reason for doubting that these guns will have the same relative value as shell guns, as they have when used with solid projectiles. The shells may be equal in length and weight, and carry equal bursting charges.

Capability of firing Round Shot.

19. The Committee attach some importance to the power of firing round shot.

The supply of rifled projectiles will always be limited, from their bulk and weight, and cost. It is not to be expected that they will be expended so freely as round shot, which will also be good enough for many instructional and other purposes, and can be carried in any desirable quantities. The existing 18-pr., 24-pr., 32-pr., and 68-pr. round shot of the service are not prepared for wooden bottoms, but those for 6-pr., 9-pr., and 12-pr. brass field guns, are so; the Committee, therefore, fired some round shot loose and some riveted. They were specially cast for the calibre, and weighed 43 lbs. 6 oz. Mr Lancaster prepared his round shot for firing with special wooden tops and bottoms of an oval form, fitting the bore of the gun accurately. No material advantage was gained by their use, and it is evident that such a special provision would, on many accounts, be objectionable.

Table III.

RESULTS OF PRACTICE WITH ROUND SHOT, BOTH LOOSE AND RIVETED TO WOODEN BOTTOMS. THE SHOT FIRED FROM THE LANCASTER GUN HAD OVAL TOPS AND BOTTOMS.

Charge.	Elevation.	No. of rounds.	Scott.			Lancaster.			French.		
			Mean range.	Mean difference of range.	Mean reduced deflection.	Mean range.	Mean difference of range.	Mean reduced deflection.	Mean range.	Mean difference of range.	Mean reduced deflection.
lbs.	°		yds.	yds.	yds.	yds.	yds.	yds.	yds.	yds.	yds.
Shot, loose.											
12	2	10	1276	63·6	4·6	1096	68·2	3·3	1176	50·0	3·9
"	5	10	2140	97·4	9·5	1956	69·3	8·6	2034	54·3	7·2
20	2	10	1497	52·9	6·9	1262	72·7	4·8	1410	62·1	5·4
"	5	5	2278	56·4	21·5	2211	20·4	12·2	2264	30·8	8·0
Shot riveted to wood bottoms.											
12	2	10	1350	104·0	5·1	1157	64·1	4·3	1247	54·5	5·3
"	5	5	2260	116·7	24·1	1943	87·8	7·0	2116	90·2	7·8
20	2	10	1473	84·4	6·2	1387	99·6	5·2	1375	63·7	4·4
"	5	5	2274	77·6	14·5	2232	84·8	10·1	2238	42·0	11·8

Commander Scott's gun has the advantage of both the others in point of range with round shot, but is very much inferior to both in uniformity of range and accuracy. The French rifled gun is the best in these respects. It is worthy of remark that the charge of 20 lbs., which is nearly half the shot's weight, gives an increase of velocity of only 271 ft., and only 200 yds., or thereabouts, of additional range, over the charge of 12 lbs.; which latter charge, with the small windage allowed, gives a considerably higher velocity than that of the service 32.pr. or 68-pr. shot.

20. The Committee have now placed the Secretary of State in possession of all the data that are requisite for comparing these five systems of rifling as applicable to heavy battering guns using a charge of one fifth or one-fourth the weight of the shot.

The gun rifled on the French system, with arrangement of the studs suggested by Major Palliser, gives by far the best result so far, in point of accuracy, the trial not having proceeded beyond solid shot of the forms and weights specified. It was the easiest to load, and, although somewhat inferior to Commander Scott's gun, in respect to firing round shot, is in every other respect equal or superior to it. The Committee also prefer it to Lancaster's, although Mr Lancaster has subsequently shown how, in his opinion, his shot may be made very easy to load without increase of mean windage, by taking the windage allowed chiefly off the third quadrant of the shot.

The Committee are confirmed in the preference expressed above by the superiority which the French system of rifling evinced over the former plans of the same gentleman when tried in rifled cast-iron 32-pr. guns in 1862.

For reasons already given they reject both the systems of lead-coated projectiles as unsuitable for heavy charges.

21. The charge of 12 lbs. being that of the service breech-loading 7-in. gun, the Committee subjoin a table by which it will be seen that, notwithstanding the advantage the muzzle-loading guns had in point of length and weight, they none of them quite equal that gun in point of accuracy, even with the shot of the third supply, weighing 100 lbs., which are to be chiefly regarded.

However, the French rifled gun is but inferior up to 5°. The practice quoted was made in February last, to try a 110-pr. gun from which the muzzle grip had been removed.* Something may, perhaps, be allowed for a small difference in the form of head, but this difference was not sufficient to have operated materially against the competitive shot.

TABLE IV.

Gun.	Charge.	Shot.	No. of rounds.	2°			No. of rounds.	5°			No. of rounds.	10°		
				Mean range.	Mean difference of range.	Mean reduced deflection.		Mean range.	Mean difference of range.	Mean reduced deflection.		Mean range.	Mean difference of range.	Mean reduced deflection.
	lbs.	lbs.		yds.	yds.	yds.		yds.	yds.	yds.		yds.	yds.	yds.
Armstrong 7-in. B.L.	12	*110*	20	984	10·7	0·7	20	1972	13·0	1·6	10	3468	11·8	2·5
											10	3418	27·9	2·9
French 7-in. M.L. ...	12	*110*	4	1152	19·7	0·8	4	2219	54·5	2·8	4	3908	136·5	8·3
" "	"	100	11	1143	11·5	0·5	5	2285	46·2	1·5	5	3951	12·4	19·2
											5	3868	31·2	7·6
Scott's 7-in. M.L. ...	"	*110*	5	1213	21·4	0·8	5	2286	49·6	5·4	5	3909	109·8	40·7
" "	"	100	—	—	—	—	10	2201	62·2	3·2	5	3695	48·0	3·6
" "	"	100	10	1157	36·9	1·7	—	—	—	—	5	3730	40·8	18·0
Lancaster's 7-in. M.L.	"	*110*	5	1198	25·4	0·8	5	2287	57·2	1·2	5	3907	24·8	4·0
" "	"	100	11	1173	50·5	3·7	—	—	—	—	—	—	—	—
" "	"	100	—	—	—	—	10	2236	60·4	4·2	5	3945	58·0	21·0
											5	4010	42·8	16·3

22. The Committee having received permission on the 29th October, 1864 $\frac{80}{\text{G.No.}\ 721}$, *Minute* 13,538 to try a 149 cwt. 7-in. gun, shunt rifled, in comparison with the above competitive guns, are now waiting for the means of doing so; and until such comparison is made, do not feel warranted in making any definite recommendation on the facts now reported.

The guns also being essentially shot guns, the present trial has been restricted to solid projectiles, nor do the Committee think it probable that any disparity will appear in their performance with longer projectiles, which can alter the order in which they now stand, but at the same time they think it quite necessary to fire some common shells; and as the differences as yet elicited between the three systems left in competition are not such as to disqualify absolutely any one of them, they wish to reserve their final report until these shells have been fired, and the shunt gun tried.

* See *Minute* 11,145, p. 30.

Appendix 1 A.

Abstract of results of shot practice with 7-in. muzzle-loading gun, rifled on Commander Scott's system.

Date.	No. of rounds fired.	Elevation.	Charge.	Mean range.	Mean difference of range.	Mean observed deflection.	Mean reduced deflection.	Remarks.
1864.		°	lbs.	yds.	yds.	yds.	yds.	
			Solid shot; 1st supply; 110 lbs.					
July 14	10	2	25	1604	15·6	3·3	2·4	
〃 27	5	2	〃	1547	21·8	4·5	1·0	
〃 13	10	5	〃	2834	35·6	24·6	7·1	
〃 27	5	5	〃	2994	48·8	12·1	3·7	
〃 12	5	10	〃	4695	26·8	80·6	24·9	
〃 14	5	10	〃	4779	31·4	95·4	8·9	
〃 26	5	10	〃	4922	87·4	61·5	20·6	
〃 15	10	2	20	1462	21·5	3·7	0·9	
〃 27	5	2	〃	1495	11·2	3·8	2·2	
〃 26	10	5	〃	2741	44·7	21·2	3·3	
〃 10	10	5	〃	2621	69·7	23·8	4·3	Travelled 200 miles.
〃 27	5	5	〃	2810	56·8	4·9	3·6	
〃 15	10	10	〃	4444	63·8	29·0	28·2	
〃 26	5	10	〃	4440	69·2	7·3	7·0	
〃 27	5	2	12	1213	21·4	4·1	0·8	
〃 27	5	5	〃	2286	49·6	4·8	5·4	
〃 27	5	10	〃	3909	109·8	40·1	40·7	
			Hollow shot, zinc ribs; 2nd supply; 100 lbs.					
Oct. 20	10	2	20	1442	51·4	3·3	2·5	
Sept. 29	20	5	〃	2671	45·7	12·6	3·8	
Oct. 10	10	5	〃	2630	45·0	23·4	1·6	
〃 20	10	5	〃	2834	47·9	9·2	4·6	
			Solid shot, zinc ribs; 3rd supply; 100 lbs.					
Sept. 27	11	2	25	1560	70·7	7·1	3·2	Painted.
〃 27	10	2	20	1416	29·8	7·4	1·2	〃
〃 27	10	2	12	1157	36·9	4·9	1·7	〃
Oct. 6	10	5	25	2793	59·6	20·9	3·7	Exposed.
〃 6	10	5	20	2635	30·6	12·5	2·6	〃
〃 6	10	5	12	2201	62·2	4·9	3·2	〃
Sept. 28	5	10	25	4434	61·4	49·8	10·2	Painted.
〃 28	5	10	〃	4467	58·2	29·0	10·4	Exposed.
〃 28	5	10	20	4202	32·8	36·7	21·0	Painted.
〃 28	5	10	〃	4276	35·4	57·1	26·7	Exposed.
〃 28	5	10	12	3695	48·0	63·0	3·6	Painted.
〃 28	5	10	〃	3730	40·8	40·5	18·0	Exposed.
			Round shot of 43·4 lbs., riveted to wood bottoms.					
Oct. 11	10	2	20	1473	84·4	8·4	6·2	
〃 11	10	2	12	1350	104·0	6·3	5·1	
〃 11	5	5	20	2274	77·6	36·1	14·5	
〃 11	10	5	12	2260	116·7	26·6	24·1	
			Loose round shot.					
Oct. 12	10	5	12	2140	97·4	23·6	9·5	
			Recovered loose round shot.					
Oct. 13	10	2	20	1497	52·9	7·5	6·9	
〃 13	5	5	〃	2278	56·4	31·6	121·5	
〃 13	10	2	12	1276	63·6	9·0	4·6	

Appendix 1 B.

Abstract of results of shot practice with 7-in. muzzle-loading gun, rifled on the French system.

Date.	No. of rounds fired.	Elevation.	Charge.	Mean range.	Mean difference of range.	Mean observed deflection.	Mean reduced deflection.	Remarks.
1864.		°	lbs.	yds.	yds.	yds.	yds.	
				Solid shot; 1st supply; 110 lbs.				
July 14	10	2	25	1500	52·4	4·6	2·0	
〃 27	5	2	〃	1420	81·8	3·6	1·6	
〃 13	10	5	〃	2713	36·1	21·9	4·7	
〃 27	5	5	〃	2788	41·8	18·7	4·9	
〃 12	5	10	〃	4489	48·2	30·2	10·8	
〃 14	5	10	〃	4543	45·8	38·5	22·4	
〃 26	5	10	〃	4586	82·6	52·4	24·5	Hind buttons cut off.
〃 15	10	2	20	1386	35·4	2·2	0·7	
〃 26	10	5	〃	2612	33·3	21·2	2·0	
Oct. 10	10	5	〃	2405	57·1	21·8	5·2	Zinc buttons; travelled 200 miles, and rusty.
July 15	10	10	〃	4210	46·2	41·6	14·6	
〃 27	4	2	12	1152	19·7	3·7	0·8	
〃 27	4	5	〃	2219	54·5	6·1	2·8	
〃 27	4	10	〃	3908	136·5	33·8	8·3	
				Hollow shot; 2nd supply; 100 lbs.				
Oct. 20	10	2	20	1348	127·3*	8·2	7·5	Zinc on bearing side of button. Zinc of top button filed down to 1·94″.
〃 10	10	5	〃	2456	47·6	27·5	7·2	〃
〃 20	10	5	〃	2606	36·7	14·6	5·4	〃
Sept. 29	10	5	〃	2519	40·4	25·5	3·6	Zinc buttons.
Oct. 6	10	5	〃	2538	23·1	17·8	2·9	〃
〃 6	5	5	12	2092	52·6	8·7	5·6	Buttons filed down ·5″.
				Solid shot; 3rd supply: Palliser's buttons; 100 lbs.				
Sept. 27	10	2	25	1446	19·9	3·2	2·0	Painted.
〃 27	10	2	20	1384	29·1	3·8	0·8	〃
〃 27	11	2	12	1143	11·5	3·6	0·5	〃
Oct. 6	10	5	25	2716	35·9	22·7	2·6	Rusted.
Sept. 29	10	5	20	2640	27·4	30·6	3·3	
Oct. 6	5	5	12	2285	46·2	16·6	1·5	Exposed.
Sept. 28	5	10	25	4573	23·0	122·9	6·3	Painted.
〃 28	5	10	〃	4559	28·2	118·9	11·9	Exposed.
〃 28	5	10	20	4379	19·6	98·5	4·0	Painted.
〃 28	5	10	〃	4322	43·8	102·9	7·4	Exposed.
〃 28	5	10	12	3951	12·4	68·5	19·2	Painted.
〃 28	5	10	〃	3868	31·2	101·7	7·6	Exposed.
				Round shot of 43·4 lbs.; riveted to wood bottoms.				
Oct. 11	10	2	20	1375	63·7	8·4	4·4	
〃 11	10	2	12	1247	54·5	8·4	5·3	
〃 11	5	5	20	2238	42·0	26·2	11·8	
〃 11	10	5	12	2116	90·2	18·5	7·8	
				Loose round shot.				
Oct. 12	10	5	12	2034	54·3	13·9	7·2	
				Recovered loose round shot.				
Oct. 13	10	2	20	1410	62·1	8·9	5·4	
〃 13	5	5	〃	2264	30·8	10·3	8·0	
〃 13	10	2	12	1176	50·0	6·1	3·9	

* The first 10 rounds on this day were experimental, with all the guns, to try the effect of omitting the felt and grummet wad (par. 7), it was noticed at each round from the 3rd to the 6th

Besides the foregoing rounds, 24 preliminary rounds were fired from the French gun, on the 28th June 1864, the results of which are contained in the following abstract:—

Date.	No. of rounds fired.	Eleva-tion.	Charge.	Mean range.	Mean difference of range.	Mean observed deflection.	Mean reduced deflection.	Remarks.
1864.		°	lbs.	yds.	yds.	yds.	yds.	
June 28	3	1	20	928	24·0	2·2	1·6	Solid shot, first supply, 110 lbs.
"	3	2	20	1337	48·3	3·3	2·0	
"	3	5	20	2590	7·0	14·7	2·2	
"	3	10	20	4420	70·3	31·0	5·3	
"	3	1	25	952	9·0	2·1	0·6	
"	3	2	25	1466	25·7	5·3	0·6	
"	3	5	25	2742	31·7	17·0	0·7	
"	3	10	25	4701	53·7	34·3	8·4	

Appendix 1 C.

Abstract of results of shot practice with 7-in. muzzle-loading gun, rifled on Mr Lancaster's system.

Date.	No. of rounds fired.	Eleva-tion.	Charge.	Mean range.	Mean difference of range.	Mean observed deflection.	Mean reduced deflection.	Remarks.
1864.		°	lbs.	yds.	yds.	yds.	yds.	
			Solid shot; 1st supply; 110 lbs.					
July 14	10	2	25	1590	28·8	4·1	2·0	
" 27	5	2	"	1545	36·0	3·2	0·7	
" 13	10	5	"	2817	18·9	25·2	3·6	
" 27	5	5	"	2903	32·0	21·0	2·7	
" 12	5	10	"	4487	16·5	74·0	4·5	
" 14	5	10	"	4605	25·6	80·9	6·6	
" 26	5	10	"	4757	127·2	110·1	20·5	
" 15	10	2	20	1455	27·3	4·5	2·0	
" 27	5	2	"	1380	34·0	3·1	1·8	
" 26	10	5	"	2688	22·6	30·5	4·8	
" 27	5	5	"	2611	43·0	15·0	2·1	
Oct. 10	10	5	"	2520	55·7	33·2	3·9	Travelled 200 miles, and rusty.
July 15	10	10	"	4299	75·1	61·0	12·9	
" 26	5	10	"	4353	54·0	101·5	9·2	
" 27	5	2	12	1198	25·4	5·5	0·8	
" 27	5	5	"	2287	57·2	14·9	1·2	
" 27	5	10	"	3907	24·8	78·5	4·0	
			Hollow shot; 2nd supply; 100 lbs.					
Oct. 20	10	2	20	1433	33·7	5·8	4·2	Copper centering studs, slightly filed down; very rusty.
" 20	10	5	"	2724	59·2	25·4	5·4	
Sept. 29	20	5	"	2667	32·2	27·9	5·1	
Oct. 10	10	5	"	2586	23·4	39·2	5·5	

inclusive, that a stud appeared to detach itself from the French shot during flight. The results must therefore be neglected in comparisons of accuracy.

APPENDIX 1 C.—*continued.*

Date.	No. of rounds fired.	Elevation.	Charge.	Mean range.	Mean difference of range.	Mean observed deflection.	Mean reduced deflection.	Remarks.
1864.		°	lbs.	yds.	yds.	yds.	yds.	
	Solid shot; copper centreing studs; 3rd supply; 100 lbs.							
Sept. 27	10	2	25	1520	34·4	3·8	1·5	Painted.
Oct. 6	10	5	"	2784	36·9	24·1	2·6	Rusted.
Sept. 28	5	10	"	4607	36·8	121·9	11·5	Painted.
" 28	5	10	"	4619	37·0	132·1	9·4	Rusted.
" 27	10	2	20	1416	21·2	6·3	3·3	
Oct. 6	10	5	"	2640	17·7	24·8	4·8	Rusted.
Sept. 28	5	10	"	4487	43·8	124·9	6·1	Painted.
" 28	5	10	"	4510	28·0	102·1	28·9	Rusted.
" 27	11	2	12	1173	50·5	5·6	3·7	
Oct. 6	10	5	"	2236	60·4	23·6	4·2	Rusted.
Sept. 28	5	10	"	3945	58·0	103·3	21·0	Painted.
" 28	5	10	"	4010	42·8	80·9	16·3	Rusted.
	Round shot of 43·4 lbs.; riveted to wood bottoms.							
Oct. 11	10	2	20	1387	99·6	5·8	5·2	
"	5	5	"	2232	84·8	13·0	10·1	
"	10	2	12	1157	64·1	5·6	4·3	
"	10	5	"	1943	87·8	14·3	7·0	
	Loose round shot.							
Oct. 12	10	5	12	1956	69·3	14·6	8·6	
	Recovered loose round shot.							
Oct. 13	10	3	20	1262	72·7	5·6	4·8	
" 13	5	5	"	2211	20·4	13·3	12·2	
" 13	10	2	12	1096	68·2	5·6	3·3	

APPENDIX 1 D.

Abstract of results of shot practice with the 7-in. muzzle-loading gun, rifled in shallow grooves, and firing Mr Jeffery's projectiles with leaden bases.

Shot of 1st supply, 110 lbs.

Date.	No. of rounds fired.	Elevation.	Charge.	Mean range.	Mean difference of range	Mean observed deflection.	Mean reduced deflection.
1864.		°	lbs.	yds.	yds.	yds.	yds.
July 14th ...	1	2	25	1402	—	1·6	—
" 13th ...	10	5	"	2562	115·3	12·0	8·0
" 12th ...	5	10	"	4340	51·8	39·5	12·8

The practice was stopped in consequence of large pieces of lead coming off the shot. Some 2-in. deal targets, 230 ft. in front, were penetrated. A mantelet of $\frac{5}{8}$th inch iron, 50 ft. in front, was struck in 13 places, and deeply dented; two pieces passed through it. A flagstaff, 156 ft. from the gun, was struck in many places, and the halliards cut.

APPENDIX 1 E.

Abstract of results of shot practice with the 7-in. muzzle-loading gun, rifled in shallow grooves, and firing Mr Britten's projectiles with leaden bases.

Shot of 1st supply, 110 lbs.

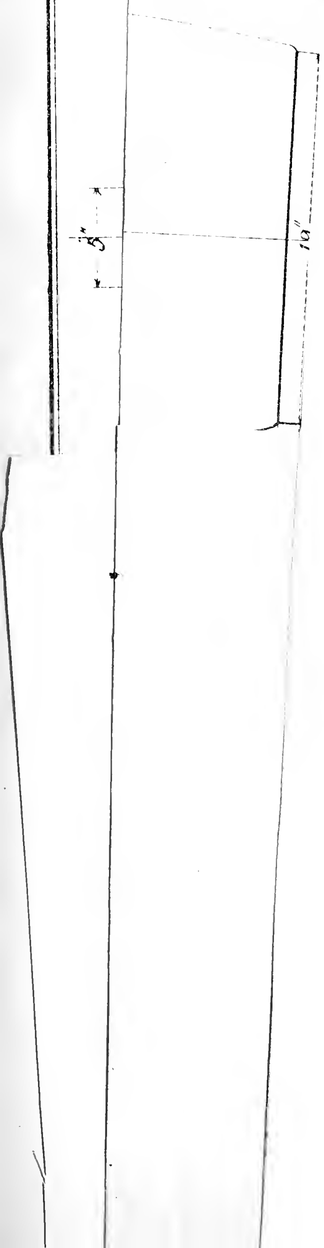
Date.	No. of rounds fired.	Elevation.	Charge.	Mean range.	Mean difference of range.	Mean observed deflection.	Mean reduced deflection.	Remarks.
1864.		°	lbs.	yds.	yds.	yds.	yds.	Mr Britten tried the effect of removing a portion of the lead, and dispensed with the wooden bottom in the practice at 2° and 5°.
July 14	10	2	25	1361	104·2	5·9	5·0	
„ 13	10	5	„	2516	63·6	12·3	10·4	
„ 12	5	10	„	3690	162·6	121·3	122·1	

The practice was stopped in consequence of its irregularity, and the separation of the lead at the base of the shot.

(Signed) J. H. LEFROY,
Brigadier-General,
President.

RON) WE

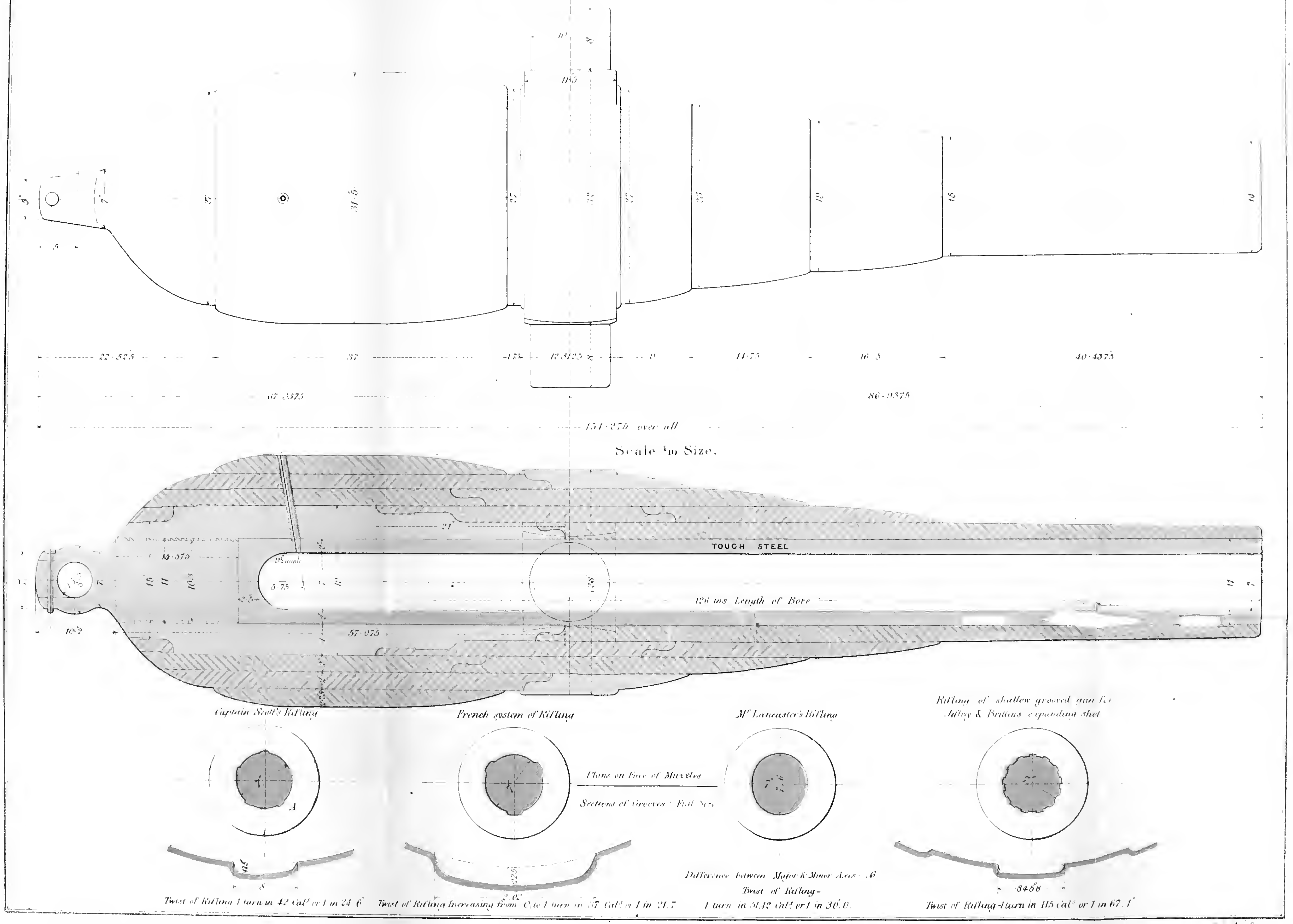
Jeffrey & L



ROYAL GUN FACTORIES.

7 Inch Muzzle Loading Guns (Wrought Iron) Weight 149 Cwts.

Rifled on Captain Scott's, the French, Messrs Lancaster's, and Jeffrey & Britten's Systems



REPORT

OF

ORDNANCE SELECT COMMITTEE.

No. 3730, dated 1st May, 1865.

COMPETITIVE 7″ WROUGHT IRON MUZZLE-LOADING GUNS. (2nd Report).

[Communicated by direction of the Secretary of State for War.]

