MINUTES OF PROCEEDINGS

OF THE

ROYAL ARTILLERY INSTITUTION.

VOLUME VII.

WOOLWICH:
PRINTED AT THE ROYAL ARTILLERY INSTITUTION.

M.DCCC.LXXI.

CONTENTS.

LIST OF PLATES.

Sets of Lithographs referred to on page 5 of Annual Report, 1870.

Royal Gun Factory.

*Nos.
2 Ordnance W.I. B.L. gun (breech screw) 40-pr. G. pattern, 35 cwt. R.
3 ″ ″ ″ ″ ″ Details.
4 Ordnance W.I. B.L. guns, 7-inch 82 cwt. R., and 40-pr. G. pattern, 35 cwt. R. Sighting.
7 Ordnance W.I. B.L. gun (breech screw), 12-pr. 8 cwt. R.
20 ″ ″ 64-pr. wedge, 61 cwt. R. (E.O.C).
23 Ordnance C.I. M.L. guns. 32-prs. of 58 cwt., 56 cwt., and 50 cwt.
24 ″ ″ 68-pr. 95 cwt., 10-inch 86 cwt., and 8-inch 65 cwt.
27 ″ ″ 32-prs. 40 cwt. and 25 cwt., and 24-pr. 50 cwt.
28 ″ ″ 18-pr. 42 cwt., 8-inch howitzer 22 cwt., and 32-pr. carronade, 17 cwt.
33 Ordnance brass M.L. guns, 9-pr. 13½ cwt., 24-pr. howitzer L.S. 12½ cwt., and 12-pr. howitzer L.S. (light) 6½ cwt.
34 Ordnance brass M.L. guns, 6-pr. gun (light) 6 cwt., coehorn howitzer 2½ cwt., and Royal mortar 1¼ cwt.
40 Mortars, cast-iron, pattern I. 13-inch L.S. 36 cwt., 13-inch S.S. (new pattern), 100 cwt., and 8-inch L.S. 9 cwt.
41 Ordnance W.I. M.L. gun, 12-inch 23½ tons, R.
47† Ordnance converted rifled 64-pr., 71 cwt., mark I. (from 8-inch gun, 65 cwt).
48† Ordnance steel M.L. gun, 7-pr., 150 lbs., R., mark III.
And the small series of 3 guns each—viz. 7, 8, 9-inch, and 64-pr.

Royal Laboratory.

1‡ Metal powder case.
2 Boxer fuzes for common, diaphragm, and mortar shells.
5*r* Tubes.
7 Pettman percussion fuze for land service.
6 & 8*a*† Lights, long, signal, and coast guard.
9 ½ lb. signal rocket.
10 1 lb. ″ ″
11*r* Cartridges for Armstrong B.L. guns.
12 ″ ″ ″
19‡ Life-buoy portfire.

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* In giving an order it is enough to quote the NUMBER only.

† These lithographs were published during the past year.

‡ Naval only.

20 Carcasses.
24 Boxer diaphragm shrapnel shell.
25 Manby life-saving apparatus.
26 Ground light-balls.
34 Common shell.
35 Mortar shell.
36 Boxer 9 seconds time fuze for B.L. rifled ordnance.
39*r* Bursters.
43 Breech-loading projectiles.
44 Fuze, percussion, Pettman, general service.
45 Fuze, time, wood, Boxer, 9 seconds, M.L. ordnance.
47 " " " 10 seconds, 7-pr. M.L. ordnance.
49 " Armstrong E, Freeth's modification.
50 " wood, Boxer, 20 seconds, B.L. ordnance.
51 " " " " M.L. ordnance.
53 Rockets, war, Hale.
54*a** Machines for firing rockets, war, Hale.
55† Case, brass, rectangular, corrugated.
56 Boxer shrapnel shell for rifled ordnance.
57*a** Boxer ammunition for Snider rifle.
58 Cartridges, drill, rifled B.L. ordnance, leather.

Royal Carriage Department.

1 Abyssinian equipment. Carriages for mountain service.
1*a* " " Carriage on mule and draught.
1*b* " " Boxes, &c., on mule.
1*c* " " Steel carriage for 7-pr. gun.
1*d* " " " fitted for draught.
1*e* " " Ammunition boxes.
1*f* " " Boxes for miscellaneous stores.
1*g* " " Portable forge.
1*h* " " Packsaddle.
1*j* " " " Otago pattern.
9*a* Field carriage for 12-pr. R.B.L. gun.
10*a* Ammunition wagon for 12-pr. R.B.L. gun.
11*a* Limber for " "
12 Field carriage for 9-pr. R.B.L. gun.
22 Small-arm ammunition wagon.
23 Forge wagon.
24*a* Store wagon, new pattern.
43 Block trail carriage for 64-pr. R.B.L. gun.
45 Limber for heavy batteries, plan.
50 Carriage, travelling, 13-inch mortar.
60*a* Traversing platform, new pattern casemate.
60*b* " " dwarf.
61*a* Transporting arrangement for dwarf and casemate W.I. platforms for 7 and 9-inch guns.

NOTE.—In consequence of the alteration of the charge of 64-pr. breech-loading rifled guns (see §. 1828 of "List of Changes in Matériel, &c.") the Royal Laboratory lithographs, Nos. 11, 12, and 58 require correction.

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* These lithographs were published during the past year.

† Naval only.

61*g* W.I. carriage and casemate platform for 9-inch gun of 12 tons.
61*h* W.I. carriage and dwarf platform for 9-inch gun of 12 tons.
61*k* W.I. carriage and casemate traversing platform for 12-inch gun of 25 tons.
61*l* W.I. carriage and dwarf traversing platform for 12-inch gun of 25 tons.
64 64-pr. W.I. garrison standing carriage.
72*a* Strengthened triangle gyn.
79 Tangye's hydraulic lifting jack.
81*b* Wrought iron 7-inch naval double plated carriage and slide. Mark II.
81*i* Details of W.I. double plated naval carriage, with nomenclature of the various parts.
81*k* Details of W.I. slide, with nomenclature of the various parts.