1. The Committee have now the honor to report in continuation of their former Report, No. 3575, Minute 13,652,

1st, The completion of the competitive trial between the Scott, Lancaster, Britten, Jeffery, and the so-called French gun;

2nd, The results of an independent trial between the above mentioned French gun, and one of the same calibre rifled on the shunt plan in accordance with a design submitted by Sir William Armstrong.

2. It will be remembered that the former report brought down the history of the competition as far as the conclusion of the solid shot trials with the system named in the first paragraph, and that the results were on the whole in favour of the so-called French gun, whilst the systems of Messrs Jeffery and Britten were condemned as unsuitable for heavy charges. Drawings of shells were then called for from Commander Scott and Mr Lancaster; the weight of the loaded shell, and the minimum thickness of metal were fixed by the Committee, but full latitude upon other points was left to those gentlemen. Fifty shells were made for each gun. The Committee added a like number for the French gun, which were identical in form, except as to their studding, with those of Commander Scott. The practice with these shells is recorded in the following table; the results are again in favour of the French gun, and thus confirmatory of the shot practice.

Table I.

Shell practice with the competitive 7-in. guns, the shells having a nearly hemispherical form of front.

Charge 20 lbs. Length { cartridge .... 17·5 in.
{ wad and grummet ring 1·9 „
19·4 „

Mean weight of common shell, filled and plugged, 100·0 lbs.

Date.	Gun.	No. of rounds fired.	Corrected elevation.		Mean time of flight.	Ranges.			Mean difference of range.	Mean observed deflection.	Mean reduced deflection.
						Min.	Max.	Mean			
			°	′	sec.	yds.	yds.	yds.	yds.	yds.	yds.
8. 3. 65	French ...	1	2	14	3·7	—	—	1412	—	7·7	—
21. 3. 65	"	19	2	15	3·45	1284	1410	1335	21·3	4·0	0·8
21. 3. 65	"	20	5	8	7·14	2411	2553	2490	33·8	19·0	1·4
22. 3. 65	"	20	10	5	12·86	4004	4216	4119	41·7	93·9	6·1
8. 3. 65	Scott	1	2	14	3·5	—	—	1414	—	1·2	—
21. 3. 65	"	19	2	15	3·46	1353	1412	1380	14·1	3·8	1·0
21. 3. 65	"	20	5	8	7·22	2487	2631	2557	36·4	17·1	2·1
22. 3. 65	"	20	10	5	12·77	4056	4244	4149	35·5	79·7	6·7
8. 3. 65	Lancaster.	1	2	15	3·5	—	—	1320	—	14·0	—
21. 3. 65	"	19	2	15	3·47	1282	1436	1346	40·6	5·4	1·0
21. 3. 65	"	20	5	8	7·15	2400	2571	2487	36·3	24·6	3·2
22. 3. 65	"	20	10	5	13·31	3925	4296	4128	77·4	109·0	25·1

Dimensions of Common Shell.

	Diameter over body.	Diameter over studs.	Length of bearing.	Total length.	Capacity.	
	in.	in.	in.	in.	lbs.	oz.
French.........	6·92	7·15	6·18	15·172	5	9
Scott............	6·92	—	12·0	15·12	5	7
Lancaster......	{6·95 7·55}		10·5	13·52	5	0

3. Much difficulty was observed, as before, in loading the Lancaster gun, and the French was again found the most easy to load; it is however right to mention that after the shells had been made, Commander Scott applied for an alteration which he said would facilitate the loading of his gun, but the Committee were obliged to refuse his request on account of the delay which it would have entailed.

4. The Lancaster shells, with only one exception, were found on recovery to be split at the head; shewing apparently (as has always been suspected), that in that system the projectile has a great tendency to jam in the bore,

bringing severe pressure both on the gun and on the projectile. The shells recovered, after being fired, from the other two guns were apparently uninjured, shewing that there was no objection to either system of grooving on the ground of its unfitness for shell firing; but in order to verify this opinion, five of the recovered shells were subsequently fired, full of powder, from each of these two guns, with equally satisfactory results; none of them exploded prematurely.*

5. The Committee had then witnessed the firing of upwards of 400 rounds from these guns, and they were unanimously of opinion that the Lancaster system should be rejected on account of the tendency to crush in the bore evinced by the condition of the recovered shells, its inferior accuracy, and the difficulty of loading; and that of the two remaining competitors, they considered the so-called French system to be the better. They formed this opinion not only upon the grounds of the superior accuracy of the gun, which is however very marked; but also upon the grounds that it is the easiest to load by day, and that at night the simple buttons on its projectile would (if they may use the expression) "find" the grooves of the gun or shot bearer more easily than would the more numerous but smaller ribs of Commander Scott's projectile. The opinion is also grounded partly on the consideration that in the case of careless manufacture incidental to large contracts in war time, the soft metal studs of the French projectile would adjust themselves to the grooves of the gun whilst any error in planing the Scott ribs would cause unequal pressure in the different grooves and tend to destroy them. It is unfortunate that the adoption of, by Commander Scott, of zinc-faced ribs in about half the projectiles fired during this competition should have prevented a practical test of the wearing of the grooves, even under the favourable circumstances as to correctness of manufacture which he has on this occasion enjoyed.

6. The single point upon which the Scott system maybe practically superior to the French is in the cheapness of its projectiles. The Superintendent Royal Laboratory reports a difference of 1s. 10d. per 100 lbs. shot in favour of the Scott, but the Committee think it probable that further experience in the mode of studding will considerably reduce this difference.

7. The so-called French gun being then in the opinion of the Committee the best of those originally placed in competition, was selected by them for comparison with a gun rifled, by permission of the Secretary of State for War, under date October 29, 1864, from a design submitted by Sir William Armstrong.

The length of bore of this gun was the same as that of the French gun, but its weight was 9 cwt. less. It was rifled in six grooves on the shunt plan, in the form in which it has been generally applied to large guns, with

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* Mr Lancaster has since produced eight shells of a different pattern, which were fired on 22nd of June, with charges of 20 lbs. and with 7 lbs. 6 oz. of bursting charge in each; six of them weighed 115 lbs. filled, two of them 109 lbs.; none of these shells burst prematurely.

the small improvement that some of the angles of the grooving were rounded off. The twist was uniform, one in 266 inches or 38 calibres, being nearly the same as the final twist of the French gun. The bore was not of the usual cylindrical form but very slightly tapered, the diameter at the chamber being 0·04 of an inch larger than at the muzzle. This peculiarity existed in several of Sir William Armstrong's earlier experimental guns, but has not been carried out in all of them. The object is to give more windage in the region in which fouling has the greatest tendency to impede loading.

8. The projectiles provided for the trial were as follows:—

100 hemispherical-headed solid shot weighing 110 lbs. for the shunt.
100 hemispherical-headed solid shot weighing 100 lbs. for each gun.
60 ogival-headed shells weighted up to 100 lbs. for each gun.

All had a windage round the body of ·08 in. when the shot were rammed home, but the taper in the bore of the shunt reduced this to ·04 in. at the muzzle of that gun.

The 100 shot weighing 110 lbs. were not fired in competition, but the results are recorded in Table II. Tables III. and IV. record the comparative results of the 100 lbs. shot and shell practice, respectively; and Table VII. the comparative facility offered by the form of groove for rifling on each system.

TABLE II.

Practice with solid shot of 110 lbs. from the shunt gun, corresponding to the shot of the first delivery in Report 3575.

Date.	No. of rounds fired.	Charge. Diameter of cartridge 6·5 inch.	Corrected elevation.	Time of flight corresponding to mean range.	Ranges.			Mean difference of range.	Mean observed deflection.	Mean reduced deflection.
					Min.	Max.	Mean.			
		lbs.	° ′	sec.	yds.	yds.	yds.	yds.	yds.	yds.
13.* & 14. 2. 65.	10	25	2 14	3·56	1,339	1,447	1,399	29·6	5·8	1·0
14. 2. 65.	10	in. 21·9	5 8	7·30	2,440	2,648	2,578	39·2	26·0	2·6
"	10	"	10 5	13·00	4,025	4,197	4,108	54·0	80·5	8·6
"	3†	"	2 0	—	—	—	—	—	—	—
"	10	lbs. 20	2 15	3·39	1,266	1,371	1,315	24·5	5·6	0·6
"	10	in. 19·4	5 8	7·02	2,349	2,491	2,417	32·7	22·7	1·9
"	10	"	10 5	12·65	3,827	3,953	3,900	27·7	72·1	9·9
"	3†	"	2 0	—	—	—	—	—	—	—
"	10	lbs. 12	2 19	3·01	1,003	1,063	1,033	16·4	4·2	0·8
"	10	in. 6·9	5 10	6·30	1,965	2,074	2,034	25·5	19·9	2·7
"	10	"	10 6	11·48	3,300	3,409	3,364	29·8	53·9	6·7
"	3†	"	2 0	—	—	—	—	—	—	—

* One round only was fired on the 13th. † Fired for initial velocity.

Table III.

Practice with solid shot of 100 lbs. from both guns, corresponding with the shot of the last delivery, Report 3575.

Date.	No. of rounds fired.	Gun.	Charge.	Corrected elevation.		Mean recoil on wet or damp platform.	Time of flight corresponding to mean range.	Ranges.			Mean difference of range.	Mean observed deflection.	Mean reduced deflection.
								Min.	Max.	Mean.			
			lbs.	°	′	ft.	sec.	yds.	yds.	yds.	yds.	yds.	yds.
7. 3. 65.	10	French	25	2	14	5·1	3·61	1,393	1,500	1,440	25·4	8·4	1·2
6. 3. 65.	10	〃	〃	5	8	7·2	7·62	2,640	2,716	2,668	17·0	29·9	2·4
7. 3. 65.	10	〃	〃	10	4	4·0‡	14·49	4,455	4,600	4,533	37·6	152·3	4·6
9. 3. 65.	3*	〃	〃										
7. 3. 65.	10	〃	20	2	15	4·7†	3·46	1,278	1,363	1,336	20·4	8·4	0·7
6. 3. 65.	10	〃	〃	5	8	5·0	7·39	2,510	2,595	2,537	26·8	20·9	6·0
7. 3. 65.	10	〃	〃	10	5	3·4	14·04	4,225	4,470	4,360	60·6	147·4	6·5
9. 3. 65.	3*	〃	〃										
6. 3. 65.	10	〃	12	2	19	3·3‡	3·05	1,025	1,118	1,064	20·9	5·9	0·9
〃	10	〃	〃	5	9	3·0	6·84	2,152	2,312	2,214	47·8	15·6	2·0
〃	10	〃	〃	10	6	3·2†	12·29	3,500	3,679	3,610	49·7	91·7	6·8
9. 3. 65.	3*	〃	〃						means	2,640	34·0		3·5
7. 3. 65.	10	Shunt:	25	2	13	3·8†	3·71	1,426	1,537	1,485	26·9	13·1	2·0
6. 3. 65.	10	〃	〃	5	7	4·4‡	7·57	2,623	2,837	2,715	60·1	41·9	4·6
7. 3. 65.	10	〃	〃	10	5	3·3‡	13·47	4,324	4,452	4,367	30·1	155·7	7·3
9. 3. 65.	3*	〃	〃										
7. 3. 65.	10	〃	20	2	14	4·0‡	3·67	1,365	1,450	1,415	23·1	11·4	1·2
6. 3. 65.	10	〃	〃	5	8	4·5	7·43	2,524	2,776	2,610	49·9	25·0	2·7
7. 3. 65.	10	〃	〃	10	5	2·6	13·11	4,195	4,286	4,224	19·3	152·6	7·8
9. 3. 65.	3*	〃	〃										
6. 3. 65.	10	〃	12	2	18	2·9‡	7·11	1,041	1,150	1,094	21·1	7·4	2·0
〃	10	〃	〃	5	9	2·2	6·76	2,120	2,288	2,186	44·5	22·0	5·0
〃	10	〃	〃	10	6	2·3†	11·84	3,414	3,613	3,531	46·9	94·1	3·9
9. 3. 65.	3*	〃	〃						means	2,625	35·8		4·1

* Fired for initial velocity. † Mean of 9, 1 not observed. ‡ Mean of 8, 2 not observed.

Table IV.

Practice with common shells of 100 lbs. from both guns, corresponding with Table I. of this Report, except that the shells had an ogival form of front.

Date.	Gun and charge.	No. of rounds fired.	Corrected elevation.	Mean windage over body of shell.	Mean recoil on a dry platform.	Time of flight corresponding to mean range.	Ranges. Min.	Ranges. Max.	Ranges. Mean.	Mean difference of range.	Mean observed deflection.	Mean reduced deflection.
			° ′	in.	ft.	sec.	yds.	yds.	yds.	yds.	yds.	yds.
6. 4. 65.	French 7-in. M. L. 20 lbs.	5*	2 0	0·09	—	—	—	—	—	—	—	—
"		15†	2 14	"	3·9	3·68	1,387	1,462	1,429	11·9	0·8	0·8
"	"	20	5 7	"	3·3	7·40	2,705	2,800	2,748	21·6	2·4	1·9
"	"	20	10 4	"	2.5	13·32	4,484	4,648	4,553	35·0	24·1	5·6
"	Shunt 7-in. M. L. 20 lbs.	5*	2 0	0·065	—	—	—	—	—	—	—	—
"		15†	2 14	"	6·2	3·47	1,400	1,540	1,450	33·9	0·6	0·5
"	"	20	5 7	"	5·2	7·41	2,744	2,882	2,809	32·3	5·6	2·1
"	"	20	10 4	"	4·6	13·36	4,516	4,676	4,588	44·9	32·5	6·2

* These shells filled with powder and plugged, were fired out to sea, to ascertain if they would burst; none did so.

† The means are of 14, one shell of each kind having broken up at the muzzle of the gun.

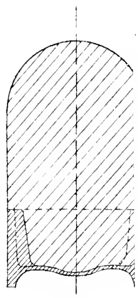
The loading with the French gun, as noticed in previous reports, was somewhat easier than with the shunt.

The iron traversing platform was observed to shake more than the one the shunt gun was mounted on; the only cause to be assigned for this is the extra weight of the French gun.

9. An inspection of Tables III. and IV. will shew that in the solid shot trial the French had a slight advantage both in range and accuracy; and that in the shell practice the shunt had a slight advantage in range although the French still maintained its general superiority in accuracy. During the practice the men employed in loading were interchanged occasionally, and their opinion was asked as to the comparative facility of loading in the two guns, it was on the whole expressed in favour of the French gun, but the difference was not great, and there was no real difficulty with either gun.

10. The initial velocities given by the two guns appears practically alike, for although the French has the advantage with 12 lbs. charge, the shunt has the best of it with 20 lbs. and 25 lbs., but it had by accident the benefit of a shot with slightly less windage than the other.

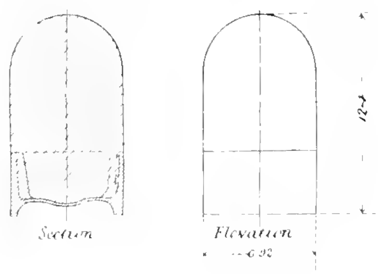
JEFFERY SH(



Section

Jeffery Shot for 7 inch M L Guns

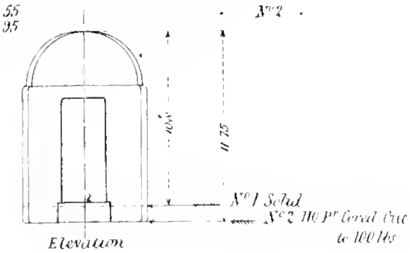
Weight 110 lbs



Lancaster Shot for 7 inch M L Guns

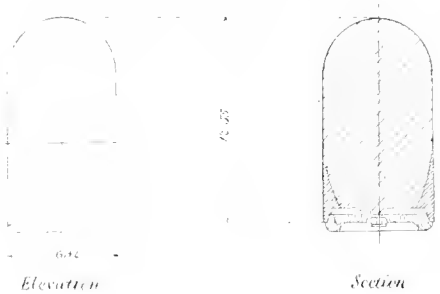
Mean Diameters
Major Axis 7.55
Minor " 6.95

Weight No 1 100 lbs
" No 2 "



Britten, Shot for 7 in. M L. Guns

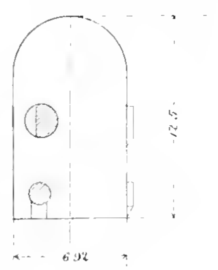
Weight 110 lbs



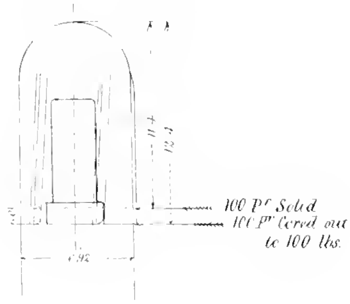
French Button Shot for 7 inch M L. Guns.

Zinc Studs

Weight 110 lbs

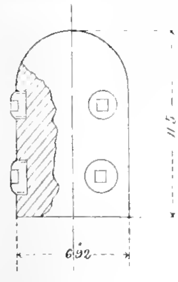


Scott, Shot for 7 inch M. L. Gun



Palliser, Shot for French 7 inch M L Guns

Weight 100 lbs.



Scale $\frac{1}{10}$.

To accompany Report No.

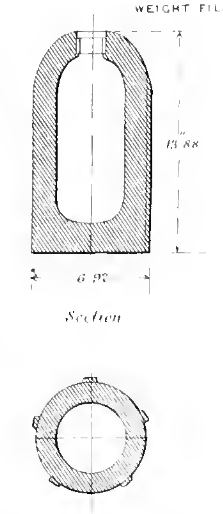
SCOTT, SHE

SCALE $\frac{1}{10}$

To accompany Report No. 3730 1 5/83 Minute 15,137. 80/8.3/77c

SCOTT, SHELL FOR 7" M L GUN.

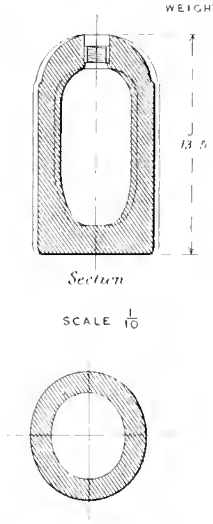
SCALE 1/10 WEIGHT FILLED 100 LBS



LANCASTER SHELL FOR 7" M L GUNS

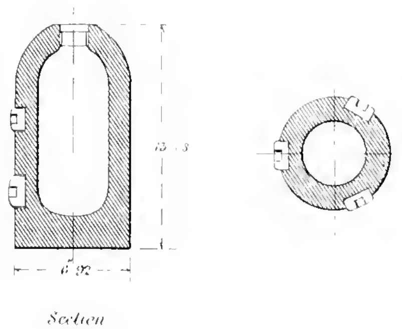
MEAN DIAMETERS
Major Axis 7.55
Minor „ 6.95

WEIGHT 100 LBS FILLED



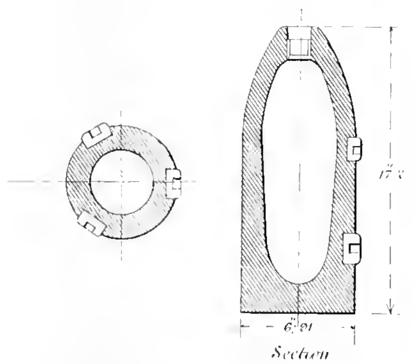
SHELL FOR FRENCH 7" M L GUN

SCALE 1/10 WEIGHT FILLED 100 LBS



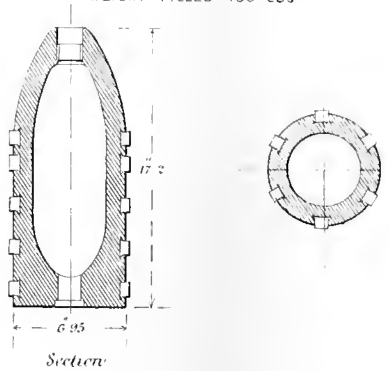
COMMON SHELL FOR 7" FRENCH M L GUN OF 149 CWT

SCALE 1/10 WEIGHT FILLED 99 LBS 4.07



COMMON SHELL FOR 7" SHUNT M.L GUN. OF 139 CWT

SCALE 1/10 WEIGHT FILLED 100 LBS



Par. & Son (Limited) Lith.

Table V.

OBSERVED VELOCITIES.

Gun.	Charge.	Cartridge. Length (without wad.	Cartridge. Diameter.	Projectiles. Weight.	Projectiles. Diameter.	Brand of powder.	Observed velocity at 40 yds. 1	Observed velocity at 40 yds. 2	Observed velocity at 40 yds. 3	Mean observed velocity at 40 yds.	Calculated mean initial velocity.	Remarks.
	lbs.	in.	in.	lbs.	in.		ft.	ft.	ft.	ft.	ft.	
7-in. shunt.	12	12·0	6·5	109·40	6·96	Rifle, L. G. Lot 728	1177·3	1207·1	1221·4	1201·9	1209·0	A grummet wad of 1·9 in. thick attached to each cartridge.
"	20	17·5	"	"	"	"	1432·6	1415·7	1420·0	1422·8	1432·0	
"	25	20·0	"	"	"	"	1485·3	1503·6	1511·3	1500·1	1510·0	
"	12	12·0	"	99·50	"	Lot 725	1277·8	1273·1	1269·6	1270·2	1279·0	
"	20	17·5	"	"	"	"	1508·2	1489·8	1512·9	1503·6	1515·0	
"	25	20·0	"	"	"	"	1563·9	1557·4	1557·4	1559·6	1571·5	
7-in. French	12	12·0	"	100·00	6·91	"	1274·2	1286·1	1294·4	1284·9	1293·4	
"	20	17·5	"	"	"	"	1474·9	1461·6	1483·9	1473·5	1484·0	
"	25	20·0	"	"	"	"	1536·5	1542·9	1534·9	1538·1	1549·2	
12-pr. Armstrong B.L. standard gun	1·5	...	...	11·75	3·074	Lot 728	...	...	...	1193·2	1206·0	Mean of 5 rounds.
"	"	...	...	"	"	Lot 725	...	...	...	*1148·3	1158·0	do.

* Velocity at 100 ft.

11. It appears from a comparison of cost of projectiles as submitted by Sir William Armstrong for his pattern, with the estimate of Superintendent Royal Laboratory for similar projectiles made by him for the French gun, that the former cost about 1s. 6d. a piece less than the latter, but as before stated this difference would probably be reduced by further experience in the manufacture of French projectiles.

Table VI.

COST OF COMMON SHELLS.

		Per 1000. £	s.	d.
Royal Laboratory Estimate.	Lancaster's	522	10	6
	Scott's	525	10	10
	French with Major Palliser's studs of the present size	602	5	7
	French same form as shunt	634	12	10
If made in R.L. upon the assumption that the relative cost is 10 per cent less than that of the 7-in. B.L. shells.	Armstrong's shunt	522	0	0
E.O. Co. Estimate.	Armstrong's shunt	663	14	0

12. The following Table shews the comparative facility offered by the form of groove for rifling on each system.

TABLE VII.

Nature of Rifling.	No. of guns per week.	Cost per gun.	
		£ s.	The number of guns per week being estimated for 10 rifling machines working 13 hours per diem. The calculations are based also upon the present capabilities of the Royal Gun Factories.
Scott's...............	10	4 5	
French	8	5 8	
Shunt 6 grooves...	4	10 16	
Lancaster's.........	2½	17 10	

13. The shooting qualities of these guns are so nearly alike that the Committee feel that they may rest their recommendation of the one or the other system upon other and more general considerations, and they have finally determined to record their unanimous opinion in favour of the so-called French system; 1st, because of the simplicity of its studding on the projectiles; 2ndly, the simplicity of the grooving of the gun; and 3rdly, from a disposition to admit the advantages of an increasing over a uniform spiral, which has been strengthened by the present trial. This advantage can best be realized with a short bearing on two points. On the first of these heads it will suffice to say that in the French shot there are but six studs, whilst in the corresponding shunt shot there are thirty. It is true that the six studs are all at present screwed in, and the thirty studs of the shunt projectile are fixed by pressure only; but the Committee do not think that this difference in mode of attachment can, as a question of manufacture, outweigh the difference of number, especially if their size should be hereafter reduced.

14. The Committee recommend that the heavy 7-in. guns now in course of manufacture should be rifled in the same manner as the competitive so-called French gun, except that the width and depth of the grooves should be slightly decreased, which will permit a reduction of the size and consequent cost of the studs; and if the exigencies of the service would allow of three weeks delay, they would be glad to fire 20 rounds solid shot and 20 shells from the first gun finished in this modified form, before the others are taken in hand.

15. The Committee recommend that the competitive shallow grooved gun, which has been ordered to be bored up to 8-in. should be immediately rifled in three grooves, with an increasing twist ending with one in forty; that fifty rounds solid shot and fifty shells be fired from it; and if successful, that the 8-in. guns ordered for the navy be rifled similarly.

16. The two 9-in. rifle guns of cheap construction being already rifled on the shunt plan, the Committee recommend that one of the 9-in. guns, which are now awaiting a decision as to rifling, be rifled on the French system for comparison, and that if there should be no material difference in the shooting of these guns, the remainder be rifled on that system.

It appears unnecessary to carry provision at present beyond the 7-in., 8-in., and 9-in. calibres. The decision respecting any larger natures that may be hereafter ordered can await the result of the present trial; but the Committee must express the hope that this trial will be considered final. If the so-called French system should fail in larger calibres, the natural course would be to fall back on Sir William Armstrong's, which holds the second place; which has been more thoroughly studied and worked out than any other; and through a wider range of calibres—which is actually in the service in the muzzle-loading 64-pr. guns—and to which so many of our existing experimental guns of large calibre, the 600-pr., 300-pr., 9·22-in. or 220-pr., are conformed. To throw away the experience gained with these guns, and the expense incurred in the preparation of patterns and means of manufacture, without good cause, would be to postpone, unnecessarily, the great desideratum of a settled system, and plunge anew into tedious and costly experiments on a mere hypothesis of improvement.

17. Under the head of "Endurance" in their preliminary report, the Committee called attention to the peculiar eating away of the centre of the powder chamber which had taken place in these guns.

They now attach, for record, the report of the Inspector of Ordnance on their present condition, observing as implied previously—that owing to the varying qualities of steel—they do not think any conclusive opinion as to the comparative durability of guns rifled on these systems, can with justice be determined by the trial they have undergone, although the general result points to the probability that with such heavy charges as have been used on this occasion the tubes of guns of large calibre will not last longer than 500 rounds.

The description and total number of rounds fired from each gun, to the present date, is as follows:—

Charge.	French.	Shunt.	Scott.	Lancaster.
lbs.				
25	123	66	84	83
20	322	126	236	236
12	122	66	97	97
Totals	567	258	417	416

The projectiles varied in weight from 110 lbs. to 100 lbs.

(Signed) L. G. HEATH,
Captain, R.N.,
Vice President.

REPORT

OF

ORDNANCE SELECT COMMITTEE.

No. 3841. Dated 21st July, 1865.

7″ M. L. WROUGHT-IRON (COMPETITIVE) GUNS RIFLED ON DIFFERENT SYSTEMS. (3rd Report).

[Communicated by direction of the Secretary of State for War].

The Committee have the honor to report, that in the course of the trials of the competitive 7-in. M.L. wrought-iron guns rifled upon different systems, a question arose, having reference to the relative serviceability of the projectiles of the different systems, viz. whether the studs of such projectiles as required them, for example, on the shunt or "Woolwich" systems, would become loosened by the corrosive action of salt water, which cannot at all times be kept from them in the naval service.

With a view to determine this point, the Committee forwarded three shot fitted with studs, which had been recovered from the range at Shoeburyness, to the chemist to the War Department, who submitted them to the following severe trial.

The lacquer was first removed from the lower portion of the projectiles, and they were then alternately immersed in salt water and exposed to the air for three days at a time, for a period of two months, after which they were exposed to the air for about a month.

At the end of this trial no indication whatever was to be found of any of the studs having become at all loosened.

The Committee think that this result fully proves the serviceability of studded shot for sea service, and their freedom from any special liability to deterioration by being kept in store: and considering the circumstances of the trial, they are of opinion that shot of uniform exterior such as those of Whitworth or Lancaster, are likely to have no advantages over studded shot as regards their resistance to the action of salt water.

(Signed) J. H. LEFROY,
Brigadier-General,
President.

Hardness of Studs.

Copy of a Report from the Superintendent, Royal Gun Factories.

ROYAL GUN FACTORIES,
Woolwich, 17. 7.'65.

SIR,

With reference to your letter of 3rd June 1865, Min. 15,560, I beg to forward copy of Report of Experiments made to show the hardness of the metal for studs of 7-inch projectiles, and to request that the specimens be carefully returned.

I have, &c.
(Signed) F. A. CAMPBELL, Col. R.A.,
Superintendent.

Dimensions of Specimens. ·″375 square and ·″75 long.

Nature of projectile.	Nature of metal for studs.	Register No.	Mark of specimen.	Weight applied. Tons per square in.	Permanent compression in inches.	Remarks.
Sir William Armstrong's shunt (100 lbs).	Copper	7075	1	10·44	·0005	
				15·5	·001	
				17·08	·003	
				20·09	·038	
				30·06	·272	
"	"	7076	8	16·12	·001	
				17·72	·0035	
				20·09	·0395	
				30·06	·2965	
French (110 lbs.)	Zinc	7077	121	5·06	·0035 }	On this weight being applied the specimen was broken.
				17·08	... }	
" "	"	7078	125	4·11	·003	
				10·44	·2065	
" (100 lbs.)	"	7079	225	4·74	·0035	
				10·44	·194	
" "	"	7080	226	3·8	·0035	
				10·44	·154	
Major Palliser's (100 lbs.)	Gun metal	7081	0	7·91	·001	
				12·18	·0035	
				20·09	·03	
				30·06	·085	
				40·1	·1375	
				50·0	·1875	
				6·8	·001	
"	"	7082	26	10·11	·0035	
				20·09	·053	
				30·06	·114	
				40·1	·1685	
				50·0	·2205	

It does not follow that the hardest metal will offer the maximum resistance to abrasion; probably the zinc when rubbed against another metal through the medium of a lubricant under a pressure less than its elastic resistance may be the best to resist abrasion.

(Signed) F. A. CAMPBELL, Col. R.A.
17. 7. '65. *Superintendent.*

To the Secretary O. S. Committee.

ON THE CONSTRUCTION OF OUR IRON-CLAD FLEET, AND A FEW REMARKS ON

IRON SHIELDS FOR COAST BATTERIES.

BY

CAPTAIN A. HARRISON, R.A.

Although the results of the various experiments which have taken place at Shoeburyness on iron-plated targets have been recorded in the "Proceedings" from time to time, I think that a general description of the several plans which have been adopted in the construction of our armour clad fleet may, notwithstanding, prove of interest.

Hardly a day passes without some allusion being made in the public prints to one or more of our iron-clads, and I therefore hope, that with the aid of a few drawings, this paper may be useful in enabling any officer, who is interested on the subject, to acquaint himself with what has been doing regarding the reconstruction of our navy, and towards obtaining the requisite protection, for our guns and gunners, from the large projectiles which will undoubtedly be used in all future warfare.

No decision has yet been arrived at relative to the plan of iron defence best adapted for coast batteries, but two of those which have been tested (Thornycroft bars and Captain Inglis's shield), have been so favourably reported on that it seems probable they may be ultimately selected for the protection of the embrasures of our fortifications. I shall therefore give a short description of each system, notwithstanding that they are still on the experimental list.

The ship targets to which I shall allude are the following:—

"Warrior," "Minotaur," "Bellerophon," "Lord Warden," and "Small Plate."*

The history of the employment of iron for defensive purposes in the shape of armour plates, has been so often related of late years in Professional Papers, Pamphlets, &c., that very few words on this part of the subject will here suffice.

Mr Holley† asserts that "the first authenticated experiments with artillery upon iron armour, were made by John Stevens, Esq., of Hoboken, United States, during the war of 1812." The exact nature of these experiments is not stated, but Mr Holley informs us that "Mr Stevens then proposed, for the defence of New York, a vessel to be propelled and rotated (to train the guns) by steam, and to be clad with inclined iron armour." I think, until this

* The description of this target does not strictly come within the province of this paper, as it is not a plan of armour plating adopted in the construction of our iron-clad fleet, but, as the plan has been largely employed in the French iron-plated ships, it is of comparative interest in considering the systems adopted in our navy.

† "Ordnance and Armour," by A. L. Holley, B.P.

statement was published, Colonel Paixhans was generally credited with the earliest suggestion of employing iron armour for the protection of ships.

In *Nouvelle Force Maritime*, a book published by Colonel Paixhans at Paris in 1821, that officer speaks of having made an experiment with a 24 lb. shot against iron armour in 1809, and after remarking on the results obtained from some subsequent experiments, he asks:—

" Quelle armure faudrait-il donc pour arrêter un boulet massif de 80 livres, tiré de près à forte charge? Et comment surtout arrêterait-on les bombes et les boulets massifs du calibre de 150?

The replies he gives to these questions are as follows:—

" Cependant, aprés avoir examiné ces faits et quelques autres, je pense qu'on peut regarder la résistance comme praticable au moyen d'un solide arrangement des parties métalliques; mais qu'on ne doit pas s'attendre à pouvoir lutter contre d'aussi grands chocs, à moins d'une épaisseur de fer de 7 à 8 pouces...........mais nos vaisseaux à trois ponts...........pourront porter cette lourde armure,...... .. en leur donnant 6 à 8 canons à grosses bombes, ils auraient une incomparable force pour tout détruire."

And again,

" Quels que soient, au reste, les moyens que l'expérience fasse trouver et adopter à cet égard, on aura toujours, pour le cas particulier de la guerre défensive, une excellente occasion d'employer les armures métalliques; ce sera de les appliquer sur de vieux vaisseaux rasés.........cette même question se résoudra encore d'une autre manière. On construira des bâtimens tout en fer;.........assez forts dans leur œuvre morte, pour arrêter les coups de l'artillerie."

In the following chapter Colonel Paixhans speaks of the nature of ships which will be required.

"Les bâtimens de guerre à vapeur.........pourraient être de deux modèles différens: un léger, non à l'epreuve de l'artillerie, et un autre fortement cuirassé.. ...

Celui sans armure devrait.........être aussi petit que le permet la condition de naviguer avec sûreté et avec vitesse. Il serait armé de quelques canons-à-bombes qui le rendraient redoutable de fort loin.

" L'autre bâtiment à vapeur.........chargé d'une armure.........n'aurait pas non plus une artillerie aussi nombreuse.........il réunirait les divers avantages offensifs et défensifs que peuvent donner les machines à vapeur, les armures métalliques, et les canons-à-bombes.

I have quoted thus largely from Colonel Paixhans book, as that officer seems to have predicted in the most striking manner what is now taking place in the reconstruction of the navies of the world. That is to say:—

(1) The employment of armour 7 or 8 inches thick. The battery of the "Bellerophon" has 7½ inches of iron in her side, 6 inches of it being in a solid plate.

(2) Two classes of vessels, the small one unprotected, accompanied by the large armour-clad.

(3) The conversion of wooden three deckers into smaller vessels, armour plated.

(4) The construction of iron vessels, instead of wooden ones, taking care also to protect them with armour.

And lastly, the reduction of the number of guns, owing to their greater power; and,—if we may consider our heavy guns as *canons-à-bombes,* which they in reality are of a most powerful description,—I think it will be admitted that the suggestions made by Colonel Paixhans in 1821, are being adopted in the most complete manner in 1865.

The first practical test to which armour clad vessels were put was in the case of the floating batteries which were employed by the French in the attack on Kinburn, in October 1855; these vessels, three in number, were protected by 4½-inch plates, and engaged the Russian batteries for some hours, at 600 or 700 yards range, and although repeatedly struck by shot they were but slightly injured,* and the only loss to the crews is said to have been occasioned by the entrance of some few shot through the ports.† The Russians however had no heavier guns than 32-prs., and the shot were cast-iron.

This practical experiment proved the utility of protecting ships with iron armour, and if this protection was necessary in 1855 against 32 and 68-prs. much more so is it in 1865, when ships are being armed with 12-ton guns, and forts with some guns even of 22 tons weight. Doubts are sometimes thrown, by the lovers of our old wooden walls, on the utility of armour plating,‡ now that thick armour plates can be penetrated by steel shell; but in my opinion even the universal adoption of this special projectile, will not in any way lessen the necessity for iron armour-clad vessels, for it is certain that wooden ships would be speedily sunk or burnt by modern

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* The following extracts from Official Reports of Officers of the U.S. Navy, published in the Annual Report of the Secretary of the U.S. Navy, shew that the use of cast-iron projectiles against iron-cased vessels, at close quarters, is likely to be more injurious to assailants than assailed. In the attack on the "Albemarle" confederate ram by the federal gunboats, on the 19th April 1864, "Lieut. Commander Flusser fired the first shell at her, and upon its bursting some fragments, either from this or the 'Southfields' shells rebounded and caused the death of Lieut. Commander Flusser, also wounding the officers and men below mentioned..........."

Again,

"A shell from gun No. 3 struck the ram, rebounded and exploded, cutting away port forward boat davit, and fragments passing through deck forward of the boiler and starboard waist, and cutting away port smokestack guys and passing through smokestack..........."—Report on damage received by U.S. steamer "Miami" in engagement in Albemarle Sound, 5th May, 1864.

"Acting Ensign Mayer sent a 100-pr. solid shot at her port, which broke into fragments, one of which rebounded and fell on our deck..........."—Report of Lieut. Commander Roe in command of "Sassacus" in attack on "Albemarle."

The following directions were subsequently given by Rear Admiral Lee regarding the plan of attacking the "Albemarle:"—"Your guns should have double breeching, and be loaded with heavy charges (say from 15 to 18 lbs. of powder for the 9-inch guns) and solid shot, and they should be so depressed as to fire as near a perpendicular line to the slope of the roof as practicable. If all hands lie down when the guns are fired, they will escape the rebound of broken parts from the shot. At the time of this attack if some shell were thrown down the ram's smokestack, she might thus be disabled."—Letter from Rear Admiral Lee, 23rd April, 1864.

† The ports of the English iron-clads (with the exception of the "Bellerophon" class which have to carry the heaviest ordnance), have been much reduced in size since this date, the main deck ports of the wooden ships measured 2′ 11″ in depth by 3′ 6″ fore and aft; this has been altered to 3′ 8″ × 2′ in the case of the "Warrior," "Resistance," &c., 3′ 8″ × 2′ 4″ in the "Lord Warden," "Pallas," &c., but the main deck ports of the "Bellerophon" are 4′ × 2′ 9″; the French, adhered to the large port holes, which were in fashion in the days of smooth-bore guns, in the early specimens of their iron-clad fleet, but in their newest ships they have likewise reduced the area of the port-holes.

‡ See Appendix A, p. 437.

artillery, whilst iron-clads are, at any rate, free from the latter eventuality; and again, iron-clads, such as those in our navy, could run the gauntlet of forts armed with any guns lighter than those of 10 or 12 tons, whilst we learnt at Sebastopol that a crew could be driven out of a wooden ship by cast-iron shells fired from 8″ or 10″ cast-iron guns.

Lord Clarence Paget in moving this year's navy estimates in the House of Commons, made the following statement regarding our iron-clad fleet:*—

"Our armour-plated fleet may be classed as follows:—We have seven ships of very great speed, but having a very great draught of water, and therefore they cannot be docked out of this country. This class consists of the "Warrior," "Black Prince," Achilles," "Minotaur," "Agincourt," "Northumberland," and the "Bellerophon." The second class consists of seven vessels possessing less speed, but also drawing less water, and their names are the "Lord Clyde," "Royal Oak," "Prince Consort," "Ocean," "Caledonia," "Royal Alfred," and the "Lord Warden." The third class consists of the "Zealous," "Hector," "Valiant," "Defence," and the "Resistance," of still less speed and draught. We have therefore, a total of 19 armour-plated ships of the line. The next in order on the list are the frigates and corvettes—namely, the "Favourite," "Research," "Enterprise," "Pallas," "Viper," "Vixen," and the "Waterwitch," and then we come to four ships which will be invaluable for coast defences—namely, the "Royal Sovereign," "Prince Albert," "Scorpion," and the "Wyvern," making altogether a total of 30 armour-plated ships."

The Warrior.†

The "Warrior" is an iron ship of 6109 tons and 1250 horse power, is 380 ft. in length (between perpendiculars) and has 40 guns, her draught of water is 26 ft. She is only protected for a length of 208 ft. or 26 guns, thus leaving 80′ forward, 90′ aft, and 14 guns unprotected; the unprotected portion is $\frac{5}{8}$″ iron. The cost of the hull and fittings was £286,285.

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* The iron-clad fleet of the United States Navy, number 62 vessels, carrying 189 guns, but out of this number only five are sea going ships, viz. the casemated vessels "Dunderberg," and "New Ironsides," carrying 14 guns each; two turret vessels "Dictator," and "Puritan," and the "Roanoke," one of the old frigates which has been armoured; the three last named carry 12 guns. —"Report Secretary U.S. Navy," December 1864.

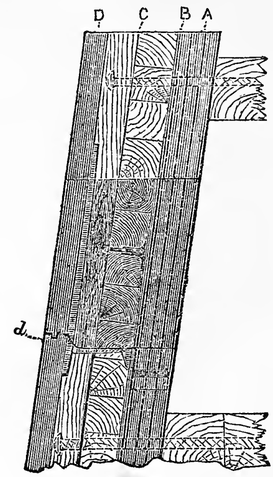
The iron-clad fleet of France consists of 29 vessels; out of this number 17 are sea-going ships, only two of which are iron. The French are the only nation possessing two-decked iron-clads.

† In "Ordnance and Armour," an American book by Alexander L. Holley, I find it stated that a "Warrior" target was tested at St Petersburg on 17th October, 1863, the 4½″ plates of the target having been supplied by Messrs John Brown & Co., of Sheffield. The gun used was a 9 inch, firing steel shells of 270 lbs. weight, with a burster of 8 lbs., the charge 50 lbs., range 700 ft.

The shells were of two qualities, one from Krupp, the other from a Mr Povtieloff, in Finland. Three of Krupp's were filled with sand, and broke up after passing through the plates, making each a hole 10½″ × 9½″, two were fired live, they made a slightly larger hole. Two of Mr Povtieloff's shell penetrated the target without breaking up and a *cast-iron* shell, which was fired, went through the plate similarly to Krupp's, and was crushed by the concussion. "The conclusion arrived at was that the cast-iron shell was, as against armour plates, equal to Krupp's steel shells in penetrative power, but not equal to Povtieloff's, and that the penetrative power of Povtieloff's compared with Krupp's was as 5 to 3."

There is no instance in this country of a *cast-iron* shell having penetrated a 4½″ plate on "Warrior" backing.

The "Warrior" target represented a midship section of the ship which, by reference to the accompanying drawing, it will be seen is of the following construction.



Ribs (*A*), about 2 ft. apart, 10 inches deep made up of $\frac{1}{2}''$ web and angle-irons $4'' \times 3\frac{1}{2}'' \times \frac{5}{8}''$, outside these the skin (*B*) $\frac{5}{8}''$ thick in two plates, then 18″ of teak backing (*C*), in two layers, the inner layer 10″ thick and placed horizontally, the outer layer 8″ thick, and placed vertically. The armour plates (*D*) of hammered iron $4\frac{1}{2}''$ thick, with tongues and grooves as shown at (*d*), were secured to the skin by $1\frac{1}{2}''$ through bolts, in the proportion of one bolt to about $3\frac{1}{4}$ ft. superficial of the ship's side.

The weight per superficial foot of the target was 341 lbs.

The results of the firing at this target are recorded at pp. 43, 89 of Vol. III. of the "Proceedings," and it will therefore be sufficient here to state that at 200 yards range the target was not penetrated by spherical cast-iron shot of 150 lbs. weight fired from a 10·5″ gun with 50 lbs. of powder (the heaviest shot and charge used in the experiment), but, where two shot of this nature and weight, only fired with a 40 lbs. charge, struck close together on a weak spot, viz. at the junction of two plates, the skin was *penetrated* by splinters of shot and backing. The total weight of shot which struck the target was 3979 lbs. The chief faults which this experiment brought to light were 1st, the insufficient diameter of the armour plate bolts, and 2nd, the disadvantage of tongueing and grooving armour plates; the latter arrangement,—which not only weakens each particular plate when struck by shot, but also assists in damaging the adjoining plates; and in addition renders it very difficult, if not quite impossible, to replace a damaged plate,—was, therefore, at once condemned and discontinued, whereby considerable extra expense is saved. All armour plates are now made with plane edges.

Since the date of the experiments above referred to, several targets of the "Warrior" construction have been fired at with various experimental guns and projectiles, and these experiments, which are all recorded in the "Proceedings,"* show that a ship of the "Warrior" construction is no longer impenetrable, even at 2000 yards range, when steel projectiles are used with a 600-pr.

The "Defence," "Resistance," "Black Prince," "Hector," "Valiant," and "Achilles," are of the "Warrior" class, in so far as regards the thickness of armour and backing, but the three last named differ slightly from the "Warrior." The armour of the "Achilles" does not differ from that of the "Warrior" on the main or gun deck, but is continued to the bow and stern below the gun deck; whilst in the "Hector" and "Valiant" the main deck batteries are entirely plated, but a portion at each end below the main deck is left unprotected.

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* Vide pp. 63, 176.

Minotaur.

The "Minotaur" class are the largest of the iron-clad fleet. Three vessels, the "Minotaur," "Agincourt," and the "Northumberland," are all that have been built of this class.

They are iron ships of about 6600 tons, and 1350 horse power, their length is 400 ft., they have about the same draught of water as the "Warrior," viz. 26 ft.; the two first named are pierced for 50 guns, but the "Northumberland" will only carry 26 heavy guns in a central battery, as with the "Bellerophon;" they are wholly protected.

No drawing of this class of vessel is necessary, as the only difference in the plan of armour-plating adopted in their construction, from that employed in the "Warrior" class, is occasioned by increasing the thickness of the armour plates* (1 inch), and reducing the teak backing (9 inches), so as to retain the same weight per foot superficial. The armour plates are thus $5\frac{1}{2}$ inches thick, and the teak backing 9 inches.

The armour plates of the "Minotaur" target were secured to the skin by three rows of bolts, the upper and lower rows being $1\frac{3}{4}''$ diameter, and the centre row only $1\frac{1}{2}''$.

The target was only struck by six spherical shot, viz. four from a 10·5″ 12-ton gun (three of cast-iron weighing 150 lbs. each, and one of wrought-iron weighing 162 lbs.), and one service, and one wrought-iron, shot fired from a 68-pr. service gun, the two last rounds having for object to test the quality of the plates.

It would not be safe to draw any positive conclusion from this experiment regarding the relative strength of the "Minotaur" and "Warrior" targets, for only one round which would furnish the required information, was fired at the former, $2A_4$ powder having been used with the subsequent 150 lbs. shot whereby the striking velocity was increased 120′, and the *work* in the shot by over 1,000,000 foot pounds.

The actual result of the comparative round at the two targets was as follows:—

"Warrior," total penetration 15″, skin slightly cracked.
"Minotaur," total penetration 13″, skin slightly cracked.

The effects being almost identical, but the fastenings suffered considerably more in the "Minotaur" than in the "Warrior."

The comparison, however, is not satisfactory in any way, for on the one hand the "Warrior" target had been much battered by previous firing before it was struck by the 150 lbs. shot, whilst the "Minotaur" was intact; but on the other hand the "Minotaur" was a few pounds per square foot lighter than the "Warrior," was of smaller area, and the armour plates were of bad quality.

A "Minotaur" target no longer exists, but if it is desirable that the relative strength of these targets should be decided, a few rounds of 150 lbs. shot fired with $2A_4$ powder at the "Warrior" target now at Shoeburyness would give this information.

This experiment confirmed the experience gained by the trial of previous targets, relative to the necessity of employing bolts of large diameter

* "In a letter dated Aug. 13th, 1841, written by the Messrs Stevens, of Hoboken, to a Government Committee on coast and harbour defences, a series of experiments is mentioned, and the following conclusions are given:......... 'it would appear that it takes wood 16 times the thickness of iron to offer the same resistance to a ball fired with a full charge. Four inches of wrought-iron, therefore, would be equal to 5 ft. 4 in. of oak........' "—"Ordnance and Armour." Holley.

for securing heavy armour plates to ship's sides. The Committee in their Report on the experiment state:—

"The defects of the fastenings were very apparent, as shown by the large number of bolts broken* (after the firing of only four rounds), thus causing the plates to buckle to such an extent, that in the case of a ship at sea they would soon roll off. The prevention of buckling is of very great importance, and the Committee are confirmed in the opinion they have expressed in their Report, viz. that 'the bolts used as fastenings should be *at least* two inches in diameter.'"

It is greatly to be feared that in the event of the early specimens of our iron-clad fleet being put to the practical test of war, the small bolts and the absence of elastic washers will be found very serious defects. It always struck me that the Portsmouth experiments led to a good deal of misconception on this part of the subject. Any one referring to the records of the Iron-plate experiments which have been carried on at Portsmouth and at Shoeburyness, will find that the endurance of the armour plate bolts is almost invariably favourably noted in the Portsmouth experiments, and almost invariably *un*favourably in all the earlier Shoeburyness experiments, although the diameter of bolt used was the same in both cases. I think this apparent discrepancy is easily reconciled when it is remembered that the iron plates at Portsmouth are always attached to *wooden* ships, whilst the experiments at Shoeburyness have been chiefly on targets with *iron* skins, the strain on the bolt being thus much greater in one case than in the other. It must, however, be remembered that the practical test, if one ever takes place, will be in many cases under the conditions tested at Shoeburyness, and it is therefore to be regretted that bolts of larger diameter and elastic washers were not earlier adopted; for experiments have proved that by using bolts of larger diameter ($2\frac{1}{2}$ or 3 inches) and elastic washers under the nuts a tolerably secure fastening can be obtained, and one which will prevent the buckling and distortion of the plates.

The next construction for consideration is that adopted in the "Bellerophon." But before passing on to a description of this class of ships it is desirable to notice some other experiments which were made at Shoeburyness between 7th July 1862, and 8th December 1863, the dates of trial of the "Minotaur" target, and of the "Bellerophon" target respectively.

We have seen that the "Warrior" and the "Minotaur" are *iron* ships protected by iron armour plates on wooden backing, but at the date of the appointment of the Special Committee on Iron, no point was more in dispute than the combination of iron and wood in armour-clad vessels, as it was considered by many that the timber backing would soon rot,† and afforded at best but a bad support to the plates, and it was, therefore, argued that *iron* ships protected solely by *iron* plates, was the proper plan for armour-plated vessels.

The relative value, for resistance to projectiles, of wholly *iron* structures, and those with wooden backing, (such as the "Warrior"), could only be ascertained by experiment, for we find the names of Armstrong, Fairbairn, Samuda, Scott Russell, and others as advocates of the former, whilst those of Hardy (of the Thames Iron Works), Hewlett, Lancaster, and Mallet are on the side of the latter. This being the case several targets, composed wholly

* In a report by Commander Colhoun, U.S. Navy, to Rear Admiral Lee, dated June 23, '64, it is stated, "On the 21st instant, the "Saugus" was struck only once by a round shot near the centre of the deck, a few feet from the turret; thence glancing, it struck the turret, breaking six (6) bolts......"

† A plan has been tried of passing a gas flame over the surface of the timber previous to affixing the armour plates, with a view of preventing decay.

of iron, were constructed and tested in 1862–63; these were Mr Fairbairn's (two), Mr Scott Russell's, Mr Samuda's, and Mr Hawkshaw's (two).

The result of the experiments on some of these targets is recorded, in the "Proceedings,"* and it is sufficient here to state that, weight for weight, the wholly iron structure proved inferior, for resistance to projectiles, to the combination of iron and wood as adopted in the "Warrior."

It may be well to say a few words on Mr Hawkshaw's targets, for they were constructed on a plan which has found much favour in the United States of America, viz. the employment of laminated armour in lieu of thick armour plates.

Mr Hawkshaw's reason for approving this method of plating is thus explained by him:—

"He had designed two targets for the Iron-plate Committee, and in doing so, he had merely considered the best mode of structural arrangement. They were made of plates of such a size and thickness, as to prevent the joints from coming in the same line with each other, and to secure as nearly as possible, a perfect bond and a uniform strength throughout. The iron in the targets was also disposed in such a manner, that each plate should bear a strain, as nearly as might be, in all directions. He considered, that such a mode of construction would be that which would be most available for fixing armour plates to a vessel's side. But he was quite aware, and he had stated before the targets were made, that plates so laminated, would not be so successful in resisting shot, as if they were welded into one solid mass. On the other hand, such an arrangement of the plates afforded great facility of construction. By its means the thickness of the plating could be increased, or diminished as required, and the iron could be wrought into any form which might be thought desirable. A ship, or a fort, could thus be made more structurally perfect, than by any other system with which he was acquainted; and at present, he was not aware of any other plan so good for securing a homogeneous structure."