Instructions.

13 Hydraulic buffer for checking the recoil of guns.
14 Self-acting compressor fitted to W.I. carriages and slides.

List of Lithographs published since last Annual Report.

Royal Carriage Department.

LARGE SERIES.

72*b* W.I. triangle gyn.

SMALL SERIES.

21 Ammunition wagon for 9-pr. brass gun.
26 Store cart.
44 Limber for heavy batteries, plan.
51 Platform wagon.
72*b* W.I. triangle gyn.
73 Bell's and Gibraltar gyns.
74 Large and small drugs.

List of War Office Photographs received since last Annual Report.

These photographs will in future be printed by the permanent carbon process, and will be charged for as follows:—

			s.	*d.*
Demy pictures,		mounted	2	6
"	"	unmounted	2	0
Quarto	"	mounted	1	8
"	"	unmounted	1	4

2800—2800*a* The Martini-Henry arm.
2809 Masonry wall, strengthened by armour plates, after 13 rounds from 7-inch M.L. rifled gun, to ascertain comparative value of different kinds of backing for armour plates on fortifications. Jan. 15, 1869.
2834 View after explosion of the shell caused by firing one 9-inch Palliser shell into them.

2835 Western end of casemate, after the explosion.

2836 Iron cramp wall, or eastern end of casemate, after the following rounds:— Nos. 1623 to 1631, 7-inch M.L. rifled gun, charge 9 lbs.; and 1632 to 1639, 7-inch M.L. rifled gun, charge 18 lbs. Feb. 16, 1869.

2842 Front of No. 30 target after four rounds from 9-inch M.L. rifled gun, with Palliser shell. March 3, 1869.

2843 Back of do. do. do.

2864 Front of target representing Plymouth Breakwater Fort, after three rounds from 15-inch Rodman gun, March 31, 1869, to test Dr. Price's shot.

2865 Back of do. do. do.

2866 9-inch wrought-iron howitzer, No. 357. April 2, 1869.

2893 Front of 8-inch plate, 13′ × 3′ 2½″ (unbacked), after six rounds with Palliser's cored shot from 7-inch M.L. rifled gun. May 21, 1869.

2894 Back of do. do. do.

2895 Front of 9-inch plate 8′ 1″ × 4′ (unbacked), after two rounds with Palliser's cored shot from 8-inch M.L. rifled gun. May 21, 1869.

2896 Back of do. do. do.

2897 Front of 10-inch plate, 19′ 5″ × 3′ 6½″, after two rounds with Palliser cored shot from 9-inch M.L. rifled gun. May 21, 1869.

2898 Back of do. do. do.

2905 Front of Chalmers' portion of No. 30 target (the lower plate having been removed, and iron concrete introduced in lieu of the original backing), after six rounds from 9-inch M.L. rifled gun. April 4, 1869.

2906 Back of do. do. do.

2907 Front of Chalmers' portion of No. 30 target, after three rounds from 9-inch M.L. rifled gun. June 7, 1869.

2908 Back of do. do. do.

2909 Front of Chalmers' portion of No. 30 target, after two rounds with Palliser shell from 9-inch M.L. rifled gun. June 14, 1869.

2910 Back of do. do. do.

2911 Front of 8-inch portion of No. 30 target, after nine rounds with Palliser shell, of different manufactures, from 9-inch M.L. rifled gun. June 14, 1869.

2912 Back of do. do. do.

2913 Front of "Sandwich" target, consisting of three 5-inch plates with iron concrete between, having a total thickness of 1′ 11″, after round No. 1664 with Palliser cored shot, from 12-inch M.L. rifled gun. June 4, 1869.

2914 Left side of do. do. do.

2915 Front of "Sandwich" target, after round No. 1679 with Palliser cored shot from 12-inch M.L. rifled gun. June 14, 1869.

2916 Right side of do. do. do.

R.A. INSTITUTION, WOOLWICH,
18th May, 1870.

MEMOIR

OF

MAJOR ROBERT WOLSELEY HAIG, R.A., F.R.S.

BY

MAJOR-GEN. J. H. LEFROY, R.A., F.R.S.

ROBERT WOLSELEY HAIG, late Secretary to this Institution, was one of whom it is difficult for friends to speak without using language which may seem exaggerated to those to whom he was not personally known. His endowments of intellect were unusual; but those who admired his talents most, were in one sense least conscious of his superiority, because they had even more prominently before them that lovable simplicity of character, that inborn manliness, modesty, and humble estimate of himself, which is not always an attribute of genius, and which, when it exists, makes genius command lifelong affection. His character was as pure as it was elevated—full of playfulness, until bodily suffering laid its hand on him; but even then, brave, patient, and cheerful under it, submissive to that all-wise decree which cut so early the brightest ties of domestic happiness, and apparently unconscious how many would look long round the horizon of life before such another light to them would rise above it. He was, perhaps, one of the best mathematicians who ever entered the Artillery in the pre-competitive period. Applications of analysis were to him so easy, that he was hardly aware how exceptional his powers were; and they were at the service of all his friends, or at the command of the numerous committees with which he was associated from time to time, without a pretension on his part. They were never, indeed, adequately brought out; for as Astronomer of the North-West Boundary Commission, precise observation was more requisite than analysis; but if a question requiring the calculus of probabilities arose,* or some mechanical fact were wanted—such as the place of the centre of gravity of a solid of irregular form and density†—Major Haig was ready at once, not with a "practical" or tentative solution, but with a precise one; and he handled his integral tables as other people do logarithmic ones. It is to be regretted that he did not write more; but this was very much an effect of that total absence of pretension already remarked. His early contributions

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* See secs. 134–143 of Captain W. H. Noble's second Report on Ballistic Experiments. 1865.

† See Vol. VII. p. 212, where the determination in the note is Major Haig's, who however would not attach his name. 1871.

to the "Proceedings" of this Institution were of no great importance, and as Secretary his life was not spared long enough for him to impress, as he would have done, his character upon them; but those who had most to do with difficult questions in artillery between 1860 and 1870, best know how often his clear head and scientific attainments helped them.

Among other qualities significant of natural powers, he was a first-rate chess player—but so good-natured and unconscious that it was almost a pleasure to be beaten by him. The proximate cause of the lingering and fatal heart disease to which he fell a victim, was itself characteristic. He must needs enter for the "Veteran Race" at the Garrison Games at Woolwich, in 1868, and the over-exertion developed aneurism, the true nature of which was not detected in time.

Allusion has been made to his temporary employment on the Commission for laying out the boundary between British Columbia and the territory of the United States, under the treaty of June, 1846. Colonel J. S. Hawkins, R.E., the British Commissioner, has kindly furnished the following notice of this service:—

Major Haig left England with the Commission in April, 1858, and returned home with it in July, 1862, when he was employed upon the astronomical computations connected with the operations and the preparation of the boundary maps, until appointed Assistant-Secretary to the Ordnance Select Committee, in 1864. He had joined the Commission as Assistant-Astronomer, but on Colonel Hawkins' recommendation he was appointed Chief Astronomer, in which capacity he shewed a natural aptitude for the practical application of his very high mathematical talents, and for which appointment, in Colonel Hawkins' opinion, "no officer more competent could have been found throughout the services;" and as he also possessed health, strength, and energy, he was peculiarly well fitted for an expedition of the kind the Commission was engaged upon. When difficulties arose, he was always sanguine; and he impressed the same spirit upon the men under him, who were much attached to him, and willingly undertook whatever he required of them; while the energy he showed in everything which he entered into—whether shooting, fishing, canoeing, taking his turn with the axe, or the laborious duties which devolved upon him—the good temper and cheerfulness with which he bore hardships, and his unfailing high spirits and kindly nature, endeared him to all the officers of both the British and American Commissions.

Major Haig was appointed Secretary to the R.A. Institution on the 11th Dec. 1871, and performed his duties evidently under great bodily suffering (though he rarely complained) till the 6th June, 1872, when he was taken from the scene where it was hoped his eminent talents would have conferred great benefit on the Establishment which, by this brief memoir, records the loss it has sustained.

Royal Artillery Institution.

The Committee regret that the circulation of No. 12, Vol. VI. of the "Proceedings" has been unavoidably postponed, consequent on some of the diagrams to accompany one of the papers having only recently been received, and which now have to be lithographed.

The paper in question having been printed off and paged, could not be withdrawn from the number; the delay in the non-receipt of the diagrams not having been anticipated.

By order,

A. D. BURNABY,

Capt. R.A.,

Secretary.

WOOLWICH,

21 . 6 . '70.

ANNUAL REPORT

AND

ABSTRACT OF PROCEEDINGS OF A GENERAL MEETING OF THE ROYAL ARTILLERY INSTITUTION, HELD ON MAY 18, 1870.

COLONEL C. J. WRIGHT IN THE CHAIR.

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1. The Committee of the Royal Artillery Institution has the honor to present to the Annual General Meeting its Report and the Abstract of Accounts for the year ending 31st March, 1870.

It will be seen by the accompanying table, that during the past year 42 officers have joined the Institution.

RANK.				April, 1869.	Additions due to promotion, &c.	New members.	Promoted, withdrawn, and deceased.	April, 1870.
EFFECTIVE LIST.	£	*s.*	*d.*					
General and Regimental Field Officers, paying annually	1	5	0	193	+ 7	+ 1	−11	190
Captains	0	16	0	456	+21	+ 9	−25	461
Lieutenants	0	10	0	527	0	+31	−45	513
Paymasters	0	16	0	9	0	0	− 2	7
Quarter-Masters	0	10	0	12	0	0	− 2	10
Riding-Masters	0	10	0	5	0	0	0	5
Surgeons-Major	1	5	0	6	0	0	− 1	5
Surgeons	0	16	0	2	0	0	0	2
Assistant-Surgeons	0	16	0	20	0	0	− 4	16
Veterinary Surgeons	0	10	0	4	0	+ 1	0	5
RETIRED LIST.								
General and Regimental Field Officers	1	5	0	46	+ 2	0	− 3	45
do. do.	0	16	0	1	+ 2	0	0	3
do. do.	0	10	0	7	+ 2	0	− 1	8
do. do.	0	7	6	3	0	0	− 1	2
Captains	1	5	0	1	0	0	0	1
do.	0	16	0	20	+10	0	0	30
do.	0	10	0	9	0	0	− 3	6
do.	0	5	0	6	0	0	0	6
Lieutenants	0	10	0	5	0	0	− 1	4
Surgeons-Major	1	5	0	1	+ 1	0	0	2
Surgeons	0	16	0	0	+ 1	0	0	1
Chaplains	1	5	0	1	0	0	0	1
Quarter-Masters	0	10	0	0	+ 1	0	0	1
				1334	+47	+42	−99	1324
Honorary Members	0	10	6	43	0	0	− 1	42

2. With regard to the funds, the Committee is glad to inform the meeting that they are in a sound and flourishing state, and that a

further sum of £150 (realising £161 1s. 6d.) has been invested in 3 per cent. Consols Stock during the past year.

The abstract of the year's income and expenditure is shewn on the opposite page, and it will be seen by the D^r. and C^r. account, which is attached thereto, that the Institution has now a Balance C^r. of £2423 4s.

3. *Printing and Publication.*—Four numbers of Volume VI. of the "Proceedings" have been issued (Nos. 8, 10, and 11 being double numbers), and the papers enumerated in the annexed list have been published during the past year, very many of them being of great interest; and the Committee begs to express its thanks to those gentlemen who have contributed to the "Proceedings." In addition to the four numbers of "Proceedings," three pamphlets on promotion, and a lecture by Dr. Ruskin, have been issued to each member.

List of "Proceedings" printed during the year.