Mr Holley gives the following reasons for the adoption by the Americans of the "laminated" principle:—

"Laminated armour, takes hold of a large area of the ship's side, and has great continuity and tenacity compared with single rigid detached slabs, held each by its own fastenings without aid from the rest. In addition to this, laminated armour forms a practically continuous girder to resist the other strains brought upon the vessel............Americans having great guns and knowing their effects, at once selected laminated armour for the purpose of resisting *these effects*.........."

And again,

"The thin armour plates employed to give continuity to the side of a ship need not constitute the entire protection. The 14″ armour—six 1″ plates, one 4″ plate, and four 1″ plates—illustrates the principle of the "Dictator's" armour. The outer thin plates, breaking joints, may be compared to a continuous elastic skin which holds the thick resisting plates in their places. The inner thin plates are an elastic backing, which gives room for the thick plates to yield without breaking the ribs and prevents damage from splinters."

The Special Committee on Iron in reporting on one of Mr Hawkshaw's targets, stated that the damage was confined to a small portion round the spot where the shot struck, and considered that the plan afforded great facilities of construction, but they added that the targets "were found to be very weak in proportion to the quantity of metal they contained."

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* Vide Vol. III. pp. 44, 91, 99.

When it is remembered that the object of iron armour is to afford protection against projectiles, I think it will be evident that the rejection in this country of the system of laminated armour has been a wise decision. That the Americans themselves disapprove of this plan of armour plating, notwithstanding the large use which they have, from necessity, made of it, is tolerably evident from the orders which have for some time been given in this country for thick plates.

Lord Clarence Paget, in the House of Commons, on 23rd of February 1863, gave the following opinion regarding iron ships :—

"Undoubtedly, when we come to ships of very large tonnage, iron has the advantage. Wooden vessels are subject to great vibration when put to high speed, and this damaged them and caused them to decay......... In consequence of their fouling* they are not so useful as wooden ships, as long as the latter last......... As an argument in favour of iron vessels, I may say that Admiral Robinson, the Controller of the Navy, has gone very carefully into the average cost to the country of maintaining a wooden fleet, and he has come to the conclusion that for every man that you vote for the Navy you must put down £10 for the mere wages of artificers to keep the ships in repair."

Admiral Robinson, the Controller of the Navy, sets against the admitted advantages of iron ships,—

"The serious local weakness of the comparatively thin plates of which the bottom of an iron ship is necessarily composed; the danger, therefore, of getting on rocks in such ships."

The Special Committee on Iron considered the advantage of the "Warrior" wood backing† as fourfold.

(1) It stops small fragments of iron from entering the ship.

(2) If large pieces of the plate are broken off, it holds them in their places, and makes them still useful, to a certain extent.

(3) It deadens the jar, and so preserves the fastenings and the structure generally.

(4) It distributes the effect of the blow over a larger area of the skin and frame of the ship.

The Committee did not attach importance to wood as a *support* to the plates, conceiving that in this respect it is inferior to more rigid material.

Independent of the supporters of wholly iron *v.* iron with a wood backing, there existed certain gentlemen who, after studying the subject of armour

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* "Captain Cochrane (late in command of the 'Warrior,') has said that when six weeks afloat she (the 'Warrior') lost one knot an hour from fouling."—Lord C. Paget's speech, House of Commons, March 12th.

Rear Admiral Dahlgren in a report to the Secretary of the U. S. Navy, dated 4th November, 1863, states, "Since my last, our own part has still been restricted to the repair of the monitors and the cleansing of their bottoms, which had become so foul by the adherence of grass and barnacles as to reduce their speed from 6½ or 7 knots to 3½ and 4..........."

† There are two vessels in this squadron, which give proof of the value of heavy backing to iron. These vessels were built with heavy frames, covered on the outside with gutta-percha and then with a light thickness of iron. Whenever these vessels have been struck on the iron where the wood backing was heavy, they resisted the shot of heaviest calibre, but where the backing was light, shot went in at one side and out at the other. The defence of gutta-percha was not of the slightest use ; on the contrary it was a detriment, and aided very much in destroying the vessels by rot........."—Report of Rear Admiral Porter, U.S. Navy to the Secretary of the Navy, February 16, 1864.

plating, declared that the proper thing was a combined backing of wood and iron; and to test this principle two targets, Mr Chalmers' and Mr Clark's were constructed and experimented on in 1863.

The record of these experiments will be found in the "Proceedings,"* but I find from the Report of the Special Committee on Iron that the Committee considered the system of compound backing adopted in the "Chalmers" target of considerable advantage in adding strength and resisting power to the structure, and that it afforded great support to the armour plates and prevented buckling.

This construction, however, was not considered well adapted for ship building, and has therefore not been adopted. Mr Clark's target was very complicated in its construction and was not favourably reported on.

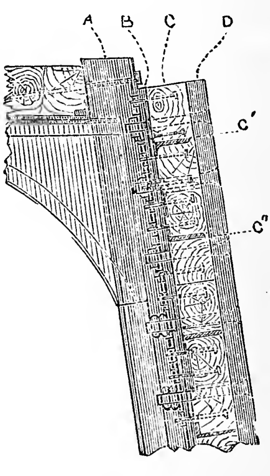
It will be seen from what I have stated, that up to this time three systems had been tested: (1) Iron armour plates on wood backing; (2) Structures wholly of iron; (3) Iron armour plates on a combined backing of wood and iron, and of these three, speaking only of their merits in resistance to projectiles, Class No. 3 are decidedly the best.

With this digression we may now pass on to a consideration of the "Bellerophon."

Until the introduction of very heavy guns and steel projectiles, the protection afforded by the "Warrior" was amply sufficient, but in order to enable defence to keep pace with attack it has become necessary largely to increase the thickness of armour. This necessity has led to the area of protection being reduced, and thus ships are now being constructed (the "Bellerophon," "Hercules," &c.) with square boxes, or turrets, and a belt of iron to protect the water line.

The "Bellerophon" is an iron ship of 4,246 tons and 1000 horse power, and is being constructed to carry 14 guns.

Her length is 300 feet, and her battery is about 90 feet in length; her armour extends all round the ship, as high as the main deck, and is carried up to the upper deck on the bow and the central battery; her draught of water is 21 ft. forward and 26 ft. aft.



The "Bellerophon" target was constructed to represent a portion of the side of the "Bellerophon" iron-cased frigate.

The construction is as follows:—

Ribs (A), 2 feet apart, made of an angle-iron $10'' \times 3\frac{1}{2}'' \times \frac{1}{2}''$ and two angle-irons $3\frac{1}{2}'' \times 3\frac{1}{2}'' \times \frac{5}{8}''$ riveted together; to the double angle-irons of this frame the skin (B), composed of two thicknesses of $\frac{3}{4}''$ plating, was riveted with a layer of painted canvas interposed. On the outside of the skin, horizontal angle-iron stringers, (C''), are attached, and the wood backing (C), $10''$ thick, is worked longtitudinally on the skin plating between the angle-iron stringers and is bolted with nut and screw bolts through the skin plating. The armour consists of wrought-iron rolled plates (D) $6''$ thick, secured with bolts $2\frac{1}{2}''$ and $2\frac{3}{4}''$ diameter.

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* Vide Vol. III. p. 316.

The weight of this target per superficial foot was considerably in excess of the "Warrior," being as 393 lbs. to 341 lbs.

This construction differs from the "Warrior" in the following particulars:

(1) An increase in the thickness of the armour plates from 4½″ to 6″.

(2) A reduction in the thickness of the backing from 18″ to 10″, the stringers being placed at much more frequent intervals and being made the same thickness* as the wood backing so as to come in contact with the armour plates.

(3) Increased thickness of skin.

(4) Increased diameter of armour plate bolts.

The detailed account of the result of the firing at this target is recorded in the "Proceedings,"† I shall, therefore, here only state that a total weight of 1525 lbs. of steel and cast-iron shot and shell struck the target at 200 yards range, fired from guns varying from a 68-pr. S. B. gun to a 10·5″ 12-ton rifled gun and with terminal velocities varying from 1000 to 1600 feet, the highest charge used being 35 lbs. The target was not penetrated, and the following seem to be the general results obtained from the experiment:—

(1) That armour plates 6″ in thickness, and of the largest required dimensions—(those in the "Bellerophon" measured 20′ 9″ × 4′ 3″ and weighed over 9 tons each)—can now be made of good quality.

(2) That a compound backing of wood and iron is advantageous, and

(3) That great benefit is obtained from using armour plate bolts of large diameter and elastic washers under the nuts.

This experiment, however, unfortunately afforded no *comparative* result with previous targets, for all the necessary conditions for any such comparison were wanting. The target was much heavier than its predecessors; experimental guns were employed in the trial; and a different charge was used with the 10·5″ gun.

There can, however, be no doubt that the "Bellerophon" possesses great structural strength, and the Committee in their report on the experiment state that although it is difficult to estimate the value of each of the differences of construction separately (as between the "Warrior" and "Bellerophon"), "yet" (as regards the "Bellerophon,") "the effect of the whole combined has undoubtedly been to produce a target of great resisting power and considerable structural merit."

The armour-clad fleet of this country does not consist exclusively of iron ships, we have, either afloat or in course of construction and excluding the old floating batteries, thirteen wood ships protected by armour plates. These are of various construction: 1st, large ships of the "Royal Oak" class, of 4000 tons, 1000 horse-power, 270 feet long, and having a draught of water aft of about 26 ft. To this class belong the "Caledonia," the "Prince Consort," "Ocean," &c. They carry 35 guns and are completely protected with 4½″ armour plates, except on the upper decks; these are converted ships. Then there are the more recent ships of various sizes, viz. the "Lord Clyde" and "Lord Warden," having about the same tonnage, horse-power, &c. as above

* In the *target* this was only carried out in rear of one plate. The stringers did not touch the rear of the upper armour plate. I am not aware which arrangement has been adopted in the "Bellerophon" ship.

† Vide p. 31.

stated, but carrying 24 guns of greater weight than those of the "Royal Oak" class; these are new ships, and they are wholly armour-clad.

And lastly, there are the smaller converted ships on Mr Reed's plan, viz.: the "Enterprise," (to carry 4 guns,) the "Research," and the "Favorite," of the following dimensions: "Enterprise,"* 993 tons, 160 horse-power, 180 ft. long, and 15 ft. 6 in. draught of water; "Research" 1253 tons, 200 horse-power, length 195 feet, draught of water 15 feet; "Favorite," to carry 10 guns, 2186 tons, 400 horse-power, 225 ft. long, and has a draught aft of nearly 22 ft. The battery and water line of the "Enterprise" and "Favorite" are alone protected, but in the "Research" the armour reaches to the upper deck throughout the length of the ship. In the "Enterprise" the battery is about 34 ft. 6 in. long and the protection at the water line is for a width of about 4 feet. The guns are placed in the centre of the ship, two on each side, and are protected by 4½ inch armour; transverse bulkheads are placed at the extremities of the battery (the same as in the "Warrior"), as a protection against a raking fire, the battery is decked over; the rudder head is also protected by iron, and the exposed upper works are of light iron, so as to be incombustible; the transverse bulkheads are pierced with ports, so that by shifting the guns from the sides of the ship, a fore and aft fire can be obtained when required, and to enable this fire to be used, short lengths of the bulwarks are constructed so as to turn down. The object of this plan of construction is to enable a small sea-going ship to be protected with armour plating in all her vital points—viz. the waterline, the engines and magazine, the rudder and the battery, and, thus protected, to be able to proceed to any part of the world. A ship of this sort would of course be no match for large iron-clads of the "Warrior" class, any more than in old days a wooden sloop would have been prudent in attacking a line-of-battle ship; but vessels of this description whether better or worse than turret ships,—a point on which I will not venture to give any opinion—are undoubtedly more useful than unprotected wooden ships, which, even when much larger, would fare badly in an encounter with these partially clad converted sloops.

Of new wooden ships of the partial armour-clad class now building on Mr Reed's plan are the "Pallas" and "Vixen," they are of the following dimensions:—

"Pallas," to carry 6 guns (four 6¼ ton and two 7″ B. L. R. guns), 2372 tons, 600 horse power, 225 ft. long, and 24 ft. draught of water, plated with 4½-inch iron on 22 inches of wood frame; the plating consists of a belt, extending 4 ft. under water, and a square box protecting guns, engines, &c.

The "Vixen" (the hull of which is composed of wood and iron), is to carry 4 guns, and will be of the following dimensions,—tonnage 754, horse power 160, length 160 ft., draught of water 10 ft. 9 in.

The only wooden ship on Captain Coles' plan is the (converted† "Royal

* Admiral Dacres, the Commander-in-Chief of the Channel Squdaron, thus reports regarding this ship.—"The 'Enterprise' has only a belt round her water-line and a covering for her battery. She steams and sails fairly, and is exceedingly buoyant. She is well ventilated and berths officers and men well. Her construction is excellent; her rudder hidden and safe, acts upon the ship remarkably well. A lining of wood inside the iron skin is required to obviate inconvenience arising from sudden change of temperatnre."

† Captain Sherard Osborn, who commanded this ship, reported as follows:—"To recapitulate, I

Sovereign." She has four turrets, one for two guns, the remainder for one gun each, and thus has an armament of 5 guns.

This ship of 3765 tons, 800 horse power and 240 ft. in length, is wholly cased with 5½″ plates and has 1″ of iron on her deck. Her draught of water aft is 23 ft. 9 in., and the estimated cost of the *conversion* was £66,000. The cost of a turret for two guns is, at present, about £4500.

The other turret ships in the service are the "Wyvern," "Scorpion," and "Prince Albert." The two first (the celebrated Birkenhead rams) are iron ships of 1857 tons and have 250 horse-power engines; they have two turrets for two 12-ton guns each.

"The "Prince Albert," also an iron ship, has four turrets for one gun each.

The following are some of the advantages* which are claimed for turret ships by the advocates of the system:—

(1) The power of carrying the heaviest ordnance that can be manufactured.

(2) A greater power of broadside in comparison to tonnage.

(3) Rapidity of fire and facility for working guns in bad weather, when broadside guns could not be used.

(4) Great speed, great defensive power, cheap of construction.

These are *some* of the advantages urged. It must, however, be stated that the advocates of broadside ships deny that these points are *specialities* of turret ships, whilst on the other hand the leakage hitherto found to be consequent upon the penetration of the upper deck by the turret is said to have proved a serious drawback to ships of the *American* monitor type. There is one point of the turret system about which I think all must agree. I allude to the additional protection thus afforded to men and guns during action. A few turns† of the winch places the port holes out of the line of fire, and thus whilst the gun is being reloaded, the detachments are completely protected.

The interior width of a two gun turret, for 12-ton guns, is 19 ft., and the turrets consist of 5½″ plates on 7½″ of teak, except at the ports where an additional thickness of 4″ of iron is used; the iron skin is ½″ thick.

No experiment has yet been made in this country by firing at turrets with the heavy artillery now being introduced into the service, it is therefore impossible to say how the machinery will answer after receiving repeated blows from the impact of heavy shot. The system has fallen into disfavour with some, owing to failures of American turret ships;‡ but I think

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am of opinion that the 'Royal Sovereign,' as she now stands, is the most formidable vessel of war I have ever been on board of, she would easily destroy, if her guns were rifled, any one of our present iron-clads, whether of the 'Warrior,' 'Hector,' or 'Research' class. Her handiness, speed, weight of broadside, and the small target she offers, increases tenfold her power of assault and retreat......"

* See Appendix B, p. 444.

† The turrets only take 30 seconds to revolve.

‡ The following report and extracts give the damage caused to federal iron-clads,—

"Sir,—I have the honor to report the following damages sustained by this ship (iron-clad 'Manhattan') in action of to-day with the rebel 'Fort Morgan' and the rebel iron-clad 'Tennessee':—

"*Turret.*—One two and a quarter inch indentation from conical steel-pointed shot, four feet from deck; one seven-eighth inch indentation just above base ring; outside three rivet heads knocked off and seven started; base ring separated slightly.

Captain Coles has most satisfactorily shown that this failure in no way affects his plan, for the American turrets are entirely above the level of the deck, with a pilot house on the roof, both working round a spindle, which passes through the deck, the whole of this arrangement being manifestly weak, on account of the great leverage the turret would exert in a sea way, the liability to injury of the spindle, and also the liability of the turret to jam from the exposure of the machinery; and strong evidence exists of the value of monitors, even of the American type.*

Captain Coles' plan has none of these weak points, and although nothing short of actual experiment can prove whether his system is free from some of the defects urged against it, it must be borne in mind that the "Trusty" experiments (when cupolas were fired at) were considered decidedly successful, but of course in that experiment only light guns† (comparatively speaking) were used.

There seems no longer to be any dispute of the value of turret ships for harbour and coast defence, for the controller of the navy states, "I consider a modified turret ship superior to all others for harbour and coast defence." The difference of opinion is now narrowed to the relative value of turret and broadside ships as sea-going vessels.

I have thought it desirable to make this short digression, in order not to omit, altogether, reference to two classes of armour-clad ships, which, although without representatives in the long list of Shoeburyness targets, are amongst the experimental ships in our navy.

"*Pilot House.*—One and a quarter inch indentation from conical shot, four feet three inches from base; outside, one rivet-head knocked off and two started; inside, one rivet-head knocked off and two started.

"*Armour.*—Struck by glancing shot on starboard quarter, a few feet forward of propeller and ten inches below the deck; separated armour-plates slightly for five feet; a shot passed through both quarters of one boat, and through the gunwale of the other; one ventilator-stay was shot away; ventilator dented by a fragment of shell; a shot passed through boiler-iron around rim of turret; the carriage of port fifteen-inch gun was disabled by the recoil, carrying away six bolt-heads, securing composition plates.

Commander Stevens, U.S. Monitor "Winnebago":—

"………At fifteen minutes past seven opened fire on the fort, the enemy firing rapidly.

"………At ten minutes past nine the after-turret broke down.

"………The 'Winnebago' was struck nineteen times, three of the shot having penetrated the deck near the after turret, I have to report no casualties."

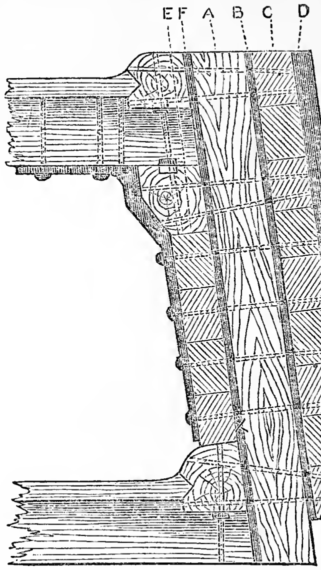
Extract from Report of Lieut. Simpson, U.S. Iron-clad "Passaic," April 21st, 1864.

"This was very difficult to do," (to keep her in an effective condition) "in consequence of her turret having been jammed on the night of the 6th of September, which had caused the spindle and pilot-house to take up motion with the turret, thus disabling the steering gear. Ingenious expedients were adopted (of all of which Rear-Admiral Dahlgren has reports,) and the vessel was carried successfully into action notwithstanding her disabled condition."

* See Appendix C, p. 446.

† 68-pr. S.B.; 110-pr., 40-pr. } rifled. } No difficulty whatever having been experienced in working the machinery of the cupola after a very heavy battering.

I shall now pass on to a description of the "Lord Warden."



The "Lord Warden" is a wooden ship of 4067 tons, 1000 horse power, 280 ft. long, and is to carry 24 guns. Her draught of water is 26 ft., 6 aft, and the total cost fitted for sea is estimated at £285,400.

From the accompanying drawing it will be seen that the construction of this ship is as follows:—

Frame timbers (*A*) placed continuously 12½″ thick, inner planking (*E*) 8″ thick, iron skin (*B*) 1½″ thick, outside planking (*C*) 8½″ thick, and rolled armour plates (*D*) 4½″ thick; occasional iron riders (*F*) are spaced several feet apart, inclined at about an angle of 45°. The armour plate bolts were 2½″ diameter, one bolt to about 4 ft. superficial. The weight per superficial foot was about 482 lbs.

*The guns used in the experiment on the target of this name were, with the exception of the 68-pr., all experimental, and thus no comparative result was obtained of the power of resistance between a structure of this nature and other plans.

The target was subjected to a very severe trial, 2198 lbs. weight of steel and special cast-iron projectiles (chiefly the former), having struck it at 200 yds. range with velocities varying from 1000 to 1590 ft., the heaviest charge used being 50 lbs.

It must be borne in mind that the weight per superficial foot of this structure was largely in excess of the "Warrior," and the result of the experiment although favourable to a certain degree to armour-clad wooden ships, also showed a serious defect which must arise from the use of such structures, whenever they are opposed to guns of sufficient power to effect *penetration*. On the one hand, it must be considered satisfactory, that a wooden ship like the "Lord Warden" can be made capable of affording protection against steel spherical shot of 168 lbs. weight, fired at 200 yds. range with 50 lbs. of powder, but on the other hand the large area of damage to the inner planking, and the great number of splinters of wood caused by the projectiles which penetrated the target, prove the great additional security which is afforded by the skin of an iron ship.

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* The relative damaging power of the guns was found to be as follows:—

10·5″ gun, with cylindrical shot 300 lbs. weight, and 45 lbs. charge.
9·22″ 12½ ton gun, with cylindrical shot 220 lbs. weight, and 44 lbs. charge.
10·5″ gun, with spherical shot 168 lbs. weight, and 50 lbs. charge.
9·22″ 6½ ton gun, with spherical shot 114 lbs. weight, and 25 lbs. charge.
7″ gun, with cylindrical shot 100 lbs. weight, and 25 lbs. charge.

The Special Committee on Iron reported that in their opinion, "the weight of iron which entered into the structure would have afforded greater resistance if it had been otherwise distributed."

With this opinion I quite agree. Of course I must be understood as solely speaking with reference to the resistance to projectiles offered by these several structures, and not as giving any opinion of their merits as *ships*. There may well be ship-building reasons which make it necessary to dispose the material in the manner in which we find it in the "Lord Warden," but I have no hesitation in saying that this disposition is not advantageous for resistance to projectiles, and this can, I think, be explained in a very few words. The two great disadvantages which the firing at the "Lord Warden" target, showed to exist in this structure were, 1st, a very large area of destruction to the inner lining from the absence of an iron skin, and 2nd, the large number of splinters of wood (varying in weight from 2 lbs. to 14 lbs.) which were driven through the target.

Both these defects might be remedied, to a great extent, by means of an iron lining; for a steel shot which penetrated the target, damaged the inner planking of the "Lord Warden," over an area of 8′ × 4′,* but only made a hole 2′ × 1½′ in the iron skin of the "Chalmers" target,—the advantage of an iron lining is therefore manifest. Another alternative plan which might be adopted, without any increase of weight, would be to use armour plates 6″ in thickness, in lieu of a 4½″ plate and 1½″ inner plate, and as all experiments have proved that one solid plate offers more resistance to projectiles than a series of thin plates superimposed of equal weight and area, by this means greater resistance to projectiles might be obtained; and although, only two years ago, it would have been impossible to procure plates of this thickness of uniform good quality, they are now being supplied to government in large quantities, and have constantly received the highest mark of merit in the Portsmouth trials, viz. A1. At the present time there is in fact no difficulty in obtaining plates of any required thickness up to 12″; a plate 19′ × 3′ 9″ × 12″ weighing 15 tons has actually been manufactured by Messrs John Brown and Co. of the Atlas Works, Sheffield, for the Russian government.

Captain Inglis, R.E. does not approve of this arrangement of material adopted in the "Lord Warden,"† he states:—

"The division of the armour into two independent thicknesses in the manner here adopted cannot be an advantageous distribution of the material. Armour in two thicknesses, of 4½ inches and 1½ inches, placed a few inches apart, would offer considerably less resistance to the passage of a shot than would the same armour collected in one thickness of 6 inches, and the mere presence of 10 inches of timber in the interval cannot materially affect the question either way."

The last ship construction, to which I have to allude, is that which was tested in the experiment on the "Small Plate" target.

The object of this experiment was to test the power of resistance of a system of armour plating which has been used to a considerable extent in France,

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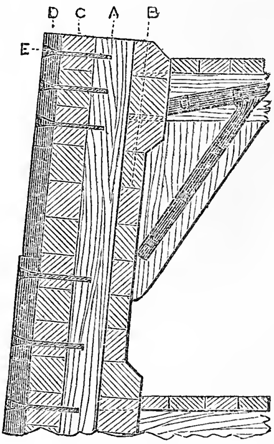
* This was the *extreme* damage from splintering.
† Vide R.E. Professional Papers, Vol XIII. p. 143.

viz. protecting ordinary wooden ships with thick armour plates of small area, and securing them to the side of the ship by a large number of "wood screws."

The fastenings were very numerous, being placed 14″ from centre to centre, thus allowing about one screw to every square foot of surface, in place of to every $3\frac{1}{4}$ ft. as in the "Warrior." The form of the "wood screws" *E* will be seen on reference to the accompanying drawing, but it may be as well to state, that they are merely screws of iron with raised threads to be screwed into wood.* Those used in the "Small Plate" target were 19 inches long and $1\frac{1}{2}$ inches in diameter; they were procured from Messrs Petin and Gaudet of Rive-de-Gier, the leading armour plate manufacturers in France, and were sent as a sample of those supplied by them for the "*frégates cuirassées*" of the French navy. They proved of excellent quality, and it is recorded that during the firing some of them were "bent almost into a knot without cracking."



The total thickness of timber in the "Small Plate" target was 2′ 3″, viz. frame timbers (*A*) 11″; inner planking (*B*) 6″; and outer planking (*C*) 10″. The armour plates (*D*) were of two thicknesses, viz. the upper rows $4\frac{3}{4}$″ and the lower 5·9″, this being the plan adopted in France in order to afford additional protection at the water line.

3,113 lbs. weight of shot (chiefly steel and chilled cast-iron) struck the target at 200 yards range, and the following appears to be the general results obtained from the experiment :—

(1) A wooden ship simply plated with 6 inches. of iron (although proof against the 68-pr. smooth bore or 110-pr. rifled artillery with steel shot), may be successfully attacked at 1500 yards distance by steel shot from rifled guns capable of bearing about 40 lbs. charges of powder.

(2) The great number of splinters of wood, in rear of this target, shows how untenable wooden ships must be when penetrated by heavy artillery, without the protection afforded by an iron skin.

(3) Plates being decidedly weaker towards the edges than in the middle, small area is a disadvantage.

(4) When plates are of good quality, bolt holes are less injurious than had been supposed.

(5) The method of fastening the plates was a marked success.

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* This description may appear superfluous, but I give it, on account of much misconception having existed on the subject. In an article in Frazer's Magazine for January, on "The Condition and Prospects of the Navy," the writer makes the following statement........."the French system of fastening their plates to the side of the ship with large *wooden* screws is superior to our own, in which for all ships hitherto launched, *iron* bolts with the old-fashioned nut are still adhered to."