Organization for the Transport of large bodies of Troops on Railways. By Captain J. T. Barrington, R.A.

Old Woolwich. By J. Hewitt, Esq.

The Field Artillery of the Great Rebellion; its nature and use. By Lieut. H. W. L. Hime, R.A.

Heaton's Steel Converting Process. Communicated by Captain E. Keate, R.A.

A Table of the Names of the Great Ordnance now used, extracted from "The Complete Souldier," Auctore Thomas Smith, 1628. Communicated by Colonel H. Clerk, R.A., F.R.S.

Annual Report and Abstract of Proceedings of a General Meeting of the Royal Artillery Institution, held on May 19th, 1869. Colonel A. Benn, R.A. in the chair.

The new Field Artillery of Mattei-Rossi, translated from the Italian of "L'Opinione," 23rd–26th October, 1868, with a note by the Translator. By Colonel H. H. Maxwell, R.A.

The Theory of Gun Architecture. By Captain F. S. Stoney, R.A., Captain Instructor, Royal Gun Factories.

Austrian Mountain Artillery. By Friedrich Müller, Captain I. and R. Austrian Artillery Staff. Second edition, Vienna, 1868. Translated from the German, by H. H. Maxwell, Lieut.-Colonel R.A., and Brevet-Colonel.

Central Asia, and our Military Position on the North-West Frontier of India. A paper read at the R.A. Institution, Woolwich, by Colonel John Adye, C.B., R.A. January 20th, 1870.

The Construction of our Heavy Guns. By Captain F. S. Stoney, R.A., Captain Instructor, Royal Gun Factories.

Short Notes on Professional Subjects, 1869.

Trial of improved Chassepôt's, fired in comparison with the Martini-Henry arm for accuracy, at 500 yards range.

Experiments to ascertain the Penetration of Small-arm Bullets into various substances.

Mallet's 36-inch Mortar.

"In Memoriam" of the late Lieut. H. E. Baines, 10th Brigade, R.A.

On Lyson's improved signals for rifle practice. By Captain and Adjutant F. Duncan, R.A., M.A., D.C.L., F.G.S., F.R.G.S.

General Abstract of the Income and Expenditure of the Royal Artillery Institution, from 1st *April*, 1869, *to* 31st *March*, 1870.

Expenditure.		£	s.	d.
Printing and Publication	Wages	191	3	10
	Paper, £242 12s., Type and Materials, £352 0s. 8d.	594	12	8
	Wood Cuts, £37 15s., Lithography, £136 9s. 6d.	174	4	6
Chemistry		32	17	4
Photography	Chemicals and Apparatus	48	14	10
	Printing, Mounting, &c.	187	16	3
Drawing		96	7	4
Lectures		16	12	3
Taxidermy		11	10	6
Classes		5	11	0
Library, Books, &c.		116	7	5
Museum		35	13	9
Instruments		12	15	0
Carpenter's Wages, £18 14s., Materials, £51 10s. 5d.		70	4	5
Insurance on £5000, to 24th June, 1870		12	10	0
Furniture and Repairs		25	1	2
Subs to Societies, £4 4s., Annual do. refunded, £1 19s.		6	3	0
Stationery		177	13	2
Postage and Parcels		69	8	8
Wages, Clerks and Orderlies		138	19	8
Incidental		61	3	6½
War Office Photographs and Lithographs		65	10	1½
Paid for £161 1s. 6d. Consols, and Power of Attorney		150	5	0
Cash in hand, 31st March, 1870,	Secretary £0 16s. 11d. Messrs. Cox & Co. 111 2s. 6d.	111	19	5
		£2413	4	10

Income.		£	s.	d.
Cash in hand, 1st April, 1869		9	6	3
Dividend on £1361 1s. 6d. Consols (to 5th Jan. 1870)		37	13	3
Subscriptions to 31st March, 1870	Annual	1027	8	6
	Entrance	49	0	0
	Paid in advance	7	14	0
General Printing		523	1	4
Chemistry		14	5	4
Photography	Chemicals and Apparatus	30	19	5
	Printing, Mounting, &c.	243	12	4
Drawing		57	2	10
Taxidermy		11	5	6
Classes		5	0	0
Library, Books, &c.		92	19	8
Museum		0	12	0
Carpenter, Wood, &c.		18	7	8
Stationery		197	4	7
Postage and Parcels		39	0	9
War Office Photographs and Lithographs		48	11	5
		£2413	4	10

DEBTOR AND CREDITOR ACCOUNT, 31st MARCH, 1870.

	£	s.	d.
Due for Books	72	17	2
Balance Creditor	2423	4	0
	£2496	1	2

		£	s.	d.
Balance Creditor	Consols Stock	1361	1	6
	Cash in hand, 31st March, 1870	111	19	5
Approximate value of	Books for Sale £24 3s. 7d., Stationery for Sale £125 1s. 2d.	149	4	9
	Printing Paper, on Stock	57	14	0
	Chemicals (Laboratory) £20, (Photographical) £20	40	0	0
	"Handbooks," £165, "Kane's List," £245	410	0	0
Amount owing by Officers and others.	Books, &c.	19	13	3
	"Handbooks"	81	14	0
	Drawing	7	1	0
	Photography	25	8	10
	Postage	23	19	11
	Printing	16	1	11
	Stationery	57	19	4
	Wood, &c.	0	12	1
	W.O. Photographs and Lithographs	6	13	2
	"Kane's List"	95	13	0
Amount due for back Subscriptions		31	5	0
		£2496	1	2

Examined and found correct,

G. H. VESEY, Lt.-Col. R.A. and Colonel, President Sub-Committee.

A. D. BURNABY, Capt. R.A., Secretary & Treasurer.

WOOLWICH, 12th April, 1870.

Description of a method of taking Heavy Weights over broad and deep Ditches. By Lieut. G. Mackinlay, R.A.
Hints on Shoeing Horses.
The Chronograph.
Mitrailleur Christophe et Montigny.
Dogwood Charcoal.
Small-arm Ammunition in the British Service. 1869.
Arms in use in the British Service. 1869.

While thanking the contributors to the "Short Notes on Professional and other Subjects," the Committee hopes for continued co-operation in this method of imparting information on subjects of professional interest.

The Committee has great pleasure in informing the meeting, that the revised edition of "Kane's List" has been published, and many copies have already been disposed of, and copies have been presented to—

H.R.H. the Colonel of the Regiment.
H.R.H. Prince Arthur.
Secretary of State for War.
,, for India.
The Under Secretary of State for War.
Director General of Ordnance.
Deputy Adjutant-General.

In a work which includes so many names and dates, it is possible that notwithstanding every precaution minor errors may have crept in, and the Committee will be glad to receive communications regarding any that may be discovered, with a view to corrections being made in a future edition.

Particular attention is called to a new feature in this publication—viz. the short biographies of some of the more distinguished officers. Every endeavour has been made to render them as complete as possible, with the materials at the disposal of the Committee, but some of the biographies are rather incomplete, and the names of officers who have rendered valuable services may have been altogether omitted. As regards this part of the book, the Committee invites further co-operation.

The Committee purposes publishing similar lists of the late Hon. East India Company's Artillery, from the time of its formation to the date of amalgamation; as also biographies, tables of strength, distribution, changes in battalions, troops, and companies, and any other statistics of interest.

Many officers have already signified their intention of subscribing to this last named work, and others who may wish to add their names, are requested to notify the same to the Secretary. The expense of this book will certainly not exceed that of the new Kane, and will, it is hoped, be considerably less.

The Committee has decided on not publishing the "List of Service Guns and Ammunition" for this year till the 1st June next; consequent on the number of changes in Laboratory and other stores.

A copy of this list, when published, will be sent to each member, as well as to all commanding officers and batteries, as heretofore.

4. *Library.*—A work on "Exotic Ornithology," containing figures and descriptions of new or rare species of American birds, has been purchased, and is a most valuable addition to the library.

A scrap book, containing extracts from the newspapers on professional subjects, is now kept in the reading room.

Photographs of Abyssinia, taken by 10th Company, Royal Engineers, during the late war, have been kindly presented to the Institution, by the Secretary of State for War.

There has been a sale of 185 War Office photographs and 1000 lithographs during the past year.

A list of the more important lithographs issued by the different departments, and arranged in sets, accompanies this report.

These, as well as others not included in the sets, and photographs of various drills and exercises, can be obtained singly as heretofore by members.

Books, &c., presented.

Index to the several articles in the Periodical Publications received in the War Office Library, during the year 1868	2	The Librarian, War Office.
Index to the Periodical Publications received in the War Office Library, Nos. 1, 2, and 3. 1869	2	
Les Hovas et Autres Tribus Caractèristiques de Madagascar, par S. P. Oliver, Lieut. R.A., F.R.G.S.	...	The Author.
Monthly Notices of the Royal Astronomical Society	...	The Council, Royal Astronomical Society.
Diagram illustrating the course of Promotion in the Corps of Royal Engineers, by Lieut. G. E. Grover, R.E.	...	The Author.
Hart's Quarterly Army List, October, 1868, and January, April, and July, 1869	...	The Committee, R.A. Library.
Pamphlet on "Some applications of Electricity to Naval and Military Purposes," by F. A. Abel, F.R.S.	...	The Author.
Contribution to the history of Explosive Agents, by F. A. Abel, F.R.S.	...	The Author.
Laboratory Teaching, or Progressive Exercises in Practical Chemistry, by C. L. Bloxam, F.C.S.	...	The Author.
The Orbs of Heaven, or the Stellar Worlds, by O. M. Mitchell, A.M.	...	Lieut. J. C. Greene, R.A.
MS. Copy of Repository Exercises, by Col. Congreve, 1800	...	
Stereoscopic View of the Moon, by Warren De La Rue	...	

War Department Photographs	29	Secretary of State for War.
R.L. Lithographs	5	
R.C.D. Lithographs	2	
R.C.D. Photo-Lithographs	7	
Set of Photographs taken by the 10th Company, Royal Engineers, in Abyssinia	...	
Report of the Committee appointed to enquire into the construction, condition, and cost of the Fortifications erected, or in course of erection, under 30th and 31st Vict. and previous statutes	...	
Notes on the manufactures of the Royal Carriage Department, Rl. Arsenal, 1869	...	
Report of the Universal Exhibition at Paris, 1867, by the Executive Committee. Vol. I.	...	
Report of Her Majesty's Commissioners for the Exhibition of Works of Industry, Agriculture, and Fine Arts, held at Paris, 1867	...	
Index to Vols. II., III., IV., and V. of Reports of the Paris Universal Exhibition....................................	...	
Report on the Mitrailleur of Colonel Claxton, by Major Fosbery, V.C., Bengal Staff Corps	...	Director-Gen. of Ordnance.
Extracts from the Reports and Proceedings of the Ordnance Select Committee, Part 4, Vol. VI.	6	
Extracts from the Proceedings of the Department of the Director-General of Ordnance, Parts 1 and 2, Vol. VII.	6	
Extracts from various Reports relative to the merits of Segment as compared with Shrapnel Shells, for field guns ...	...	
Report and Proceedings of the Gun-Cotton Committee, 1864 to 1868	...	
Table of Small-arm Ammunition in the British Service	3	
Arms in use in the British Service.	4	
Report of the Special Committee on Shrapnel *v.* Segment Shell, 1869, with plates and appendices	...	
Summary of Experiments made with cast-iron Guns converted on Major Palliser's system, since January, 1868	6	
Results of Experiments made with Armour Plates in the Royal Gun Factory in 1869, and investigations by Sir W. Fairbairn, during the years 1861–4, for the Special Committee on Iron	3	
Preliminary Report of the Committee on Explosives, with plates	3	