As regards No. 3 of the results here specified, the Special Committee on Iron point out in their report that "it should be borne in mind that the smaller the plates the easier their manufacture, the more trustworthy their quality, and the less they cost per ton,"—all very important considerations in dealing with thousands of tons of armour plates. We are, however, able to procure plates in this country of uniform good quality, of the largest size ever required, but till very recently this was not the case in France—Messrs Petin and Gaudet having in 1863 forwarded some plates for trial at Portsmouth, they proved to be of excellent quality, and eventually a contract was given to the firm for the supply of some tons of armour plates; some of the samples subsequently forwarded under this contract, proved, however, very inferior, and Messrs Petin and Gaudet attributed the failure to the size of the plates, stating that the largest plates manufactured for the French government were only 12 feet long, instead of 15 or 16 feet, the length required by our government, in consequence of which the pile was required to be so much thicker that they could not depend on its being properly heated.

Subsequently Messrs Petin and Gaudet constructed new and larger furnaces and have again been successful in the quality of their plates.

In a speech at the Institution of Civil Engineers in January 1862, Mr Samuda, one of our most eminent iron ship builders, is reported to have said that:—

"Although he had expressed the opinion, that iron vessels of war would eventually supersede those built of iron and wood combined, he still thought, that the Government was pursuing a right course in utilizing the present wooden ships by plating them; and he believed that the transition, from wood to iron, would not be the less effectual for being gradual. Those ships would be effective and valuable ships for a time; and, looking to the necessity which existed for obtaining a mail-clad navy, within the shortest possible period, and to the length of time, which iron structures necessarily occupied in building, he had no doubt, that the Government was exercising a wise discretion in fortifying the wooden vessels, with iron armour plates, to the extent to which they were capable of carrying them. At the same time, this expedient should only be considered as a provisional measure. In armour-plating wooden vessels, iron longitudinal ribs should be let into the wood back, to support the edges of the plates, upon a similar system to that which he had proposed for iron vessels. The plates should be bolted to the timber sides, and the longitudinal ribs, while they prevented the edges of the plates from curling up, would add strength to the sides of the vessels."

Since this speech was made, not only have some of the existing wooden ships been plated, but new vessels of the "Lord Warden" class have been constructed, and the advisability of the course which has thus been adopted has been very severely criticized. On the one hand those who agree with Mr Samuda's views assert that all our iron-clad fleet ought to be iron vessels, whilst the advocates of wooden ships bring forward many arguments in favour of wood. For instance; wooden ships are less expensive to build, they can be coppered and therefore kept clean, and furthermore that as long as other nations are content with wooden ships armour-plated, we have no occasion to resort to the expensive luxury of iron ships.

There can, however, be no doubt that one great point in favour of wooden ships is the facility thus obtained for coppering, for the fouling of iron ships is a most serious disadvantage, and one for which no remedy has yet been successfully applied in the navy.

If wooden ships are to be armour-plated, the Special Committee on Iron appear to agree with Mr Samuda in thinking that iron* should be let into the wood backing, for in their report on the "Lord Warden" experiment, they record their conviction "of the advantage to be derived from horizontal iron stringers, as shown in the 'Chalmers' and 'Bellerophon' targets."

From a speech of the Secretary of the Navy it appears that two ships of a different construction, to any I have referred to, are in course of building. Lord C. Paget states that the sister ship to the "Bellerophon," and which is to be called the "Hercules" will have

"A thickness at the water-line of 9 in. of iron plating, 10 in. of wood backing, $1\frac{1}{2}$ in. of double skin of iron inside of that, 22 in. of wood inside of that, and then $\frac{3}{4}$ of an inch of iron inner skin. So that she will have a thickness of $11\frac{1}{4}$ in. of iron and 32 in. of wood, in all, at the water-line. In other respects she will be very similar to the "Bellerophon," and she will be armed with the newest fashion of guns. We propose to build at Pembroke an armour-plated corvette. She will be a vessel of about 3000 tons, with a very light draught, or 16 ft., and with twin screws, and we propose to make her at the water-line of a thickness of 6 in. of iron and 10 in. of wood, besides a $\frac{3}{4}$ in. inner skin of iron. We hope that she will be able to carry eight of these 12-ton guns."

A section similar in construction to the first of these ships ("Hercules" target) has been tested at Shoeburyness, and has, I believe, given most satisfactory results regarding its power of resistance to heavy projectiles. No official report of the experiment has yet been published, but Sir William Armstrong has stated his belief that this target will be proof against the 600-pr.; the record will, I hope, eventually be furnished to the Institution for publication in the "Proceedings."

I shall now make a few remarks on two plans of armour-plating which have been tested for land defences. These are Thornycroft bars and Captain Inglis's shield.

In all parapets, constructed either of masonry or of earth, the weakest spot must be the embrasures, and not only is it desirable to give some extra strength to the parapet itself at these points, but in these days of accurate and heavy fire from large rifled guns, it is of paramount importance, that the greatest possible amount of protection should be afforded to the guns and detachments in all works. There can be no doubt that in coast batteries and sea forts, likely to be exposed to the attack of ships carrying guns of large calibre, iron is the material best suited for use, the one drawback to this arrangement being expense.

Captain Dahlgren in his Report to the Secretary of the Navy, on the subject of coast defences in November 1862, stated that:—

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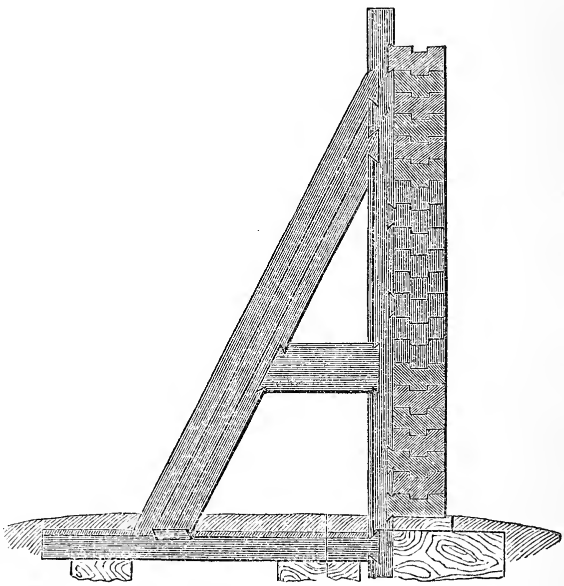
* Wood ship-builders object to this arrangement on account of difficulty in ensuring the effective caulking of the seams under such circumstances.

"Whatever may be selected as the material of the interior structure of the fort, the exterior must be iron. Lines of earthworks will also be useful in assisting and completing the position of the main work, but by no means should bare masonry be exposed to the action of rifle cannon."

But as we are never likely to have iron forts, experiments have been made with a view of obtaining the best description of shield for the protection of the guns and detachments; these shields will also strengthen the parapets at their weakest points.

The accompanying sketch shows a section of Thornycroft bars.



As far back as 1859 an iron embrasure composed of bars of this description 14″ thick and 4″ deep, was tested at Portsmouth by the Ordnance Select Committee, at a range of 400 yds.; the bars were fixed together by bolts passing vertically through them. The result of the experiment was reported as affording "very good ground for believing that iron screens or targets made on this plan (with certain improvements in their details of construction) will resist the heaviest shot and will prove of the greatest value in protecting casemates." A second trial of this system was made in 1860 on bars 10″ thick, but the bad method of fastening employed in the previous shield by means of vertical through bolts, was abandoned, and the bars were held together at the back by 3″ vertical tie bolts at each end—the shield was tested, both with, and without, a masonry backing, at 600 and 400 yds. ranges, and received 21 direct blows when backed, and 29 after the stone backing had been removed and when an abutment of 30″ only of stone had been left at each end of the shield;—the Committee expressed themselves satisfied with this mode of construction as thoroughly efficient for the purpose in view, and stated that the stone backing might safely be dispensed with, as it appeared to add little, if anything, to the power of resistance of the shield.

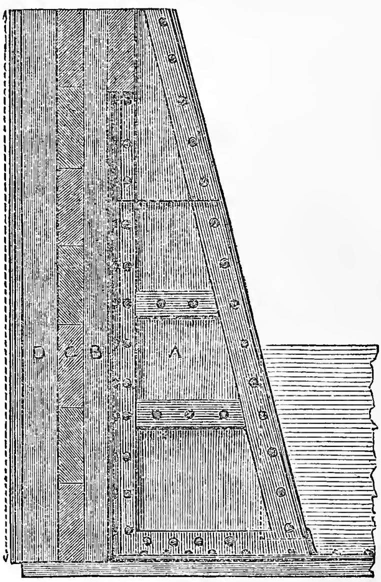
The heaviest shot, however, used in these experiments was 97 lbs. weight, fired from an Armstrong 80-pr. rifled gun with a 12 lbs. charge.

In consequence of the favourable nature of these reports, the Special Committee on Iron caused two shields to be constructed on this plan in 1861—one 10″ thick, the other 8″ thick—the heaviest gun used in the experiments being a 120-pr. shunt rifled gun, throwing a 140 lb. shot, with an 18 lbs. charge.

The result was not considered favourable, owing to the shearing of the tongues, and the fracture and displacement of the bars. The Committee in their Report state that,

"The fixing together of the bars presents a difficulty of construction which it may not be easy to overcome. It is to be observed, that the first experiments were made with targets only 4 or 5 ft. high, whilst, if applied to casemated forts, they could not well be less than 8 ft. high; and that, therefore, the difficulty of keeping together a large number of bars was not experienced in any great degree."

The great recommendations of this plan,—viz. simple rolled bars of iron with tongues and grooves,—are simplicity and economy, the cost being only about £16 a ton; and the Special Committee on Iron appear to consider it still worthy of consideration, for in their final report, in alluding to shields of this nature, they state that although their experiments have not warranted them in recommending it for adoption, "further experiments are needed to justify a decided conclusion respecting this plan."



The most successful plan which has yet been tried for protecting embrasures in casemated or open coast batteries is Captain Inglis's shield, of which the accompanying sketch represents a section.

It consists of planks of wrought-iron, (*C, D,*) crossing each other in alternate layers, and secured by screw-bolts passing through their centres. The shields are supported by diagonal boiler-plate struts (*A*) at each end, secured to a strong iron beam in rear built into masonry, these shields are otherwise independent of the masonry.*

The record of experiments on a shield of this description, which has been tested at Shoeburyness will be found in the "Proceedings;"† in the experiment on No. 1 shield (15″ thick, in three planks, on one half its area, and 10″ thick, in two planks, on the other half,) a total weight of 1972 lbs. of cast-iron shot struck the target at 200 yds. range from guns of various calibres from a 40-pr. Armstrong rifled gun up to a 12-ton 10·5″ smooth-bore gun. The Committee reported that they considered the result of the experiment very satisfactory, "as at its conclusion, the shield was capable of affording very good protection; the struts stood remarkably well........." and they pointed out that this method of construction "combines strength, simplicity and cheapness of manufacture."

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* This is a great advantage, as however much of the masonry in the vicinity of the shield may be displaced, the gun and detachment would still be protected.

† Vide Vol. III, pp. 224, 253.

The second shield which was tested, was constructed on the same principle as the first, but, only two layers of planks were used, the planks of the front layer (*D*) varying in thickness from 6″ to 8″, placed on a horizontal layer (*C*) 5″ thick.

This target was subjected to two days experiment, and a total weight of 2,148 lbs. of steel and cast-iron projectiles, from some of the heaviest* guns which could be got for the purpose, struck the shield at 200 yds. range with velocities ranging up to 1460 ft. The reports are decidedly favourable. After the first day's trial the Committee reported that "the result of this experiment is very satisfactory, and Captain Inglis appears to have succeeded in producing a shield well adapted for the purpose intended. The fastenings† in this case stood the test remarkably well;" and after the final experiment the report states:—"This shield was exposed to a very severe trial, but was in very good order at the conclusion of the experiment, and the result proved that it is by far the best which has yet been tried for land purposes." The total amount of *work* expended on the target, by the projectiles fired at it, was 28,579,225 foot pounds, and yet the shield at the conclusion of the second day's firing was "in very good order and could easily be made as good as ever, the mode adopted in its construction admitting of its being very readily repaired.‡"

One of the greatest advantages of this plan appears to consist in its capability of universal application, for it must be evident that when once the struts are in place, any required amount of protection can be given, either at the time of the construction of the work or subsequently; for instance, where only slight protection is required one layer of planks would be used, at a more important point, two layers and so on,—and these planks could be put up without the use of any skilled labour.

A large casemate, which has been built at Shoeburyness, will test the merits of two other plans of protection for embrasures, but whatever may prove to be their power of resistance, I do not believe that in the three points of economy, simplicity, and capability of universal application, Captain Inglis's shield has any probability of being distanced.

The following points are considered to be now well established in regard to iron armour:§—

(1) No material for armour plates yet tested has been found to be equal to wrought-iron of the softest quality.

(2) All irregularities, such as corrugations, projections, bosses, &c., are rather a source of weakness than of strength, it having been proved that the best application of the material is a plane-surfaced plate of uniform thickness.

(3) Small and narrow plates are weaker than large and wide ones of the same thickness.

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* 10·5″ rifled gun, was the heaviest used.

† This has reference to the report on the 1st shield, in which the Committee state that "the mode of fastening, appeared a source of weakness to the planks........."

‡ As bearing on this point it may be stated that during the last day's trial one of the through bolts was broken at the 2nd round, and was easily knocked out and replaced by a new bolt before No. 3 round was fired.

§ Report Special Committee on Iron 1862.

(4) Tongueing and grooving not only weakens each particular plate when struck by shot, but assists in damaging the adjoining plates.

(5) Combinations of bars are inferior to solid plates of the same thickness or weight of metal.

(6) A series of thin plates superimposed offers less resistance to projectiles than one solid plate of equal weight and area.

(7) In all trials which have been made with a view of testing combined substances in comparison with a solid iron plate of the same weight, the solid plate has been found in every instance to offer the greater resistance.

(8) No advantage is gained by opposing iron plates to rifled projectiles of good quality at an angle, where, by doing so, the plate must be made thinner to compensate for a more extended area.

(9) The more rigid the backing, the greater is the support of the plate; but, on the other hand, a soft backing has the advantages of yielding, in some degree, to the distortion of the plate; of distributing the effect of the blow over a larger area; of diminishing the damage to the general structure; and of retaining the broken fragments in case of fracture.

(10) For these reasons it is not desirable, as far as the experiments have yet shown, to construct any ships for war purposes without a wooden backing in rear of the armour plates.

(11) A facing of wood, or other soft substance upon armour plates, affords a considerable amount of protection from solid shot, but is soon destroyed by shell.

(12) Experiments have shown that a good shield for coast batteries can be obtained at a reasonable cost, by the use of two layers of plates, or rather "planks" of wrought-iron, crossing each other, and secured through their centres with screw bolts.

In conclusion, I think it may be interesting to give a few of the results which have been obtained in America, both from practical experience in war and from experiments against iron armour. The information on this subject, which will be found in Appendix A, C, and D is extracted from the Annual Report of the Secretary of the United States Navy, and from Mr Holley's book on "Ordnance and Armour."

APPENDIX A.

The following extracts bear on the disputed point relative to the value of iron-clads.

" Our entire safety on the southern coast depends on these vessels (the 'Ironsides' and Monitors). Without these the rebel iron-clads would quickly ruin the blockade and capture our land forces."—*Letter from Rear Admiral Dahlgren to the Secretary U.S. Navy* 19*th January*, 1864.

"I am satisfied that if I had one iron-clad at this time, I could destroy their whole force in the bay, and reduce the forts at my leisure...... The experience I had of the fight between the 'Arkansas' and Admiral Davis's vessels, on the Mississipi, showed plainly how unequal the contest is between iron-clads and wooden vessels in loss of life, unless you succeed in destroying the iron-clad. I therefore deeply regret that the department has not been able to give us ONE of the many iron-clads......" *Letters from Rear Admiral Farragut to the Secretary U.S. Navy*, 22*nd January and* 9*th May*, 1864, *ralative to attack on Mobile.*

Such were the expressed opinions of American naval officers of great experience, and the following extracts furnish, I think, conclusive evidence of the value of, even, makeshift armour :—

The confederate iron-clad ram "Albemarle," was attacked by seven federal gun boats on 5th May 1864. The Secretary of the Navy in his report to the President of the U.S., states :—" The action continued from 4.40 to 7.30 p.m., when darkness intervened, and the 'Albemarle' retreated up the river. Shot fell from her armour apparently without effect, and the efforts to run her down were unsuccessful......"

This engagement took place chiefly at 150 yards range, and the following extracts are from the reports of the officers commanding the federal gunboats :—

Captain Smith to Rear Admiral Lee :—

" The ram is certainly very formidable...........the shot fired at him was seen to strike fire upon the casemates and hull, flying upwards and falling in the water without having had any perceptible effect upon the vessel."

The following ammunition was expended by Captain Smith's gunboat on May 5th, 1865 :—

Twenty-three solid 9-inch shot, from IX-inch (S.B. guns), nineteen rounds with 13 lbs. and four rounds with 10 lbs. charges; twenty-seven solid shot from 100-pr. Parrott (R. gun), 10 lbs. charges, besides some rounds from small guns.

Report of the Officer commanding the "Whitehead,"—

"...........I opened fire with the 100-pr. rifle, using solid shot first at a distance of 1000 yards but it was soon lessened to 400 yards......I approached within 200 yards of her. At this distance we succeeded in making some excellent shots, the projectiles used being solid chilled-end shot, which must have made a serious impression on the iron armour of the ram, as I judged from the appearance of the plating on her when viewed through a glass."

Ammunition expended :—17 solid shot from 100-pr. rifle with 10 lbs. charge.

The officer commanding " Miami " reports :—

" At 20 minutes to five, I opened fire with solid shot and continued firing rapidly with good range. The ram was struck by us at almost our first fire, and I have to report, throughout the action, excellent firing by both divisions of these ships......

" For more than ten minutes we poured solid shot upon her as rapidly as we could fire.........."

Ammunition expended :—

Seventy-six IX-inch solid shot with 13 lbs.
Forty-one solid 6-inch shot (chilled ends), four long and thirty-seven short, from 100-pr. rifle with 10 lbs. charges.

Again, Commander Roe states :—

"I am forced to think that the 'Albemarle' is more formidable than the 'Merrimack' or 'Atlanta' for our solid 100-pr., rifle shot flew into splinters upon her plates..........."

"I would respectfully report the 'Sassacus' as disabled for active operations until she can be repaired......In this unequal conflict of the wooden gunboats against an iron-clad, it gives me special pleasure..........."

Captain Smith in a report dated May 24, 1864, states :—

"I have heard from contrabands and refugees direct from Plymouth that the plating of the ram was much injured; that four of our shots penetrated his outer armour, and that the concussion caused by our fire was so severe that it was found impossible to keep a light burning, and that one of the guns was rendered useless..........." Notwithstanding this fire, Captain Smith, in a report to the Secretary of the Navy, dated June 4th, states that "not a man on board (the 'Albemarle') was injured."

In addition to the ammunition which was expended as shewn above, the following rounds were fired from the "Wyalusing" and from the "Commodore Hull."

By "Wyalusing" on May 5th :—

Thirty-seven solid shot from IX-inch S.B. gun, and thirty-three 5-inch shell from ditto, forty rounds with 13 lbs., and thirty rounds with 10 lbs.; forty-seven solid shot, twenty 5-inch shell and eight percussion shell from 100-pr. Parrott with 10 lbs. charges, besides forty-five rounds from 24-pr. howitzer.

By "Commodore Hull :"—

30-pr. Parrott shell 60	24-pr. Howitzer 21

Thus, after an expenditure of 136 rounds of 9-in. shot (90 lbs. each), of 85 rounds of 100-pr. Parrott rifle shot and 61 shell at a range of 150 yards, the ram was able to retire, when its commanding officer saw fit to do so, without a man on board being injured. This ram, in addition, being only a make-shift, plated with railway iron.

The "Albemarle" was eventually destroyed by a torpedo* on the night of October 27th, 1864, whilst moored alongside a wharf at Plymouth, N. C.

The following extracts relating to the attack on the Confederate ram "Tennessee" afford confirmatory evidence :—

Lieut.-Commander Perkins, U.S. Monitor "Chickasaw," reported,—

"Afterwards, in obedience to orders, I attacked the rebel ram 'Tennessee,' following her up closely, shooting away her smoke-stack, and firing solid shot at her till her flag was hauled down and a white flag raised.

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* Torpedoes do not appear to be in favour with the officers of the federal navy. Admiral Farragut calls them "Devilish means for our destruction," and again, "Among other devilish inventions is a torpedo resembling a lump of coal, to be placed in coal pits and amongst the coal put on board vessels...... I have given orders to commanders of vessels not to be very particular about the treatment of any of these desperadoes (alluding to the manufacturers of torpedoes) if caught......... Torpedoes are not so agreeable when used on both sides; therefore I have reluctantly brought myself to it. I have always deemed it unworthy of a chivalrous nation, but it does not do to give your enemy such a decided superiority over you."

Captain Alden commanding U.S. ship "Brooklyn" in alluding to the blowing up of the federal gunboat "Tecumseh," says "Sunk by a torpedo! Assassination in its worst form!........"

"During the entire action the vessel was struck a number of times, the smoke-stack was shot almost entirely away, and one shot penetrated the deck on the starboard bow. No serious injury was suffered, and there were no casualties among officers or men."

Commander Strong, U.S. steamer "Monongahela," Aug. 6th, 1864,—

"I struck her (the 'Tennessee') fair, and swinging round poured in a broad-side of solid 11-inch shot, which apparently had but little, if any, effect upon her."

Captain Alden, U.S. ship "Brooklyn," Aug. 6th, 1864.

"........Our shot—solid nine-inch, with thirteen pounds of powder—struck him repeatedly, but without any material effect, except one, which, as it is believed, carried away his smoke-stack."

The wooden ships of Rear-Admiral Farragut's fleet, previous to going into action, in Mobile Bay, had had "heavy iron cutters" placed on their bows, and they were otherwise protected with chains and sandbags on the decks, and chains hung over the sides. These arrangements, however, failed to make them either efficient rams to cope with iron-clads, or a good protection for the crews, as I think the following extracts prove:—

From Reports of Captain Drayton and Lieut. Tyson, Flag Ship "Hartford," August 6, 1864.

"...........A shell which came through the side and exploded a little abaft the mainmast, killing and wounding a large portion of number seven gun's crew, being the only one that caused much destruction. As we, however, were getting by the shore batteries, we came directly under the fire of the gunboats 'Selma,' 'Morgan,' and 'Gaines,' and the ram 'Tennessee,' and being only able to direct our fire on one of them at a time, the shots from the others were delivered with great deliberation and consequent effect, a single shot having killed ten and wounded five men at numbers one and two guns.

"...........After striking we dropped close alongside, and delivered our broad-side of solid nine-inch shot with thirteen pounds of powder, at a distance of perhaps not more than eight feet from her side, as I believe, however, from subsequent observation, without doing any injury. The ram at the time had only two guns in broadside.

"One missed fire several times, as we could distinctly hear; the shell from the other passed through our berth deck, and exploded just inside, killing and wounding a number of men, and the pieces broke through the spar and berth decks, even going through the launch and into the hold where were the wounded.

"...........There might, perhaps, have been a little excuse had such a disposition (to leave their quarters) been exhibited, when it is considered that a great part of four guns crews were at different times swept away almost entirely by as many shells."

From Lieut. H. B. Tyson,—

"...........A rifle shell burst between the two forward 9-inch guns, killing and wounding fifteen men..........."

From Report of Lieut. Huntingdon, and Chief-Engineer Hunt, U. S. Steam Sloop "Oneida," August 6th, 1864.

"...........At fifty minutes past seven a 7-inch rifle shell passed through the chain armour and the ship's side at the water-line into the starbord boiler, exploding there. Nearly the whole watch below of firemen and coal-heavers were scalded to death, or disabled by escaping steam......... About this time also a 7-inch rifle shell entered at the water-line, exploded in the cabin, cutting both wheel ropes.

"In passing the fort we received a shell forward on the berth deck which exploded, knocking out a dead-light on the port side, starting a fire on the top of the magazine. Owing to the presence of mind of Acting Ensign Hall, commanding the powder division, and Gunner William Parker, the fire was promptly extinguished, and the supply of powder was as rapid as ever before.

"All the berths, bulkheads, and furniture in the cabin a total wreck, caused by the explosion of a 7-inch shell which entered at the water-line........."

From Chief-Engineer Hunt,—

"A 7-inch Brooke's rifle projectile penetrated the forward out-board end of the starboard boiler, about eight inches above upper tube sheet, carrying away the entire sheet through which it entered, and, exploding inside the boiler, inflicted serious damage to the entire forward end of the same, destroying all the angle-iron and the fore and aft braces thereto attached, starting the tube sheets and all the tubes in the two forward tube boxes. Two of the heaviest fragments of the shell were driven through the front of the boiler, destroying the upper man-hole plate, the entire sheet to which it was attached, and starting the riveting of the adjoining sheets.

"In its present condition the boiler is totally unfit for use."

From Lieut. Lull, U. S. Steamer "Brooklyn," August 6th, 1864.

"A shell which exploded on the berth deck forward killed or wounded every man at the two shell-whips, and those who were passing shell between them, also carrying away one whip.

"Acting Ensign Utter, and his assistant, Sailmaker Brayton, rigged another whip and stationed new men to man it, and just as they were recommencing work a second shell exploded again, clearing away every man.........

"......... Our chain cable, ranged up and down the starboard side, saved our boilers from one shot, and the sand-bags upon the berth deck saved them from one if not two more."

Extracts from Report of Captain Marchand, U. S. Steam Sloop "Lackawanna," August 5th, 1864.

"Soon after the fleet had passed the middle ground the rebel iron-clad 'Tennessee' commenced approaching with the design of attacking our vessels, and in obedience to your signal, I started under the heaviest headway to run her down, and succeeded in striking her at right angles at the after end of the casemate.

"The concussion was great, but the effect on her was only a heavy list, whilst our stern was cut and crushed to the plank ends for a distance of three feet above the water's edge to five feet below, and causing a considerable leak in forward store-room and peak. Fortunately our yards and topmasts were down, otherwise they, in all probability, would have been carried away by the concussion, which caused the ship to rebound and the stern of the 'Tennessee' to recede. Some panic must have existed on board the enemy, as they fired but two guns through our bows. After striking, the two swung head and stern alongside of each other, and as our guns have been pivoted for the opposite side, we succeeded in discharging but one 9-inch shell, that struck one of the enemy's port shutters, which was distant about twelve feet, destroying it, and driving some of the fragments into her casemate."