Third General Report of the Council of Military Education	The Council of Military Education.
Reports on the Examinations for admission to the Royal Military Academy at Woolwich, July 1869, and January 1870	
Smithsonian Report, 1867	Smithsonian Institution.
Astronomical Observations, 1867	
Proceedings of the National Academy of Sciences, 1866–7	
Monthly Report, Treasury Department	
The Sanitary Commission of the United States; its work and purposes. 1863 Do. do. do. 1864	
History of the United States Sanitary Commission	
Series of Medical and Surgical Monographs. A to T.	
Memorial of the Great Central Fair for the United States Sanitary Commission, held at Philadelphia, June 1864	
History of the Brooklyn and Long Island Fair, February 1864	
Record of the Metropolitan Fair in aid of the United States Sanitary Commission, held at New York, April 1864	
The application of Photography to Military Purposes, by H. Baden Pritchard	The Author.
Proceedings of the Zoological Society of London. 1869	The Council, Zoological Society of London.
Some observations on the Mobility of Field Artillery, by Lt.-Col. F. J. Soady, R.A.	The Author.
Six Lectures on Water-wheels and Machinery for Raising Water, by W. C. Unwin, Esq.	The Director, Rl. Engineer Establishment, Chatham.
Lectures on the Steam Engine, by W. C. Unwin, Esq.	
Pamphlet on the Duties of a Royal Engineer Officer in time of Peace, with a few suggestions for the Organization of the Staff of the Army	Capt. C. E. Webber, R.E.
Russian Artillery Journal, Nos. 2 to 11, 1869 " Small-arms " " 1, 2, 3, 4, " " Military " " 1 & 2, "	Maj.-General N. de Novitzky.
Journal of the Royal Geographical Society. Vol. XXXVIII	The Council, Royal Geographical Society.
Proceedings of the Royal Geographical Society	
Second Report of the President of the Ordnance Select Committee	Maj.-Gen. J. H. Lefroy, R.A.
View of the Docks of Sebastopol Plan of the Graving Docks of Sebastopol 17 MS. Military Plans	
5 sheets of Artillery Atlas Work entitled, "Rapport du Département de la Guerre."	Netherlands Government.

Summary of Experiments with Palliser converted cast-iron rifled M.L. Guns, since January, 1868	...	The Deputy Adjt.-General, Royal Artillery.
Report of the Special Committee on Shrapnel *v.* Segment Shell, with appendices and plates, 1869	...	
Brigade and General Order Books of the Royal Artillery, forming a part of the force under Gen. Sir Ralph Abercrombie in the year 1800	2	Qr.-Master H. Behenna, R.A.
Military Breech-loading Rifles and Ammunition, by Capts. V. D. Majendie, R.A., and C. O. Browne, R.A.	...	The Authors.
Proceedings of the Institution of Mechanical Engineers, 1861 to 1869 inclusive. Do. do. Newcastle Meeting, Parts 1 and 2.	...	The Council, Institution of Mechanical Engineers.
Proceedings of the Institution of Civil Engineers, Vols. XXVII. and XXVIII.	...	The Council, Institution of Civil Engineers.
Administration of the Austrian Army, translated by Lieut. E. H. Wickham, R.A.	...	Lieut. E. H. Wickham, R.A.
Series of 12 Photographic Views of the Neighbourhood of Niagara, North America	...	Lt.-Col. C. E. Burt, R.A.
Collection of Curious Old French Maps...	...	Lt.-Col. H. L. Chermside, R.A.
Examination Papers, Royal Military Academy, June and December, 1869...	...	The Inspector of Studies, Royal Military Academy.
Pamphlet on Helmets in the Rotunda, from the Turkish Arsenal at Rhodes, by J. Hewitt	...	The Author.
Address to the Mathematical and Physical Section of the British Association, Exeter, 19th August, 1869, by J. J. Sylvester, LL.D., F.R.S.	...	The Author.
Notes on the Great Pyramid of Egypt and the cubits used in its design, by Colonel Sir Henry James, R.E., F.R.S.	...	The Author.
Standing Orders for Woolwich Garrison.	...	The Brigade Major, Woolwich.
Professional Papers of the Corps of Royal Engineers, Vols. XVII. and XVIII. ...	...	The Officers of Rl. Engineers.
Journal of the Royal United Service Institution, Nos. 51, 52, 53, 54, and 55, Vol. XII	...	The Council, Royal United Service Institution.
The Russian approach towards India, explained and exposed	...	Anonymously.
Military Work by Military Labour, with a few remarks on Mr. Hanbury Tracey's motion before Parliament, by an Officer of Royal Engineers	...	The Author.
Journal of the East India Association, No. 2, Vol. III	...	The Council, East India Association.
Moncrieff System of working Artillery, as applied to Coast Defence	...	Capt. A. Moncrieff.

The Constitutional Forces of Great Britain, by Capt. C. B. Brackenbury, R.A. ...	...	The Author.
The Engineer's and Machinist's Assistant, 2 Vols.	...	Lieut. T. Jesson, R.A.
Coloured Engravings (framed) of:— Artillerie Royale, Anglaise.............. " " Prussienne........... " Impériale, Française .... " " Autrichienne...... " " Russe	5	Major-General Sir J. L. A. Simmons, K.C.B., R.E.
Pamphlet, "Colonel Boxer and the War Office," by Maj.-Gen. E. M. Boxer, R.A.	...	The Author.
Notes on the Gunpowder Works at Bouchet, by F. A. Abel, F.R.S.......	...	The Under Secretary of State for War.
Photographic View of Malta (in frame)...	...	Lieut. J. Speranza, Royal Malta Fencible Artillery.

Books purchased.

Anthropological Review. Nos. 25, 26, 27.
Hackney Carriages. Fares, and Abstract of Laws in force within the Metropolitan Police District, and City of London.
Monograph of the Kingfishers. Parts IV., V., VI., VII., and VIII.
Gould's Birds of Asia. Parts XXI. and XXII.
The Ibis. Nos. 18, 19, 20, and 21.
Revue Maratime et Coloniale. January, February, and March, 1869.
Revue Militaire Française. Nos. 4, 5, 6, 7, 8, 9, 10, 11, 12—1869; 1, 2, 3—1870.
Les Phénomènes de la Physique, par Amédée Guillemin.
Mutiny Act and Articles of War, 1869.
Chambers' Etymological English Dictionary. Two copies.
Molecular and Microscopic Science, by Mary Somerville. Two Vols.
The Soldier's Pocket Book for Field Service, by Colonel G. J. Wolseley.
Cavalry Regulations. August, 1869.
The Operations of War, by Colonel E. B. Hamley, R.A. Second Edition.
Practical Hygiene, by Dr. Parkes. Third Edition.
Commission des Conférences Régimentaires. Parts I. to XII.
100 Specimens of Nature-Printed Butterflies.
Gould's Birds of Great Britain. Parts XV. and XVI.
First Report of the Royal Commission appointed to enquire into the present state of Military Education.
British Imperial Calendar, 1870.
Nautical Almanack, 1870.
Exotic Ornithology, by Sclater and Salvin.
Hand List of Genera and Species of Birds. Part I.
Army Estimates, 1870-71.
The Amateur Mechanic's Workshop.
Report of a Committee appointed to enquire into the arrangements in force for the Control of Business in the Army Departments. Two copies.
Roscoe's Lessons in Elementary Chemistry.
The Natural History of Man, by the Rev. J. G. Wood. Two Vols.
Monograph of the Capitonidæ, or Scansorial Barbets. Part I.
Constanceau's French Dictionary.

Arundel Society Plates.

Judges and Warriors—Hermits and Pilgrims.
Portraits of Judocus Vyts, Lord of Pompele, and his wife Isabelle de Borhut, with their patron saints.
The Ordination of St. Lawrence.

5. *Museum.*—During the past year, some additions have been made to the natural history collection of the Institution, consisting of birds from India, by Lieut. J. Biddulph, 19th Hussars (through Lt.-Col. R. Biddulph); of animals and birds also from India, by Captain J. S. Stirling; and of Lepidoptera from Barbadoes and Trinidad, by Lieut. G. S. Parry; and for which the best thanks of the Committee are due.

It is most desirable to complete the collection of British birds and eggs. As a guide to those members willing to assist, a list is given of specimens required to complete this part of the museum.

There has been no addition of shells to the museum, many families of which are deficient, and some not even represented. There are hardly any specimens of British insects, and the Committee trust that members who have the opportunity will assist in the completion of this most interesting part of the museum.

A very valuable addition has been made to the museum of a coffin and mummy, found with about thirty others in the course of some excavations undertaken by H.R.H. the Prince of Wales, at Old Gourneh, near Thebes, in 1869. The existence of the tomb was known to an Arab, whose grandfather had discovered it, and probably when first found, the mummies were partially opened in search of scarabæi and other ornaments.

The thanks of the Committee are due to the Rev. J. G. Wood, M.A., F.L.S., for his arrangement of the collection of weapons of uncivilized races, and for information regarding some of them; as also for a list he has drawn up of weapons required to complete the collection.

Presentations to Museum.

Fossils from the Coal Measures Echina from Brighton Flint Shark's teeth, &c., from Brighton Chalk	...	Lt.-Col. H. L. Chermside, R.A.
Specimen of Great Northern Diver	...	Lieut. J. F. Owen, R.A.
Photograph of Deer's Head, shot by Lt.-Col. Burt, R.A.	...	Lt.-Col. C. E. Burt, R.A.
40 Objects for the Microscope	...	Capt. R. O'Hara, R.A.
A View of Gibraltar, taken from the Devil's Tongue Battery in 1804, by H. A. Barker, Esq. (in frame)	...	Lieut. H. A. Barker, R.A.
4 Animals from India 2 Birds 〃 1 Skull 〃	...	Capt. J. S. Stirling, R.A.
16 Birds from India	...	Lieut. J. Biddulph, 19th Hussars.
Venus' Cup, from the Phillipine Islands.	...	Lieut. C. H. Spragge, R.A.
43 Butterflies from Peru	...	H. Whitely, Esq., jun.

Bandolier for holding cartridges, worn round the waist by the Amazons of the West Coast of Africa, in the army of the King of Dahomey	...	Lieut. F. H. Eardley-Wilmot, R.A.
44 Specimens of Halloysite from India... 1 Specimen of Stalactitic Peroxide of Iron	...	Major W. A. Ross, R.A.
Model in Soapstone, of the Monument erected to the memory of Sir Henry Lawrence, K.C.B., and those who fell in defence of the Residency, 1857......	...	Major J. G. Clarke.
2 Specimens of Hang Nests	...	Major H. Le G. Geary, R.A.
Collection of Pottery from Madagascar ...	...	Lieut. J. C. Robinson, R.A.
145 Insects from West Indies	...	Lieut. G. S. Parry, R.A.
Portable Pocket Gunner	...	Qr.-Master D. Hoge, R.A.
Chinese Dice Box	...	Capt. C. J. M'Mahon, R.A.
Japanese Compass........................	...	Lieut. W. E. Sharp, R.A.

Birds from India, presented by Lieut. J. Biddulph, 19*th Hussars.*

Nectarinia mahrattensis. ♂ ♀
Ceriornis melanocephala. ♀
" satyra. ♀
Pucrasia macrolopha. ♂ ♀
Euplocamus albocristatus. ♂ ♀
Arboricola torquata. ♂ ♀
Lerwa nivicola. ♂ ♀
Numenius arquata.
Hydrophasianus sinensis. ♂ ♀
Dendrocygna ansuree.

Animals and Birds from India, presented by Captain J. S. Stirling, R.A.

Chaus lybicus.
Viverra civetta.
Viverricula indica.
Herpestes griseus.
Skull of felis leopardus.
Bubo bengalensis.
Athene brama.

Presented by Lieut. J. F. Owen, R.A.