From Acting Masters McCurley and Allen, &c.,—

"The damages sustained by running down the rebel iron-clad ram 'Tennessee' are as follows:—

"The head and cutwater badly injured; the stem, for a distance of eighteen feet, and up to wood ends, completely gone; that portion of it comprised between the water line and draught-mark eight forced in, causing the planking for distance of several feet to be wrenched from fastening, the ends of which, exposed considerably, and leaving that portion of the bow in a much exposed condition."

From Lieut. Batcheller, U. S. Steamer "Monongahela," August 5th, 1864.

"In twice attempting to run down the rebel iron-clad ram 'Tennessee' our iron prow was entirely carried away, together with the cutwater. The butt ends of the planking on both bows are started from the stem and badly shattered, the port ones considerably sprung off."

From Commander Le Roy, U.S. Steam Sloop "Ossipee,"—

"Our stem is somewhat injured by running against the 'Tennessee'"

Extracts from Rear-Admiral Farragut's report on the attack on the Defences of Mobile.

"...........The iron-clads—'Tecumseh,' Commander T. A. M. Craven; the 'Manhattan,' Commander J. W. A. Nicholson; the 'Winnebago,' Commander T. H. Stevens; and the 'Chickasaw,' Lieutenant Commander G. H. Perkins—were already inside the bar, and had been ordered to take up their positions on the starboard side of the wooden ships, or between them and Fort Morgan, for the double purpose of keeping down the fire from the water battery and the parapet guns of the fort, as well as to attack the ram 'Tennessee' as soon as the fort was passed.

"Having passed the forts and dispersed the enemy's gunboats, I had ordered most of the vessels to anchor, when I perceived the ram 'Tennessee' standing up for this ship. This was at forty-five minutes past eight. I was not long in comprehending his intentions to be the destruction of the flag-ship. The monitors, and such of the wooden vessels as I thought best adapted for the purpose, were immediately ordered to attack the ram, not only with their guns, but bows on at full speed, and then began one of the fiercest naval combats on record.

"The 'Monongahela,' Commander Strong, was the first vessel that struck her, and in doing so carried away his own iron prow, together with the cutwater, without apparently doing her adversary much injury. The 'Lackawanna,' Captain Marchand, was the next vessel to strike her, which she did at full speed; but though her stem was cut and crushed to the plank ends for the distance of three feet above the water's edge to five feet below, the only perceptible effect on the ram was to give her a heavy list.

"The 'Hartford' was the third vessel which struck her, but, as the 'Tennessee' quickly shifted her helm, the blow was a glancing one, and, as she rasped along our side, we poured our whole port broadside of 9-inch solid shot within ten feet of her casement.

"The monitors worked slowly, but delivered their fire as opportunity offered. The 'Chickasaw' succeeded in getting under her stern, and a 15-inch shot from the 'Manhattan' broke through her iron plating and heavy wooden backing, though the missile itself did not enter the vessel.

"She was at this time sore beset; the 'Chickasaw' was pounding away at her stern, the 'Ossipee' was approaching her at full speed, and the 'Monongahela,' 'Lackawanna,' and this ship were bearing down upon her, determined upon her destruction. Her smoke-stack had been shot away, her steering chains were gone, compelling a resort to her relieving tackles, and several of her port shutters were jammed. Indeed, from the time the 'Hartford' struck her, until her surrender, she never fired a gun. As the 'Ossipee,' Commander Le Roy, was about to strike her, she hoisted the white flag, and that vessel immediately stopped her engine, though not in time to avoid a glancing blow.

"During this contest with the rebel gunboats and the ram 'Tennessee,' and which terminated by her surrender at ten o'clock, we lost many more men than from the fire of the batteries of Fort Morgan.

"Our iron clads, from their slow speed and bad steering, had some difficulty in getting into and maintaining their position in line as we passed the fort, and, in the subsequent encounter with the 'Tennessee' from the same causes were not as effective as could have been desired..........

"The 'Winnebago' steers very badly, and neither of his turrets will work, which compelled him to turn his vessel every time to get a shot, so that he could not fire very often.........

"The 'Manhattan' appeared to work well, though she moved slowly. Commander Nicholson delivered his fire deliberately, and, as before stated, with one of his 15-inch shot broke through the armour of the 'Tennessee,' with its wooden backing, though the shot itself did not enter the vessel. No other shot broke through the armour, though many of her plates were started, and several of her port shutters jammed by the fire from the different ships."

The following is the report of a survey of the 'Tennessee,' made by Officers of the Federal Navy after the engagement in Mobile Bay.

DESCRIPTION OF TENNESSEE'S HULL.

"The hull of the vessel appears to be exceedingly strongly built in every part, the materials being oak and yellow pine, with iron fastenings. Length from stem to stern on deck, two hundred and nine feet. Greatest breadth of beam on deck, forty-eight feet. Mean average draught of water, about fourteen feet.

"The deck is covered fore and aft with wrought-iron plates two inches thick.

"The sides of the vessel are protected by an overhang, sponsoned and covered with two layers of two-inch wrought-iron.

"This overhang extends about six feet below the water-line.

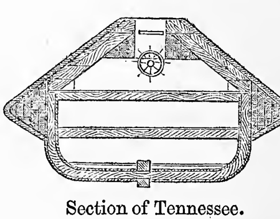
"The sides of the vessel below the deck are believed to be eight feet thick, and the distance from the knuckle, or outside of the overhang on deck, to the base of the casemate on either side, is ten feet.

"The vessel is provided with a strong beak or prow, which projects about two feet under water, formed by the continuation of the sponsoning, and covered with wrought-iron plates.

CASEMATE.

"The casemate of the vessel is very strongly built. It is seventy-eight feet eight inches long, and twenty-eight feet nine inches wide inside, the sides of the vessel extending ten feet from it on either side at the greatest breadth of beam.

"The framing consists of heavy yellow pine beams, thirteen inches thick, and placed close together vertically. Outside planking of yellow pine, five and a half inches thick, laid on horizontally, and outside of this horizontal planking there is a layer of oak timber four inches thick, bolted on vertically, upon which the iron plating is secured.



Section of Tennessee.

"The plating or armour of the casemate forward is six inches thick, consisting of three two-inch iron plates, of about six inches wide each, and abaft and on the sides five inches thick, consisting of two two-inch and one one-inch iron plates of the same width.

"The yellow pine framing of the casemate is planked over inside with two and a half inch oak timber laid on diagonally.

"The whole of the armour plating is fastened with through-bolts, one and a quarter inch diameter, with washers and nuts inside.

"The casemate is covered on top with wrought-iron gratings, composed of bars two inches thick and six inches wide, laid flat, and supported on wooden beams twelve inches square, and about five feet distant from each other. Some of these gratings are hinged and fitted to open from the inside.

"There are ten gun-ports in the casemate—two in the broadside, on either side, three forward and three aft.

"The forward and after ports, to port and starboard, are placed so as to enable the forward and after pivot guns to be used as broadside guns. The directly forward and after ports are on a line with the keel.

"The ports are elongated and made just wide enough for the entrance of the muzzle of the guns in training, and only high enough to allow a moderate elevation and depression of the gun.

"The wooden backing is cut away on each side of the ports inside of the casemate, to allow the guns to be trained about one point forward and aft. The gun-ports are covered with wrought-iron sliding plates or shutters five inches thick; those for the four broadside guns are fitted in slides. The sliding plates or shutters for the pivot-guns are pivoted on the edge, with one bolt that can be knocked out, detaching the shutter, if necessary, and are worked by a combination of racks and pinions.

ARMAMENT.

"The armament of the 'Tennessee' consists of six rifled guns, called by the rebels Brooks's rifles.

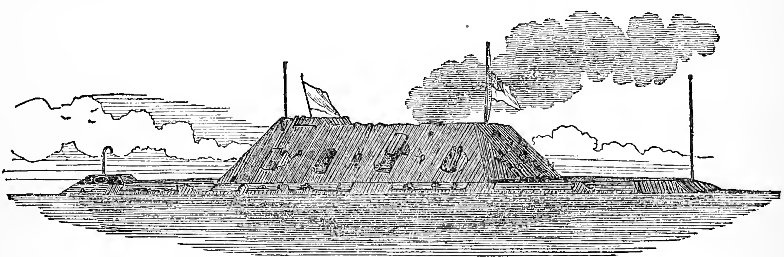
"The two pivot guns are $7\frac{1}{8}$-inch bore, and the four broadside guns are 6-inch bore. These guns are reinforced abaft by two wrought-iron bands, two inches thick, respectively. Weight of projectiles ninety-five pounds and one hundred and ten pounds solid shot.

"The pivot guns are fitted on wooden slides, with a rack let into them. On an arm attached to the carriage there is a pinion for running out the gun, and by raising the arm the rack is thrown out of gear to allow the gun to recoil.

"The arrangements for working the battery, and the implements and machinery employed, appear to be very good.

INJURIES RECEIVED IN THE ACTION.

"The injuries to the casemate of the 'Tennessee' from shot are very considerable. On its after-side nearly all the plating is started; one bolt driven in; several nuts



Confederate ram "Tennessee," after the engagement.

knocked off inside; gun-carriage of the after pivot gun damaged, and the steering rod or chain cut near that gun. There are unmistakable marks on the after part of the casemate of not less than nine eleven-inch solid shot having struck within the space of a few square feet in the immediate vicinity of that port. On the port side of the casemate the armour is also badly damaged from shot. On that side, nearly amidships of the casemate, and between the two broadside guns, a fifteen-inch solid shot knocked a hole through the armour and backing, leaving on the inside an undetached mass of oak and pine splinters, about three by four feet, and projecting inside of the casemate about two feet from the side. This is the only shot that penetrated the wooden backing of the casemate, although there are numerous places on the inside, giving evidence of the effect of the shot.

"There are visible between forty and fifty indentations and marks of shot on the hull, deck, and casemate, varying from very severe to slight; nine of the deepest indentations on the after part of the casemate, (evidently being eleven-inch shot,) and the marks of about thirty of other calibres on different parts of the vessel.

"The smoke-stack was shot away, although it is not improbable the heavy ramming by the 'Monongahela,' 'Lackawanna,' and 'Hartford,' had previously prepared it for its fall.

"Three of the wrought-iron port shutters or slides were so much damaged by shot as to prevent the firing of the guns.

"There are no external visible marks or evidence of injury inflicted upon the hull of the 'Tennessee' by the severe ramming by the 'Monongahela,' 'Lackawanna,' and 'Hartford;' but inasmuch as the decks leak badly, and when there is a moderate sea running in the bay, her reported usual leakage of three inches an hour being now increased to five or six inches an hour, it is fairly to be inferred that the increased leakage is caused by the concussion of the vessels.

"The 'Tennessee' is in a state to do good service now.

"When these small repairs and additions shall have been made, the iron-clad 'Tennessee' will be a most formidable vessel for harbour and river service, and for operating generally in smooth water, both offensively and defensively."

APPENDIX B.

A Committee of five Naval Officers was appointed by the Admiralty on 27th April last to report on the merits of sea-going turret ships, and the following in their opinion are the advantages of this system.

"The distinctive advantages of this mode of armament appear to us to be:—

"(*a*) That it is the most efficient mode of carrying and working very heavy guns in a sea way.

"A steadier platform is obtained, from which to fire.

"A gun mounted in a turret is higher out of the water, and being also in the centre of the ship, can therefore be fought longer and more efficiently in a sea-way than when mounted on the broadside.

"The extent to which the gun can be trained in a turret is only limited by the obstructions on the deck.

"There is also greater facility of training than with broadside guns, as at present fitted.

"When under the fire of musketry the port in the turret can be turned away from the enemy, while the gun is being loaded.

"More elevation can be given to the guns on the turret system than on the broadside, as ports are now fitted.

"So far as being able to keep the gun when loaded always pointed towards the object, a greater rapidity of fire is obtained by the turret system, the captain of the turret having at all times a distinct view of his object, which, in a sea-way, would be frequently lost sight of by the captain of a broadside gun; and, further, the object is less liable to be interrupted by smoke.

"(*b*) There is better protection for the men fighting the gun who are actually inside the armour-plated part of the turret, and also for the gun and carriage, in the turret system than in the broadside.

"(*c*) We believe that a turret, with 6-inch armour plating, would be almost invulnerable as regards penetration, against any guns of less weight than 12 tons.

"(*d*) A ship armed with two turrets has the advantage of being able to direct all her guns on the same object on more bearings than by any other known plan; and of throwing a heavier weight of metal on either broadside than can be done by any armour-plated vessel of equal size and tonnage armed in any other mode now afloat, or that has yet been designed, so far as we are aware of.

"(*e*) Of two vessels of the same speed, one armed on the broadside and the other armed with two turrets, the latter has a greater facility of placing herself to an advantage in action, by keeping head to sea in a sea-way than the broadside ship.

"(*f*) If the ship were totally dismasted and the crew disabled, a one-turret ship would probably, and a two-turret ship certainly, be able to continue the action to greater advantage than a ship armed on any other plan under the like circumstances.

"(*g*) When a ship has to go through an intricate channel, or up a winding river, when the enemy is always in range, the turret system would give a greater facility to a one-turret ship probably, and a two-turret ship certainly, of keeping her guns bearing on the enemy, while the ship would be following the course of the channel or stream."

Admiral Golborough, in a report dated 26th February 1864, on Iron-Clads, to the Secretary U.S. Navy, states:—

"A difference of opinion also exists among naval minds, both at home and abroad, as to whether the better expedient is to use the guns of an iron-clad turretwise, or in broadside ports, under a covering plated deck. For my own part I have little doubt on the subject, particularly if the vessel herself be confined, as in my judgment she ought to be, to moderate dimensions; to such in effect as, with a high velocity, will offer sufficient momentum, used as a ram, to crush effectually any antagonist whatever, capable of sea service; and more than this, to my apprehension, is obviously worse than superfluous. The turret I regard as decidedly preferable, and mainly for these reasons; it renders one gun of a class equivalent to at least two of the rams disposed in opposite broadside ports, and this with a great reduction of crew. It admits the use of much heavier guns. It does not necessarily involve a breadth of beam antagonistic to velocity. It affords a better protection to guns and men, and withal it secures the fighting of guns longer in a sea-way."

APPENDIX C.

Extract from Admiral Dahlgren's Report, dated 28th Jan. 1864, to the Secretary U.S. Navy, on the Services of the iron clads before Charleston.

"I shall now briefly comment on the various qualities of the monitors.

(1) Capacity for resistance.
(2) Power of ordnance.
(3) Draught of water.
(4) Speed.
(5) Number of crew.

"(1) *Endurance.*—During the operations against Morris island the nine iron-clads fired eight thousand projectiles, and received eight hundred and eighty-two (882) hits. Including the service at Sumter in April and the Ogechee, the total number was eleven hundred and ninety-four (1194) distributed as follows:—

SERVICE OF IRON-CLADS. SOUTH ATLANTIC BLOCKADING SQUADRON. SHOTS FIRED AND HITS RECEIVED BY THEM DURING OPERATIONS AGAINST MORRIS ISLAND.

Vessels.	No. of shots fired.		Hits.	Hits April 7, 1863.	Hits at Ogechee.	Total hits.
	15-in.	11-in.				
Catskill	138	425	86	20	...	106
Montauk	301	478	154	14	46	214
Lehigh	41	28	36	...	...	36
Passaic	119	107	90	35	9	134
Nahant	170	276	69	36	...	105
Patapsco	178	230	96	47	1	144
Weehawken ...	264	633	134	53	...	187
Nantucket ...	44	155	53	51	...	104
Ironsides	......	4439	164	...	...	164
Total......	1255	6771	882	256	56	1194

	No. of shots fired	Weight of projectiles fired, in tons.
By Ironsides	4439	288½
11-in., by monitors...........	2332	151½
15-in., by monitors...........	1255	213½
Total...........	8026	653½

"The consequences of the protracted firing and hard usage to which the monitors were exposed during these two months of incessant service, were unavoidably very considerable in the aggregate; and the greater, also, that all repair which could possibly be dispensed with was postponed to the conclusion. It was therefore necessarily extensive when entered upon. The battering received was without precedent. The 'Montauk' had been struck two hundred and fourteen (214) times; the 'Weehawken' one hundred and eighty-seven (187) times, and almost entirely by 10-inch shot. What vessels have ever been subjected to such a test?

"It is not surprising that they should need considerable repair after sustaining such severe pounding for so long a time, but only that they could be restored at all to a serviceable condition. The force of the 10-inch shot must be experienced to be appreciated. Any one in contact with the part of the turret struck falls senseless, and I have been nearly shaken off my feet in the pilot-house when engaging Moultrie.

"All the little defects of detail were marked by such a searching process. Decks were cut through; cannon were worn out; side armour shaken; tops of pilot-houses crushed, &c. But all these were reparable, and no vital principle was seriously touched."………

"The additions that were deemed advisable for strengthening the pilot-houses and turrets were also put on at this time, and the bottoms cleaned, for they had now become so foul with oysters and grass that the speed was reduced to three or three and a half knots, and, with the strong tide of this harbour, added considerably to the difficulties of working the vessels properly under fire.

"On one night I was caught by heavy weather from the south-east while close up to Sumter, when I had gone to attack it, and it was well that the darkness of the night prevented the slowness of our motion from being perceived while extricating the monitors from their position.

"*Power of ordnance.*—Each turret contains two guns, and from the peculiar facility which it has for giving direction to the heaviest ordnance, no doubt, arises the desire to make these of the heaviest description. How far other considerations should control the character of the ordnance is necessarily an unsettled question.

"To strike an armoured ship it may be best to use a gun capable of the greatest power; but whether this shall be derived from a projectile of great weight, driven by low velocity, or of less weight, and high velocity; whether it shall be a fifteen-inch gun, fired with thirty-five or forty pounds, or a thirteen inch, fired with fifty pounds of powder, is not here material; the weight of the gun for either purpose will not vary to any important degree. But in operations against earthworks, whose material cannot be damaged permanently, but only disturbed, and which are only to be dealt with by keeping down their fire, a much lighter projectile would be preferable, in order that the practice may be as rapid as possible. Hence a piece of 16,000 pounds for ten-inch or eleven-inch shot and shell.

"When a number of monitors are brought together it would be better also to have guns of like kind in each turret, and bring into action whichever might be preferable. Each of the monitors of this squadron had a fifteen-inch and a smaller gun, (eleven-inch or eight-inch rifle,) and hence the rapidity of fire, which was most desirable was not attained. That this was due to the calibre of the gun, and not to its being located in a turret, may be shown by one notable instance.

"November 9, 1863, the 'Montauk,' Captain Davis, was engaged in battering Sumter. In so doing, the eleven-inch gun fired twenty-five shells successively in one hour, of which twenty-one hit the wall of the fort aimed at—distance sixteen hundred yards. This is at the rate of one shell in 2.4 minutes, which is not only rapid but also exceedingly accurate practice. There is no reason why another eleven-inch, if placed in the adjoining carriage, (instead of the fifteen-inch,) could not have been fired in the same time, at which rate that monitor would have delivered an eleven-inch shell every 1.2 minute.

"The rates of fire reported for the Ironsides, by Captain Rowan, are—

	Time.	No. fired.	Time for each fire.
	h. m.		*m.*
Most rapid	0.50	25	1.74
Continuous	2.55	490	2.86
Assumed	1.00	360	1.33
Montauk	1.00	25	2.40

"It will be perceived that for a short space of time the frigate delivered a shell from each gun in 1.74 minute, for three hours in 2.86 minutes, and it is believed that a fire could be sustained at the rate of 1.33 minute. The last rate is therefore possible, but I am sure it would be difficult to sustain it long with much regard to good aim and considerable distances; and I believe, on the whole, that for every practical purpose there would be all desirable rapidity of fire from the eleven-inch in turret. Thus it is to be presumed that there will be equality of ordnance power in the same number of eleven-inch guns as to rapidity of fire, whether in a turret or broadside ".........

"In common with all iron-clads, the scope of vision is much restricted, for the plain reason that in such vessels apertures of any size must be avoided. There are some other defects, but they are not inherent, and it is believed are susceptible of being remedied wholly or in part. So much for the monitors.

"The 'Ironsides' is a fine, powerful ship. Her armour has stood heavy battering very well, and her broadside of seven eleven-inch guns and one eight-inch rifle has always told with signal effect when opened on the enemy. Draught of water about 15½ to 16 feet. Speed six to seven knots, and crew about four hundred and forty men.

"The defects of the vessel are the unplated ends, which are consequently easily damaged by a raking fire, and involve the rudder and screw more or less, while she can return no fire in either direction. This was particularly and frequently inconvenient in attacking the works on Morris island, for at certain stages of the tide vessels tail nearly across the channel, and present bow and stern to the beach of Morris island, so that sometimes it was necessary to delay placing the vessel in position, and at others she would swing round very awkwardly when engaged.

"The monitors, on the other hand, were almost equally well defended on all sides, and could fire in any direction. The 'Ironsides' was also open to descending shot, and her scope of fire too much restricted by badly placed ports.

"The desire for comparison which rages just now can easily be satisfied by bringing the above data in juxtaposition.

"Just as they are, the 'Ironsides' is capable of a more rapid and concentrated fire, which, under the circumstances, made her guns more effective than the fifteen-inch of the monitors. On the other hand, she was restricted by draught to the mid-channel, was very vulnerable to a raking fire, and the direction of her own guns was very limited laterally.

"The monitors could operate in most of the channels—could direct their fire around the whole circle—and were almost equally well defended on all sides.

"The defects in both classes of vessels are susceptible of being remedied partially or entirely. The defence of the 'Ironsides' could be made complete, and that of the monitors equally so. The armament of the monitors could be perfected so as to give all desirable rapidity of fire, but by no contrivance could the 'Ironsides' be enabled to use much heavier guns than those mounted. Yet when such changes were made as experience has suggested, there still would remain to the monitors the lighter draught, choice of guns from the heaviest to the lightest, defensibility, and direction of fire around the whole circle; consequently the ability to carry a heavy battery into the least depth of water, with equal power of offence and defence in any direction, and that with half the number of guns carried in broadside by another vessel.

"The comparison now made is to be understood as having relation to existing circumstances, and not at all intended as conclusive in regard to the general merits of iron-clads.

"It is in this case that the action of the Navy Department is to be considered with reference to the selection of one class of vessels over another.

"It is evident that it was not designed to adopt any one style exclusively, for of the three vessels first ordered two were of the ordinary broadside class—the 'Ironsides' and the 'Galena.' The latter was quickly proved to be absolutely inefficient, and so must any armoured steamer of that size. It is universally admitted that plates of less than four and a half (4½) inches cannot stand the shock of heavy projectiles, and vessels so armoured must be of considerable tonnage.

"I presume the department only intended to build such vessels as were best adapted to the service at the scene of war.

"Keeping in view the peculiar exigencies of the case, which required light draught and great ordnance power, it appears that the selection of the department could not have been more judicious in preferring a number of monitors to operate from a heavy frigate as a base...........

"These four monitors, who thus keep watch and ward, muster eight (8) guns and three hundred and twenty (320) men, which is almost insignificant in contrast with the work done."...........

ADDITIONAL LIST OF ACTIONS IN WHICH THE IRON-CLADS WERE ENGAGED WITH THE REBEL BATTERIES IN CHARLESTON HARBOUR WHILE REDUCING MORRIS ISLAND.

Date.	Name.	Rounds fired.	Hits by enemy.	Distance.	Object.	Remarks.
1863				yds.		
July 18	New Ironsides.	805	4	1400	Fort Wagner.	
" 20	"	168	13	1300	"	
Aug. 23	"	90	4	...	"	Ship was under way; distance varied from 1100 to 1300 yds.
Sept. 2	"	41	7	1000	Fort Gregg	Hits from Gregg & Moultrie; ship at anchor.
" 2	"	9	...	1500	Fort Sumter .	
" 5	"	488	...	1300	Fort Wagner.	
" 5	"	32	1	1800	Fort Gregg...	Hit from Gregg.

STATEMENT OF FIRING BY THE UNITED STATES STEAMER NEW IRONSIDES DURING HER SEVERAL ENGAGEMENTS WITH THE REBEL FORTIFICATIONS IN CHARLESTON HARBOUR.

Date.	Rounds fired.	Hits by enemy.	Distance.	Object.	Remarks.
1863			yds.		
July 18	805	4	1400	Fort Wagner ...	At anchor.
" 20	168	13	1300	"	do
" 24	464	5	1200	"	do
" 29	183	2	1200	"	do
" 29	25	...	2500	Fort Sumter ...	50-pr. rifle on spar deck.
" 29	2	...	1900	Fort Gregg......	
" 30	329	2	1800	"	At anchor.
" 30	1	...	2250	Fort Sumter ...	50-pr. rifle on spar deck.
Aug. 17	400	31	900	Fort Wagner	Most of the hits were from 10-in. guns in Wagner and Gregg. At anchor.
" 17	30	...	1700	Fort Gregg......	
" 17	2	...	2700	Fort Sumter ...	50-pr. rifle on spar deck.
" 18	118	...	......	Fort Wagner	Under way; distance varied from 1200 to 1400 yds.
" 19	50	...	1100	"	At anchor.
" 20	158	...	1150	"	do
" 20	2	...	3400	Rebel steamer...	50-pr. rifle on spar deck.
" 21	70	1	1300	Fort Wagner	At anchor; hit from Sumter; XI-in. shot, solid.
" 22	115	...	......	"	Under way; distance varied from 1100 to 1300 yds.
" 23	90	4	......	"	do do
Sept. 2*	41	7	1000	Fort Gregg...	The hits were from Gregg and Moultrie; ship at anchor.
" 2	9	...	1500	Fort Sumter ...	
" 5	488	...	1300	Fort Wagner ...	At anchor.
" 5	32	1	1800	Fort Gregg......	Hit from Gregg.
" 6	184	...	1300	Fort Wagner ...	Firing to meridian.
" 6	38	...	1300	"	At anchor; firing from meridian to sundown.
" 7†	152	24	1200	Fort Moultrie...	These hits were from Sullivan's island batteries; at anchor.
" 8	483	70	1200	"	

* Night attack. † Night attack on Moultrie.

Statement of firings by United States iron-clad "Passaic," Lieut. Commander E. Simpson.

Date.	Rounds fired.	Hits by enemy.	Distance.	Object.	Remarks.
1863. July 29	XV", 12 shells; XV", 1 shot; 150-pr., 9 shells; 150-pr., 1 shot	None	yds. 1200	Fort Wagner	Carried away cap square bolt of rifle.
Aug. 9	Rifled 150-pr., 1 shell	None	"	Battery Gregg.........	Returning fire of Bat'y Gregg while on picket duty.
" 15	XV", 2 shells; 150-pr., 2 shells ...	None	"	Black steamer and Battery Gregg.	While on picket duty.
" 17	XV", 30 shells; 150-pr., 9 shells...	Thirteen ..	"	Fort Wagner and Ft. Sumter*	Engaged Wagner in forenoon, then engaged Sumter, and after dinner engaged Wagner again.
" 18	XV", 18 shells	Five	1000	Fort Wagner	Several bad hits, deck leading over bread-room.
" 23	XV", 9 shells; 150-pr., 1 shell and 9 shot.	Five	750	Fort Sumter...........	Shot from Sumter drove in a bolt of ring around wave of turret.
" 31	XV", 1 shell; 150-pr., 9 shells ...	Nine	875	Fort Moultrie	Three shots through; one of them over coal-bunkers, 20" by 9"; the other two causing bad leaks on berth deck. Another bolt driven in from ring around wave of turret.
Sept. 1	XV", 20 shells; 150-pr., 20 shells and 6 chilled shot	Seven......	1200 to 600	Fort Sumter...........	No bad hits, but side armour sprung apart 6" at the stern, caused by fouling a monitor.
" 6 (a.m.)	XV", 6 shells; 150-pr., 9 shells...	None	1100	Covered way between Wagner and Gregg.	No reply from the enemy.
" 6 (p.m.)	XV", 1 shell; 150-pr., 1 shell......	None	......	Obstructions...........	This firing was done on picket to prevent re-enforcements coming to Wagner. In revolving turret the spindle and pilot-house torn up. Motion with the turret; turret, spindle, pilot-house revolving together.
" 8	XV", 19 shells; 150-pr., 30 shells.	Fifty-one .	750	Battery Bee, on Sullivan's Island	Three new holes through the deck, and side armour badly injured in several places. Eleven hits on ring around base of turret; one of them at the base caused so much friction on deck plate as to require 34 lbs. of steam to revolve the turret. Twenty-nine new hits on turret.
Nov. 16 (a.m.)	XV", 3 shells; 150-pr., 31 shells...	Three......	1500	Fort Moultrie	Covering the Nahant and Montauk, towing off the Lehigh that was aground.
" 16 (p.m.)	150-pr., 3 shells	None	1750	Moultrie House	Trying to ignite Moultrie House.
1864. Feb. 2	XV", 3 shells; 150-pr., 68 shells...	None	2356	Blockade runner	Blockade runner aground off Fort Moultrie.
" 3	150-pr., 35 shells....................	None	"	Blockade runner	Trying to destroy blockade runner off Fort Moultrie.

* Distance from Wagner 900 yds., from Sumter 2000 yds.

Rear Admiral Porter's views on iron-clads. Extract from Report to Secretary U.S. Navy, February 16th, 1864.

"......I think too much has been expected of monitors heretofore, and the fact that two or three of them were not able to overcome obstacles formidable enough to keep out a large fleet of three-deckers has, in a measure, weakened the confidence of the public (who generally know little or nothing about such matters) in them.

"But the monitors, for harbour defence, are just as valuable as they were on the day when the first one drove the leviathan 'Merrimack' back to her hole, and saved the honor of the nation. I am sure that monitors would have done much better on this river than the old Pook gunboats did, which were built for temporary purposes only, or until monitors could take their places. Earthworks on elevated positions are difficult to silence, it is true, except by a concentrated fire of many guns, and monitors are not well provided in numbers. No vessels have been more successful than the Mississipi gunboats, whenever they have been called on to attack such works. Still they were very deficient in one respect, as they were very vulnerable, suffered a good deal, and proved that in the end the monitor principle, from its invulnerability, was the only thing that could be safely depended on. For this reason I often wished that I had been provided with *one* good monitor, with which, at certain times, I could have accomplished more than with a fleet of such boats as we have here.

"A new boat, the 'Ozark,' has just arrived here. As far as her turret is concerned she is all right, but her hull is too high out of water, and she lacks more than three inches of iron on fifteen inches of oak. I have, moreover, noticed that where there is a backing of wood covered with three-inch iron, and *that* iron with wood again, the resistance of the latter will prevent balls of heavy size from entering the iron. In fact, it is hardly indented. This was particularly demonstrated in the passage of the fleet past Vicksburg, when it was necessary to take every precaution to insure success and prevent injury to the steamers. Heavy logs, twenty inches in diameter, were hung perpendicularly on the sides of the vessel, close together, and so secured that no shot could strike the side without passing through the logs. Bales of hay were also packed over the decks and sterns in sufficient thickness (it was supposed) to prevent the passage of any shot. Suffice it to say, the pressed hay was no protection whatever against shot or shell. They passed through four or five bales, and very much endangered the vessels by setting the hay on fire. Wherever the projectiles of the enemy struck the logs, they did no further damage; they would pass through the logs, strike the iron without leaving more than an indentation, and glance off. Many instances of narrow escapes could be mentioned, where the vessels were saved by the intervention of the wood, and in no instance were the vessels damaged where the logs were properly placed. The incidents of that night—the passing of the Vicksburg batteries—suggested to me the idea of first having a heavy backing of wood, then a layer of iron, and then a covering of wood over the iron, which will, I am convinced, make a vessel perfectly shot-proof.......There are two vessels in this squadron, the 'Lafayette' and 'Choctaw,' which give proof of the value of heavy backing to iron. These vessels were built with heavy frames, covered on the outside with gutta-percha, and then with a light thickness of iron. Whenever these vessels have been struck on the iron where the wood backing was heavy, they resisted the shot of heaviest calibre, but where the backing was light shot went in at one side and out at the other. The defence of gutta-percha was not of the slightest use; on the contrary, it was a detriment, and aided very much in destroying the vessels by rot.

"As to approving of any of the above-mentioned styles of gunboat, as part of a permanent system of national defence to be adopted in this country, that I cannot do. Any professional man who will lay aside his prejudices caused by the discomforts incident to the monitors, must admit that, as a harbour defence, they are the best and only vessels to be built; and I hope we shall see every harbour in the United States, where there is a chance of an enemy penetrating, supplied with two or three of these floating batteries. If they have not been able to penetrate the harbour of Charleston, where fifty guns to one was opposed to them, and where they had to contend with obstructions placed in their way impossible to be removed, it in no way detracts from their well-earned reputation for efficiency. They have done at Charleston what no other vessels ever built *could possibly have accomplished;* and though the army, as usual when combined operations are carried on, has monopolized all the honours, it is a very certain fact that the monitors held their own as no other vessels could have done, and under their shelter the army was enabled to perform their work successfully.

"......I have seen a whole army kept at bay for the want of one of these little 'shot-proofs,' and have, now and then, been tempted to do foolish things, in hopes of accomplishing what I deemed impracticable."

Opinion of Admiral Lesoffsky, of the Russian navy,—

"Rejecting the high sides of vessels, to cover which thousands of pounds of iron would be required, the inventor of the Monitor has gained, in comparison with other armoured vessels, the following advantages:—

(1) A comparative cheapness in construction.

(2) The insignificance of target presented to the enemy's fire.

(3) The safety of the submerged part of the vessel from shots.

(4) The possibility of using guns of the heaviest calibres, and capability to give great thickness to the turrets and side armour easier than it could be done on armoured vessels of other systems.

"......Their reports (a Committee of Russian naval officers, sent to America to report on 'Monitors') confirmed the navy department in its conclusions that out of all known systems of iron-clads the monitor was preferred for our coast defences, especially in our shallow waters.

"In examining the reports of the captains of the monitors which participated in the bombardment of Fort Sumter, knowing exactly the kind of battle the monitors were engaged in, the injuries received by them, and remembering that, notwithstanding a severe concentrated fire from the numerous southern forts, the federal fleet had only one man killed and two wounded, we come inevitably to the conclusion that the attack on Charleston positively proves the monitors capable to compete, and probably with chances of success, with the best iron-clad vessels of the French and English navies.

"A well-considered new system of fastening iron plates in turrets, taken from experience, a large iron ring covering the space between the lower part of the turret and the deck, and the 9-inch cast-steel gun, are the means from which we expect a great deal.

"In conclusion, it will not be amiss to remark, that, in examining the reports of the captains who participated in the bombardment of the 7th April, we are far from affirming that their vessels were perfect. No, certainly not. Monitors, like all other specimens of ship-building, have their defects. They are not easily managed; they are unsuited for passages of long duration; *for fight against fortresses they are nearly useless.*"

APPENDIX D.

Results of Experiments carried on in America against iron armour; extracted from Mr Holley's book "Ordnance and Armour."

Nature of gun.	Nature and weight of projectiles.		Charge.	Range.	Plate or target.	Result.	Initial velocity. (about).	Remarks.
	Nature.	Weight.						
		lbs.	lbs.	yds.				
15″ Rodman smooth-bore	Cast-iron cored sphere.	400	40	200	10″ iron ($4\frac{1}{2}$″ plate + five 1·1″ plates) on 20″ wood backing.	$4\frac{1}{2}$″ plate broken through; others indented a little. Nearly all the bolts broken and jerked out; wood crushed a little; target violently shaken.	1000	
〃	〃	〃	60	50	6″ solid plate (French) on 30″ wood backing.	Target cracked, smashed, and completely penetrated.	1480	
〃	Cast-iron spherical.	400	not given.	300	Iron clad "Atlanta." Laminated armour of the aggregate thickness of 4·5″ thickness on $2\frac{1}{2}$ ft. of yellow pine; inclined at an angle of 35° from the horizon.	Armour smashed in and ship completely disabled.	...	Fired from the monitor "Weehawken." It is stated that an 11″ 169 lb. ball fired with 20 lbs. charge did not break through this armour.
11″ U. S. Navy smooth-bore	Cast-iron solid sphere.	169	30	200	Same as No. 1.	$4\frac{1}{2}$″ plate broken through; indent 3·5″. About half the bolts broken, and a few thrown out.	1400	
〃 ...	〃	〃	〃	50	*14″ of iron, composed of six 1″ plates, one 4″ plate, and four 1″ plates.	Slight local effect. Target framing and sea wall moved bodily several inches. Nearly all bolts broken and loosened. Indentation about 5″.	〃	
〃 ...	†〃	168	〃	30	12″ wood facing, $4\frac{1}{2}$″ iron plate, and 20″ wood backing.	$15\frac{1}{2}$″ hole through target, and 3′ 6″ into bank; most of facing thrown off; 2 bolts broken.	〃	This target rested against a solid bank of clay.
〃 ...	〃	〃	〃	〃	$4\frac{1}{2}$″ plates on 20″ of oak.	Penetrated plate, and lodged in backing, rear of shot 17″ from surface of plate; rear of backing shattered.		
〃 ...	Cast-iron (3 rounds), Wrought-iron (3 rounds),	169 each, 186 each	〃	〃	$4\frac{1}{2}$″ forged plate, backed by 20″ wood and 1″ iron skin.	Plate considerably bulged and cracked, and broken to pieces at one end by 5th shot. No breach through target.		
10″ R. (Parrott)	Cast-iron cylindrical with chilled head.	232	28	100	8″ unbacked plate (6′ 4″ long × 2′ $6\frac{1}{4}$″ wide).	Plate broken in half, and indented 1″.		
〃 ...	〃	〃	〃	〃	Three layers of bars, total thickness $7\frac{3}{16}$″ on $15\frac{1}{4}$″ wood, the whole secured with through bolts.	Indentation $11\frac{3}{4}$″, target much distorted and backing shattered.	...	These bars cross in alternate layers, as in Capt. Inglis's plan.
10″ gun S. B. ...	Cast-iron spherical	130	43	200	Same as No. 1, but with $4\frac{1}{2}$″ front plate removed.	Clean breach through target, and shot passed 100 yds. to the rear.		It will be remembered that a "Warrior" target ($5\frac{1}{8}$″ iron and 18″ wood) resists a 150 lbs. spherical cast-iron shot fired with 50 lbs. charge at 200 yards range.
〃 ...	〃	〃	〃	〃	Composed of six iron plates ($6\frac{1}{2}$″) backed by 18″ of wood.	Made a clean breach, and passed some 100 yds. to the rear	...	

* "Dictator's" armour. The target was planted against a heavy timber framework, which abutted against the cap-stones of a sea wall.

† It is stated that the shot was fractured and flattened, but did not break up; which would tend to show that the shot was either *steel* or wrought-iron, and not cast-iron.

A great many experiments appear to have been made on compound structures—such as india-rubber and iron plates in alternate layers, iron wire and wood, &c., &c.,—and with the same results as those obtained in this country, viz. to establish that these combinations are very inferior in their resisting powers to a simple iron plate of the same weight.

Mr Holley gives the following general information about American guns :—

15″ cast-iron shot of 400 lbs. weight, and fired with 60 lbs. of powder at 50 yards range, will rupture and shatter, though will not completely penetrate laminated armour 13″ thick, backed by 30″ of oak.

11″, 169 lbs. shot at 100 yards range, fired with 30 lbs. charge, will *not* penetrate a $4\frac{1}{2}$″ solid plate of the best quality.

The Parrott 8-inch rifle with 150 lbs. bolt, and 16 lbs. charge, breaks through but does not punch the best $4\frac{1}{2}$″ plates, and does not seriously injure the backing; and lastly, that the convex target representing the Monitor Turret offers very much greater resistance to both punching and racking than the flat target composed of the same materials.

Fig.1

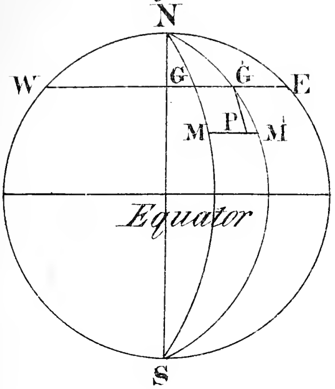


Fig.2

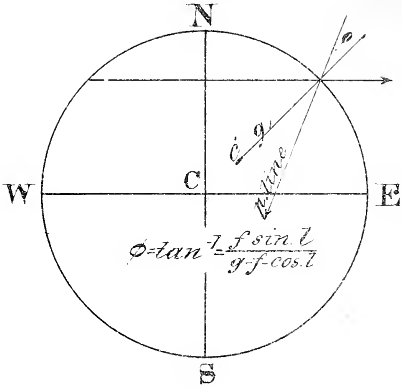


Fig.3

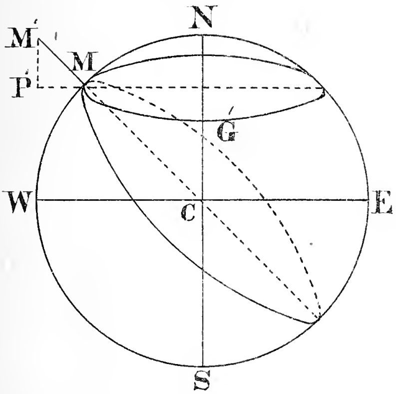


Fig.4

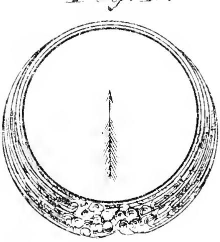


Fig.5

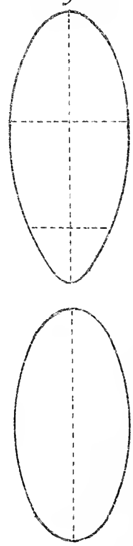
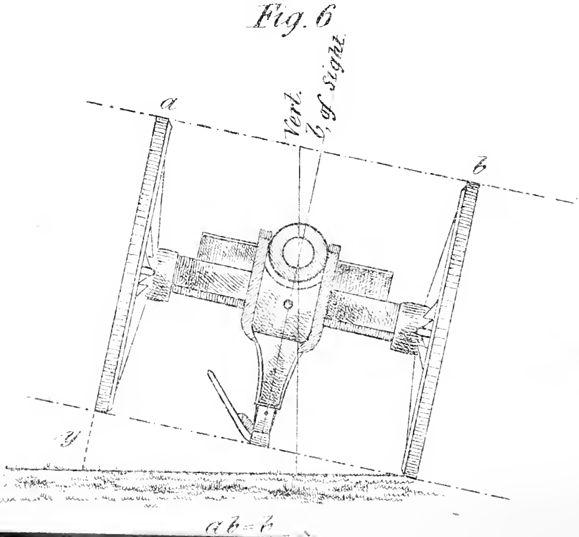


Fig.6



CAUSES

OF THE

DEVIATION OF PROJECTILES UNCONNECTED WITH RIFLING.*

BY

LIEUT. W. F. RICHARDSON, R.E.

All causes of the deviation of projectiles unconnected with rifling, are comprised under one or other of the three following heads :—

(1) Natural or physical causes ;
(2) Causes arising from defects of construction ;
(3) Accidental causes.

Natural causes may again be subdivided into two classes :—

(α) Cosmical causes ;
(β) Physical causes.

Rotation of the Earth.

The most important, and perhaps the most interesting of cosmical causes is the rotation of the earth, which has been often discussed by various authors, with whom I do not exactly agree in every particular. However, before I explain the difference in my views I will describe what occurs when a projectile is fired in our hemisphere at a mark due north or south.

Fig. 1. G is the position of a gun fired due south at a mark M. Now when the projectile leaves the gun G, it is impressed with a certain velocity west to east, which is the same by the second law of motion as that of the gun G. But the point M is rotating more rapidly than the point G, and consequently than the projectile, which will be carried to the right of M', to the point P, where $PM = GG'$. A similar deviation to the right may also be proved when the shot is fired north, the deviation in each case varying as the range and the differential of the cosine of the latitude. South of the equator the same shot will deviate to the left.

But there are an infinite number of complications attending the motion of a projectile when it is fired due east or west, or in a direction making an angle with the meridian. For if we examine Fig. 2, we see that gravity proper, and centrifugal force have a resultant which acts in the direction of the plumb

* This paper originally appeared in the R.E. Professional Papers, but has been re-written for the "Proceedings."

line, and perpendicular to the spirit level. It will be this so called vertical which will determine the position of the fictitious point in space on which the axis of the piece is directed, and the propelling force will also be exerted in this vertical plane.* But immediately the projectile leaves the earth it becomes its satellite, and tends to revolve round its centre of attraction, instead of holding its constrained orbit round the polar axis, so that centrifugal force being no longer exerted in the same direction as heretofore, the shot falls direct to the centre of the earth. The deviation under these circumstances in this hemisphere is always northerly, and if the gun be fired east or west in latitude 45°, at a range of 2700 yards, and at an elevation of 45°, the resulting error does not exceed 14 ft. The projectile is projected with a velocity compounded of that received from the earth, and that imparted by the powder.

Now there will be a correction to apply to these results, more curious than practical, which will in all cases tend to infinitesimally diminish the deviation. As the shot travels south the air will impinge against it with gradually increasing velocity, and by the impulses it will give to the projectile will tend to diminish the distance *PM*. In whatever latitude also, the shot is fired, the higher strata of the atmosphere will be moving with greater velocity from west to east than the shot, and consequently this action will also tend to diminish the deviation when the shot is fired south, but increase it when it is fired north in our hemisphere, and have the effect of increasing the range when the shot is fired east, and diminishing it, when it is fired west.

Shape of the Earth considered.

The shape of the earth is the next of the cosmical causes to consider, and the range appears to be increased in proportion to the curvature as on an oblique descending plane. But this inaccuracy is of itself very trifling, and is nearly compensated for by the retarding effect of gravity due to the central action of this force (Fig. 11). Thus in vacuo, the increased range is to the calculated range only as the arc to the chord, a difference inappreciable for arcs of 5000 yards, being nearly $\frac{(chd)^3}{24r^2}$. If we take into account the resistance of the air, this difference will be even less, as gravity will act longest on the shot† when it has the greatest retarding effect.

Spheroidal form of the Earth.

The spheroidal form of the earth is another moot point, as gravity and its corresponding effect on the shot will diminish by $\frac{1}{231}$ from the poles to the equator. This would give for ranges calculated in vacuo an increase of 10 yards in 2310 from the poles to the equator. With regard to ranges in a resisting medium, owing to the nature of the equations there is great

* It is always tacitly assumed in theory that either a plumb line or a spirit level has been used to direct the piece, as without these there is no perfect adjustment of aim.

† Owing to the resistance of the air the time of descent for all projectiles is greater than their time of ascent.

difficulty in finding the corresponding increment. I imagine however the increase of range will be very nearly as in vacuo.

An unexpected increase or decrease of range is of course a great source of radial deviation, as the angles of descent of projectiles at long ranges are very considerable. Were the angle of descent of the projectile 19°, an object six feet high, and eight yards in front of the target would be practically safe. Yet this occurs actually in practice with the Prussian cylindro-conical bullet at a range of 1000 yards.*

The great law of universal gravitation is of course applicable just as much in the consideration of the motion of projectiles, as in those of larger heavenly bodies. Thus the sun and the moon which are both in the ecliptic cause a southerly deviation of the projectile, but to counterbalance this they also cause a southerly deviation of the plummet, and a northerly deviation of the line of aim, if the plummet be used for this purpose. Happily, however, the resulting action is too imperceptible to justify attention. The lunar excess of attraction (the difference of attraction which it exercises on a body situated on the surface of the earth and a like body placed at the centre) is however nearly three times that of the sun. The corresponding deflections of the plummet in terms of the zenith distance will be $\frac{1''}{186} \sin 2\alpha$ (sun), and $\frac{1''}{60} \sin 2\alpha$ (moon); and if we wish to find the effect on the projectile we find in pounds $\frac{13}{504000000} \sin 2\alpha$ (sun), and $\frac{13}{168000000} \sin 2\alpha$ (moon), will represent the amounts of attraction, results only mathematically interesting.

Physical Causes. The Resistance of the Air.

We will now pass on to a subject already most fully considered, namely the resistance of the air, which stands first of the physical causes. The effect of this force is to render the time of descent for all projectiles greater than the time of ascent, at the same time greatly retarding their flight. For particular elongated projectiles it acts too no doubt by forming a line of descent of least resistance; perhaps only in a less degree to the well known case of the Australian boomerang. But one result I wish particularly to lay stress upon here is its action in as it were clogging the ball with a layer of air, which may increase the surface exposed to the action of the wind.

That some such action as this takes place is manifest, for as the ball passes through the air it must drive before it a considerable quantity, and this layer will be increased in proportion to the velocity of the shot, and the friction between its head and sides and the condensed air. A side wind will then act upon it to a greater extent, in proportion as this layer increases the section exposed to its action. I would point out also a curious effect of this mass of air, for when the wind acts on an elongated projectile, which has a head of smaller section than the hinder part, this would tend to steady the projectile, when otherwise it would have a tendency to turn up head to wind. The envelope of condensed air is also partly due to the attraction

* Sir Howard Douglas on "Small Arms."

caused by motion, or to the formation of infinitely small vacua, which depend on the velocity. Before I dismiss this topic I would insist that in future considerable attention should be paid to the surfaces of projectiles, as if rough and wet the friction, and consequent increase of resistance will be correspondingly great, while the contrary will be the case if they are smooth and oily.

The particles of compressed air struck by the projectile ought by analogy to produce electricity and heat, and a portion of this heat light and sound. Of these the first, electricity, will be wasted in space; light will never be manifest on the darkest night for want of solid particles to incandesce, and sound perhaps is a hum distinct from, but swallowed up by the noise of the projectile, but the remaining portion of heat is of great importance as influencing the velocity with which the compressed air will rush over the sides of the projectile to fill the vacuum behind. Now the thermal effect of the friction of the air appears, (vide Report 1859, British Association), to be independent of the shape and length of the mobile, and increases moreover as the square of the velocity. Thus if a projectile moving at the rate of 175 ft. per second were heated 1° Fahrenheit, when moving at ten times this velocity, it would be heated 100° Fahrenheit above its ordinary temperature. The heat thus caused by the projectile will increase the velocity of the compressed air in filling the void, and from a similar reason red hot shot ought to incur less resistance than cold shot of the same diameter, although they expose greater comparative section. A centre of expansion will always be generated exactly in front of the projectile.

In establishing the forms of bodies having least resistance in air, as these might practically turn out also the most accurate, it appears evident that a curved line will offer less resistance than a straight one, for the curve may be so fashioned that the greater part of the resistances may be resolved tangentially. Sir Isaac Newton gives a conoidal form (generated by the motion of a line, partly on a fixed line, and partly on a conic-section) as the best, and for this in practice may be substituted a cylindro-ogival, as better suited for rotatory purposes. The length of the best theoretical projectile should be some function of the velocity, and the best form for the hinder part of the projectile should be the curve of least resistance to the motion of the compressed air, for the compressed air will fill the vacuum behind quicker than ordinary air.

Air rushing in behind a spherical shot will produce an appearance like I have shown in the diagram (Fig. 4). By approximating to the directions of the ripples, a form analogous to the nautical wave line will be obtained, which produces no such appearance, and which will perhaps be a pear-shaped shot with a cylindro-ogival head. This form of projectile is evidently ill adapted to resist the force of the explosion, and sabôts, however ingenious, will not counteract this defect, but we can approximate to some of its important features by the method I have shown in the companion figures (Fig. 5), viz. by shortening it, and rounding off the extremity. Piobert in his *Cours d'Application d'Artillerie*, gives the best length at five times the greatest breadth, and this breadth at two-fifths the length, and nearest the fore part of the projectile.

It is necessary that the shot be of a certain density, in order to obtain a certain range and accuracy of fire, as this density of the shot will qualify the resistance of the air. The centre of gravity should also be thrown far forward in order to give more stability, and less liability to upset (Fig. 12); long shot also are to be preferred as the curves which they describe are much more nearly parabolic than round shot. For short distances up to 100 yds. it was found by experiment with the old spherical musket ball, that a string three feet long might even be attached to it with effect, as greater stability was given to the axis, and the air acting on the string steadied the ball.

In accordance with the heading of this paper, I have omitted all consideration of the unequal action of the resistance of the air due to the rotation of the projectile, as this more properly belongs to the subject of rifling. I do not of course mean to disparage its importance, as I consider it the chief cause of all deviations, when the qualities of the marksman and his weapon are not taken into account. What has been already treated of bears principally on mean radial deviations, for it is easy to conceive that the less the resistance, the lower will be the trajectory, and the more likely the projectile to hit the mark.

Hygrometric state of the Air.

The hygrometric state of the air, and its density is the next subject to be considered under this head. This will naturally have the effect of increasing or diminishing the resistance, and the projectile should range the furthest with the lowest height of the barometer. The difference of range is eight yards in a thousand from this source, between the heights of barometer 30 inches and 28 respectively.

The effect of damp is however greatly to diminish the force of the explosion, and in consequence the range. Robins writes, that he was not able to discover that the variation of density in the atmosphere affected in the slightest degree the initial velocity, but that the same quantity of powder, which in a dry day would communicate to a bullet a velocity of 1700 ft. in 1″, would not in damp weather communicate more than 1200 or 1300 ft. in 1″.

There is one more subject of interest in this section, viz. the effect of the wind. I have never heard of any experiments on this subject, so I have been reduced entirely to theory, to furnish a notion of the disturbing force. I would premise however that I have taken no account of the increased amount of section of the side of the shot exposed to the action of the wind, due to the velocity with which it moves through the air. True results however may be obtained by multiplying by some empirical coefficient of the form μV^{β} where V is the initial velocity, and β some function of the range.

Tables III. and IV. give what I think will be the minimum deviations of certain projectiles under different circumstances. They are calculated from the important formula,

$$\text{Deviation} = \tfrac{1}{2}\,\frac{PCA.gt^2}{W},$$

where P is the pressure of the wind per square foot, C is a certain coefficient of effectiveness; A is the area of the side section; W the weight of the projectile. The coefficient should properly be determined by experiment.

In theory it is $\frac{1}{2}$ for spheres, 1 for a disc, and $\frac{2}{3}$ for a cylinder (moving sideways). In practice it is perhaps $\frac{1}{4}$ for spheres.

On this supposition of incremental velocities it is easy to obtain the equations to the trajectory considering the wind. It would be necessary to use these equations to calculate on this hypothesis, the effect of wind on the shot, when it strikes it in a direction not perpendicular to the trajectory, which will in any case however be a curve of double curvature.

This will finish the first section of this paper. The second section I shall briefly dispose of. It is entitled *Defects of Construction,* and comprises:—

(γ) Defects of construction proper;
(δ) Defects of system.

Defects of construction proper are the following:—

Eccentricity of the shot arising from want of homogeneity,
Faulty position of the line of sight, otherwise bad sighting,
Irregularity of calibre,
Flexure of axis, from accident, or in manufacture.
Defects consequent on bad materials { guns, projectiles, explosive matériel.

I have left out of consideration the first of these causes of deviation, as it may be considered as a mere species of accidental rifling; for from the greater surface exposed to the action of the powder while in the bore, the shot will always have a fixed rotation round the front, from the side opposite to that on which the centre of gravity was situated in the bore at loading.

Bad Sighting.

There is a curious defect however in sighting, manifest in some six-barrel revolvers, and also in some double-barrelled guns and rifles, owing to the sights being placed between the barrels, and the axes of the latter not being parallel. For, as the breech is generally thicker than the chase, the barrels will not fit together at the same time that their axes remain parallel, unless either the breeches be filed (a very objectionable practice), or some hard substance be interposed between the barrels. An error in this way will sometimes produce six inches in 40 yards, whereas the real error ought not to be more than the radius of the bore. This circumstance has been very much attended to of late years, especially by the best makers.

Irregularity of Calibre.

Mr Whitworth, in the experiments conducted in his own ground at Manchester, and by the use of his difference gauges, which will measure sizes mechanically up to the millionth part of an inch, has proved that no reliance may be placed on the most carefully finished barrels. He found that even the best specimens had bores entirely devoid of all truthfulness, and composed of inequalities, which must have greatly detracted from the accuracy of fire. Thus the barrels were conical in one direction in one part, and the opposite direction in another, and in some parts were cylindrical when not intended to be so. On trial of these same barrels in the shooting gallery he found his idea amply corroborated by the uncertainty in the flight of the projectiles. No doubt if an absolutely true delivery can be attained, we shall be able to obtain an immense number of highly interesting results, of which at present we are ignorant.

Defects of System.

Of defects of system I shall only enumerate three out of the many that present themselves. This will be :—

Windage, Vibrations, Recoil.

Windage.

We do not yet know enough of windage to fully work out, or even to comprehend its important relations to the present subject. Could we know the exact curves, which the projectile describes inside the bore, and hence the final angle of rebound at the chase, we might be able theoretically for given conditions, to allow for the resulting error in the line of flight, and arrive at better conclusions on other subjects. For the initial direction of the shot never corresponds to that of the piece. It will in fact always make with it some small angle, which must never be neglected in calculating either a lateral or vertical deviation. If α be this angle, and R the range; $R \tan \alpha$ will be the deviation due to this cause, and $R \tan \alpha + \phi(R)$ will indeed be the general formula for all deviations.

In some bronze guns, and whenever the metal of a gun is soft, the shot will form lodgments due to excess of windage. There is in most of these lodgments a prominent ring caused by the pressing back of the metal, which will greatly assist in producing inaccuracy of fire. At the same time the ball starts up with accelerated force, and the gun will be correspondingly injured.

The axis of the best theoretical projectile should coincide perfectly with the axis of the bore, from which it is fired, and therefore the projectile itself should completely fill the bore. The expanding principle is perhaps to be preferred to the forcing, but whether compound or homogeneous shot be employed there should be an even expansion, or there would be an almost equally great inaccuracy of fire from this source. Preponderance of weight on any one side of the shot at a distance from the axis is to be avoided as producing greater eccentricity.

When a gun has been fired many times in succession the range is generally considerably increased with smooth-bored guns. This is partly due to the fouling diminishing the windage, and partly to the warming of the gun, and consequent non-wasting of the heat of the gas. Perhaps also this diminishment of windage may be owing to some peculiar action of the heat on the metal composing the gun. For if the exterior of the gun retain the same shape, while the interior be expanded by the heat the lines of least resistance to the heat forces may lie inwardly and the bore may thus contract. This phenomenon if it exists should be best shown in welded guns like Sir William Armstrong's.

Vibrations.

Our next topic is one of considerable importance, though perhaps not generally considered. Whenever a gun is fired the metal will be set into a strong vibration, the magnitude of which will depend altogether on the want of elasticity in the gun and carriage, and the mode of fixing the gun in the trunnion holes. When the gun or rifle is fixed immovably, these vibrations will be strong enough to affect the aim, even though imperceptible to the eye. Colonel Jacobs, who mentions some experiments he made on this point, says that when he fired the rifle he was trying in a mechanical rest, he was surprised at the bad results of his practice, but he discovered by grasping the barrel when it was fired, that there was a jar, accompanied by a ringing sound, at the moment of firing, and that this no doubt was the cause of his bad practice. This is also the reason why government rifles are proved from the shoulder and not from a rest. The shorter and heavier a piece is the less likely it will be to vibrate, so the weight of ordnance should not be reduced beyond a certain limit irrespective of strength. From the same cause the elasticity or hardness of the materials composing gun carriages will also be an important item in their efficiency. We cannot however distinguish in the present state of knowledge between these vibrations and heat vibrations, of which there will be plenty in connexion with the discharge. These are only mechanical undulations of an elastic material, while of the latter we know nothing; they are more silent, and probably more destructive to the weapon than injurious to the aim. It is curious that a gun is primarily less heated with ball than with blank cartridge, however the strains on the gun which also produces heat are greater in the former case than the latter, both from the re-action experienced and the friction.

We now come to the much controverted recoil. If it is proved that during the time the shot is passing along the bore, the axis of the latter has altered in direction to any appreciable extent, it is manifest that the error ought not to be neglected. Now, taking a particular example, if the trail be forced into the ground ″·2, which might be the case before the shot has left the bore, there would be an increase according to rule of 30 yds. in range, for the Armstrong field piece, in distances up to 500 yds. Consequently, the effect of an accurate aim would be nullified if the gun were fired in even ordinarily soft ground. Perhaps this change of direction might affect the initial velocity of the shot, and the two may counterbalance one another, while the range remains nearly unaltered; but if the trail rose through the same distance the difference of range would be greater still on this hypothesis. I imagine, by electricity, it would be possible to find the time during which a shot will be exposed to such influences as I have mentioned; thus the gun may be fired by electricity at a given instant, and the shot may break the connexion at leaving the muzzle. This time of passage along the bore would be useful in a variety of calculations connected with gunnery; and I have no doubt by careful experiments, that a result may be obtained, by which the action of the powder &c. may be set on a new footing.

Figs. 7.

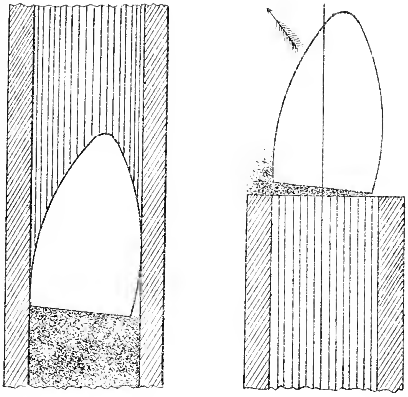


Fig. 8.

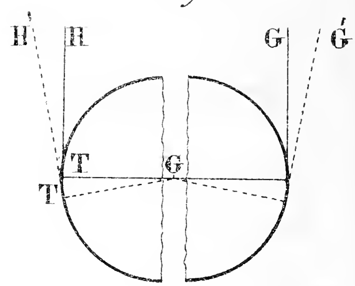


Fig. 9.

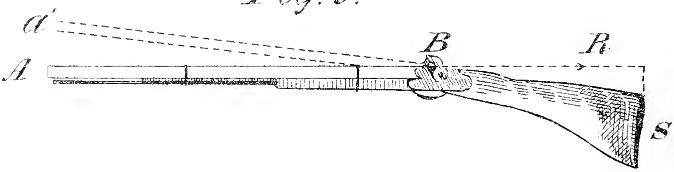


Fig. 10.

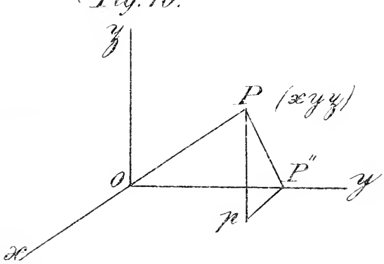


Fig. 11.

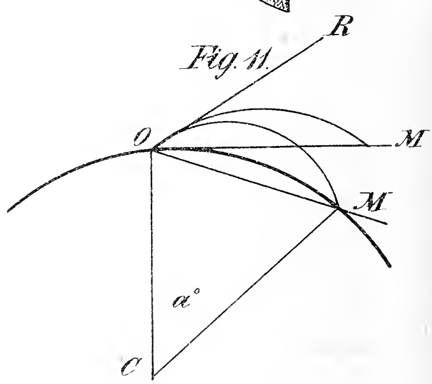


Fig. 12.

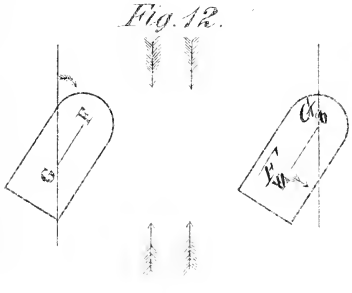
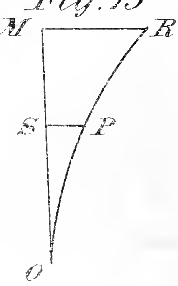


Fig. 13



Accidental Causes.

There is very little new to say about accidental causes, and their name is *legion*. Several of these are described in the *Course of Musketry Instruction for the Army*. Such are,—damage caused to the powder or ball by careless ramming home,—the effect of the sun glancing on the sights,—the powder from the cartridge being more or less carelessly weighed, or any being spilt, &c. But the perpendicularity of the sights, or in artillery practice, the horizontality of the trunnions is a more important matter. Thus, if the right wheel be raised six inches the shot is thrown to the left, and there is a deviation of 17 yds. in 2000 in this case. There would also be at the same time a slight decrease in range. Perhaps a table might be constructed with advantage, for rifle practice, showing the amounts of deviation, from the sights not being perpendicular.

The target and gun are also seldom in the same horizontal plane, so that gunners may be without knowing it, sometimes firing up, and sometimes down an inclined plane, and the ranges would be altered accordingly. This matter of ranges is especially important when firing up hill, and seems to be too often neglected.

If the axis of the bullet be inclined while in the bore, or if its base changes its form unequally during the explosion so that something of the kind was to occur that is shown in Fig. 7, the projectile would have a deviation to the side opposite to that to which it was inclined on leaving the bore. The elasticity of the gas at the open part will impede this action, but it will be much diminished outside the barrel.

If there is an overcharge, or a strong pull on the trigger, the tendency will be to incline the axis of the gun to the side of the shoulder from which it is fired, for it is evident (Fig. 8) that the leverage of the force required will be exerted about the axis on which the gun is held in this direction. A pull on to the target accounts for many a lucky shot.

There is also always a tendency in firing from the shoulder for the muzzle of the piece to rise. The reason of this I have shown in the accompanying figure (Fig. 9) is owing to the bent shape of the stock. A great deal of bad firing arises from this source, as novices contract bad habits of leaning forward and shutting their eyes, even while they are pulling the trigger, which very much impairs their chance of hitting the target.

After a considerable period of rapid firing there may not be such good practice at long distances, from the motion of the particles of air produced by heat resulting in the distortion of the aim. The amount of deviation will of course be $R \sin e$, if R be the range, and e the angle of refraction of the air between the sights.

I omitted to state, when treating of defects of system, an improvement which would certainly mitigate a great number of evils, but which has been strictly tabooed by government, viz. the introduction of telescopic sights. No one who has ever practised at long distances can have failed to see that these are the very things calculated to make rifles serviceable as an arm, and their practice, as far as aiming goes, all but perfect. It is the small angle subtended by a target at 1000 yds. compared to the coarseness of the sights which render it so difficult to score at this range.

My little stock of acquired information is now exhausted, so with this I must conclude. If I have been too prolix throughout in some trifling matters it is because they are interesting in themselves apart from the question of gunnery. Even Armstrong and Whitworth guns have their imperfections.

Table I.

SHOWING THE EFFECT OF THE ROTATION OF THE EARTH.

Description of gun.	Latitude.	Time of flight.	Elevation.	Range.	Deviation.	Remarks.
	° ′	″	° ′		yds.	
Armstrong 100-pr.	51 31 N.	14·4	11 57	4,000	3·278 R	Fired south.
"	N.P.	14·4	11 57	4,000	3·6197 R	
"	36 51 S.	14·4	11 57	4,000	2·513 L	
"	51 31 N.	10·5	8 23	3,000	1·79 R	
"	51 31 N.	6·85	5 5	2,000	·779 R	
"	51 31 N.	3·2	1 57	1,000	·1194 R	4″·5984 R.
Lynall Thomas ...	51 31 N.	37·95	37½	10,075	21·558	Greatest known range, charge 25 lbs.
"	N.P.	37·95	37½	10,075	27·807	
13-in mortar	52°	32·4	45	5,600	10·41	
"	51 31	27·38	45	4,000	6·24	

Table II.

SHOWING THE EFFECT OF THE ROTATION OF THE EARTH ON RIFLE PRACTICE, CARRIED ON AT A NORTH AND SOUTH RANGE, LAT. 51° 31′.

Range.	Time of flight.	Deviation in inches.	Remarks.
yds.	″		
300	1·051	·42	The *times* of flight in this table are taken from a French work entitled—"Cours sur les Armes à feu portatives." They are those for the carabine à tige. Accurate tables of the times of flight of Enfield bullets are greatly wanted.
400	1·334	·71	
500	1·680	1·13	
600	2·108	1·7	
700	2·610	2·45	
800	3·130	3·36	
900	3·826	4·04	
1000	4·453	5·85	

TABLE III.

SHOWING THE EFFECT OF THE WIND UPON AN ENFIELD BULLET AT VARIOUS RANGES.
DIAMETER OF BULLET 0″·568, LENGTH 1″·0625.

Range.	Time of flight.	Light air.	Light breeze.	Gentle Breeze.	Moderate breeze.	Fresh breeze.	Strong breeze.	Moderate gale.	Fresh gale.	Strong gale.	Heavy gale.	Storm.	Hurricane.
yds.	″	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.
100	·25	·0006	·004	·016	·036	·064	·081	·144	·256	·380	·575	1·02	1·60
200	·615	·004	·024	·097	·218	·387	·604	·871	1·55	2·42	3·48	6·19	9·70
300	1·051	·011	·070	·282	·636	1·13	1·76	2·54	4·52	7·06	10·18	18·08	28·2
400	1·334	·018	·114	·455	1·02	1·82	2·84	4·09	7·28	11·38	16·39	29·13	45·5
500	1·680	·029	·180	·722	1·62	2·89	4·51	6·50	11·55	18·04	25·99	46·2	72·18
600	2·108	·046	·284	1·136	2·56	4·54	7·10	10·23	18·18	28·40	40·92	72·74	136·6
700	2·610	·071	·436	1·74	3·92	6·97	10·89	15·65	27·87	43·55	62·73	111·51	174·2
800	3·130	·102	·626	2·51	5·64	10·02	15·66	22·56	39·09	62·63	90·21	160·41	251·0
900	3·826	·152	·936	3·74	8·42	14·94	23·40	33·70	59·91	93·60	134·75	239·63	374·4
1000	4·453	·206	1·27	5·07	11·41	20·29	31·69	45·65	81·15	126·78	182·58	324·60	507·0

TABLE IV.

Description of gun.	Range.	Time of flight.	Coefficient.	Weight of shot.	Diameter.	State of wind.			Remarks.
						Moderate breeze.	Strong breeze.	Strong gale.	
	yds.	″		lbs.	in.	1·107	3·075	12·300	Pressure in lbs.
						ft.	ft.	ft.	
68-pr.	720	2·25	½	68	8	·0358	·0996	·398	
〃	940	3·0	½	〃	〃	·412	1·144	4·492	
〃	2000	6·25	½	〃	〃	1·787	4·956	19·85	
13-in.	720	6·668	½	204·5	13	1·798	4·982	19·97	
〃	940	7·641	½	〃	〃	2·345	6·505	26·056	
〃	2000	11·15	½	〃	〃	4·90	13·84	55·44	
8-in.	720	6·668	½	48·625	8	2·869	7·935	31·79	
〃	940	7·641	½	〃	〃	3·735	10·36	41·50	
〃	2000	1·115	½	〃	〃	7·947	22·04	88·3	

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EXAMINATION QUESTIONS.

"LONG COURSE," OFFICERS, SHOEBURYNESS. MARCH, 1865.

By Colonel W. B. GARDNER, R.A.

1. Why is gunpowder granulated, and with what view has perforated cake powder been proposed?

Are there any objections to this particular form of gunpowder?

2. What arrangements have been adopted in consequence of the imperfect decomposition of gunpowder?

3. Is the duration and general service of the gun in any manner connected with the shape and construction of the cartridge?

Make a sectional sketch of a 40-pr. cartridge, and explain how very reduced cartridges for 7-in. guns are made up and why?

4. Describe Rodman's "pressure pistons." How were they applied, and what deductions were made from their use?

5. What practical considerations affect the position of the vent?

6. Why are tin cups and primers requisite with a certain class of guns? What stores are issued in connexion with those two articles?

7. What vent implements are considered necessary? How and when are they used?

8. Describe in detail the Boxer time fuze. How has this fuze been improved and adapted to breech-loading guns, and what are its special properties?

9. Premature bursts of shells are attributed to various causes. Mention some of them.

10. Explain and illustrate by sketch the manner in which, looking from the gun, you estimate the point of rupture of shrapnel shell, and the effect produced by your fire on targets of different dimensions.

11. The bursting charge of the 7-in. segment shell is nearly 10 times as much as that of the 68-pr. diaphragm. Is the application of these projectiles affected by this difference?

12. Describe Pettman's and Major Dyer's fuzes, and mention in general terms the difficulties attending the construction of all percussion fuzes.

13. If elongated projectiles with rifle motion possess the advantages of long range and accuracy, why are large spherical projectiles preferred under certain circumstances?

14. Why is it probable that in future artillery operations, shell firing will to a great extent supersede that of solid shot?

15. What do you understand by the term "vertical fire"? Mention the varieties of it you have seen here. When would they respectively be applicable, and in what manner could you judge of the effects produced by your fire?

16. Mention some of the characteristics of cast-iron, wrought-iron, and steel. What do you understand by the expression "coils," as applied to a gun; and what is Bessemer's process of conversion?

17. What changes have been recently made in the construction and sighting of the 12-pr, Armstrong gun? Do these changes involve any practical alterations as regards working the gun? What improvements has Lieut. Reeves made in the ammunition?

18. Why is it necessary to "*face*" Armstrong guns and vent pieces from time to time? Sketch the tools used in this operation. Explain briefly how it is performed, and the consequences of neglecting it.

19. What strains is a rifled gun subject to on firing?

20. What parts of a gun in general first shew signs of weakness? How is the exact position and extent of damage ascertained, and to what causes may it be attributed?

21. State approximately what every 100 yds. of range is represented by on the tangent scale of an Armstrong 12-pr. gun, and the value of each minute on the deflection scale per 100 yds. of range? Is this value the same with all charges?

22. In what manner has Colonel Boxer improved the construction of rockets, and what advantage does Mr Hale claim for his system?

23. What do you understand by the term "penetration?" Upon what does it depend?

24. Mention some of the principal dimensions of a cast-iron 68-pr. and a 7-in. gun; the charges of powder; windage; length of bore; length of cartridge; initial velocity; weight of gun to weight of shot; recoils and elevations due to 500, 1000, and 1500 yds. range.

25. Write down in a tabular form the bursting charges of the 13, 10, 8, and 7-in common shells, and of the 8-in. and 32-pr. diaphragm shells.

26. What platforms have you constructed here? Explain the mode of laying them. Mention their respective advantages or otherwise; the services for which they are intended; the number of men and intrenching tools required to lay them, and name the platform best suited to the rear chock carriage.

27. What number of rounds are taken into the field with the Armstrong 12-pr. gun, and how are they distributed? What additions have lately been made to the boxes, and what alteration in the trail?

28. Describe the particular operations you conducted with field guns, at the practical examination. Were you quite successful, or if you had the work to perform again, would you from experience gained, suggest any other mode of proceeding?

29. There are two classes of traversing platforms. How is the one converted into the other? Describe the sliding carriage used with them, and state why a compressor has been added of late? What does Lieut. Thornhill propose in the new construction he has just brought forward? Explain the terms "imaginary pivot" and "raised racers," and the present difficulties connected with the latter.

30. How is the naval slide laid down and worked? What improvements have been recently made in its construction?

31. Describe briefly the triangle gyn, its object and uses, and the number of men required to work it. Have you known of any accidents in using it here or elsewhere? If so to what were they attributable?

32. In raising a 6 ton gun by triangle gyn, what size of fall would you prefer and why? and what dimension and nature of blocks? What power must be applied to the ends of the levers?

33. In mounting a 68-pr. gun up the rear of a sliding carriage on a dwarf platform, shew by sketch what arrangements you would make, and state what tackle and other stores you require. Explain how the movement of the gun is affected by the position of the rollers, and the relative rate of motion of each; and why this particular manœuvre,—mounting up the rear—is unsuited to 7-in., and other guns of a similar exterior form.

34. In mounting a 68-pr. by parbuckle on to a carriage $3\frac{1}{2}$ ft. high, and using 14 ft. skids, what strain would be applied to the parbuckle ropes?

35. How would you raise heavy sheers, and place them, for example, at the end of the long pier, having no fore-guy? Shew by sketch the rigging.

36. You have to disembark a 15 ton gun by means of a derrick 35 ft. long. The distance from its foot to the back guy holdfast is 55 ft., and the length of the back-guy is 75-ft. What strain is brought on the back-guy, and what pressure on the derrick?

What arrangements would you make respecting the leading block?

37. Describe the method of embarking field guns in paddle-box boats or launches from a flat beach, so that the gun may be fired when on board. Explain how you would fit these or similar boats so as to take guns and horses on board.

38. Detail the mode of forming casks into a pier, piers into a raft, and rafts into a bridge, with moderate current. State the dimensions of our long casks, slings and braces.

39. In what manner and under what circumstances, may the metallic wagon-bodies be usefully employed as rafts?

40. Define a "Belgian trestle." How is it placed in position, using a boat or raft, and describe in what manner, last summer you formed a communication from the top of the high wharf to the opposite side of the pond.

41. What is a "flying bridge?" and how would you form a temporary wharf for the embarkation of field guns?

42. How was the heavy gun raft constructed and worked here last summer?

43. Make sketches of the earthworks you have fired against here, whether enfilading or direct. State what natures of ordnance were used against them, the ranges, projectiles, and general results of the practice.

44. Describe the cupola for melting iron,—the mode of working it,—the fuel we used,—the construction of Martin's shells, and the manner of firing them.

45. What permament fittings should be adopted in casemates to enable you to mount or shift quickly? Shew by sketch, the arrangements made for shifting the 68-pr. in the shed.

46. In the absence of any of the fittings referred to in Question 45, by what other means could a heavy,—say 12-ton,—gun be mounted on a casemate platform?

47. Mention when the sling wagon, sling cart, platform wagon and drug, are respectively applicable. In the event of your being obliged to move them by human power, what method would you adopt, and why?

48. Would you recommend any special provision being made in a fortified place for the transport of heavy guns,—12 tons or 15 tons weight for example,—and for carrying their ammunition up to the guns?

49. In what manner is the 13-in. sea service mortar mounted for coast defence?

50. Describe the arrangements adopted for elevating and controlling recoil in the new carriages for heavy guns.

Optional.

1. Describe briefly the following systems of rifled guns, mentioning their respective merits:—

The Shunt,
,, French,
,, Whitworth, with its shrapnel shell.
,, Lancaster,
,, Scott,
,, Blakeley,

and sketch the breech-loading apparatus of Mr Krupp.

2. What principle of construction did the 68-pr. carronade represent? How were its projectiles originally formed? When did it perform good service?

3. To mount a 10 ton gun on a Martello Tower 25 ft. out of water at high tide. Interior diameter of tower 26 ft., breadth of parapet 12 ft., you have a derrick 20 ft. long, and proportionally stout, and an iron crab; you depend entirely on the tower for holdfasts. What size and length of main fall do you require, and what arrangements would you make? Illustrate by sketch, shewing guys, and fastenings.

4. Describe Mr Hughes' shield for earthworks. How is it intended to be placed?

5. Have you formed any opinion as to the value of rockets? Give some examples either from personal experience or from reading, of their successful application.

6. Have recent operations in Europe or elsewhere, been much influenced by the action of rifled guns? and have the late Federal successes at Fort Fisher in any way determined the question of ships against land defences?

7. Give some examples of the application of artillery,

(*a*) In covering the passage of a river.
(*b*) In using case.
(*c*) ,, ,, common shell.

8. What is meant by a bombardment? Under what circumstances is such an operation likely to be successful?

9. What artillery reasons can be given for the failure of some of our siege operations in the Peninsular and elsewhere?

10. Describe the bridge constructed by Colonel Sturgeon of the Staff Corps at Alcantara, and Congreve's proposed bridge for the attack of field works.