Colymbus glacialis.

Presented by Major H. Le G. Geary, R.A.

Two nests of weaver finch.

Presented by Lieut. G. S. Parry, R.A.

Lepidoptera from Barbadoes and Trinidad.

Presented by Captain R. O'Hara, R.A.

Specimen of ant lion.

Specimens required for the Collection of British Birds and Eggs.

Griffon vulture.
Egyptian 〃
Golden eagle.
Spotted 〃
Osprey.
Cinereous eagle.
Rough-legged buzzard.
Honey 〃
Kite.
Swallow-tailed kite and egg.
Jerfalcon.
Peregrine falcon.
Hobby.
Merlin.
Red-footed falcon.
Goshawk.
Hen harrier.
Ash-coloured harrier.
Marsh 〃
Great-eared owl.
Hawk 〃
Snowy 〃
Tengmalm's 〃
Short-eared 〃
Little 〃
Sparrow 〃
Tawny 〃
Long-eared 〃
Barn 〃
Nightjar.
Hoopoe.
Dartford warbler.
Blue-throated warbler.
Alpine accentor.
Crested titmouse and egg.
Bearded 〃 〃
White wagtail.
Grey 〃
Ray's 〃
Grey-headed wagtail and egg.
Richard's pipit and egg.
Tawny 〃 〃
Red lark and egg.
Dipper.
Rock thrush.
Ring ouzel.
Blackbird.
Golden oriole.
Pied flycatcher.
Great grey shrike and egg.
Nutcracker and egg.
Raven.
Jackdaw.
Hooded crow.
Mealy redpole and egg.
Siskin 〃
Serin finch 〃
Painted bunting 〃
Lapland 〃 〃
Ortolan 〃
Cirl 〃
Short-toed lark and egg.
Calandre 〃 〃
Crested 〃 〃
Wood 〃
Shore 〃
Pine grosbeak and egg.
White-winged crossbill and egg.
Parrot 〃 〃
Three-toed woodpecker 〃
Downy 〃 〃
Hairy 〃 〃
Great spotted 〃 〃
Lesser 〃 〃
Great black 〃
Green 〃
Yellow-billed cuckoo and egg.
Great spotted 〃 〃
Ring dove.
Rock 〃
Palla's sand grouse and egg.
Pheasant.
Barbary partridge.
Quail.
Andalusian quail and egg.
Capercaillie.
Ptarmigan.
Ruffed bustard and egg.
Little 〃 〃
Great 〃
Little ringed plover.
Kentish 〃
Golden 〃
Oyster catcher.
Crane.
Buff-backed heron.
Great white 〃
Purple 〃
Squacco 〃
Common bittern.
Little 〃
Night heron.
Spoonbill.
Black stork and egg.
White 〃
Glossy ibis.

Whimbrel.
Esquimaux curlew and egg.
Bartailed godwit.
Black-tailed 〃
Spotted redshank and egg.
Yellow-shanked sandpiper & egg.
Green 〃 〃
Green-shank 〃 〃
Buff-breasted 〃 〃
Bartram's 〃 〃
Wood 〃
Spotted 〃
Avocet.
Black-winged stilt and egg.
Ruff.
Knot and egg.
Bonaparte's sandpiper and egg.
Purple 〃 〃
Pectoral 〃 〃
Temminck's stint and egg.
Little 〃 〃
Broad-billed sandpiper and egg.
Curlew 〃 〃
Sanderling and egg.
Brown snipe and egg.
Great snipe.
Woodcock.
Grey phalarope and egg.
Red-necked phalarope.
Little crake and egg.
Moor hen.
Coot.
Spurwinged goose.
Egyptian 〃
Bernicle 〃
Red-breasted 〃
Canada 〃
Grey lag 〃
Bean 〃
Pink-footed 〃
White-fronted 〃
Hooper.
Bewrick's swan and egg.
Polish 〃
Shieldrake.
Ruddy shieldrake and egg.
Wigeon.
Wild duck.
Teal.
Bimaculated duck and egg.
Garganey.
Gadwall and egg.
Shoveler.
Red-crested duck and egg.
Ferruginous 〃 〃

Tufted duck.
Golden eye.
Buffle-headed duck and egg.
Harlequin 〃 〃
Western 〃 〃
Eider 〃
Velvet scoter and egg.
Common 〃 〃
Surf 〃 〃
Goosander.
Hooded merganser and egg.
Red-breasted 〃
Smew and egg.
Great northern diver and egg.
Black-throated 〃
Red-throated 〃
Red-necked grebe.
Sclavonian 〃
Great crested 〃
Eared 〃
Puffin.
Brunnich's guillemot.
Black 〃
Little auk and egg.
Dusky shearwater and egg.
Greater 〃
Manx 〃
Forked-tailed petrel and egg.
Wilson's 〃 〃
Stormy 〃
Fulmar 〃
Bulwer's 〃
Pomarine skua and egg.
Common 〃
Arctic 〃
Buffon's 〃
Great black-backed gull.
Lesser 〃 〃
Black-headed 〃
Bonaparte's gull and egg.
Little 〃 〃
Sabine's 〃 〃
Ivory 〃 〃
Caspian tern and egg.
Gull-billed 〃 〃
Whiskered 〃 〃
Sooty 〃 〃
Sandwich 〃
Roseate 〃
Common 〃
Arctic 〃
Lesser 〃
Gannet.
Cormorant.
Green cormorant.

6. *Classes.*—The classes for German and French have met as usual.

The Drawing Class has been particularly well attended, the present instructor, Mr. Needham, giving great satisfaction.

7. *Surveying and Practical Astronomy.*—During the past year the Surveying Class has been attended by several officers, all of whom have been instructed in military sketching and measuring distances, Lieut.-Colonel Drayson having attended twice in each week for this purpose.

8. *Photography.*—The photographic department is in good working order, and continues to prosper. Five officers have received instruction in photography since the last report. 450 negatives have been taken during the year, from which over 4000 copies have been printed.

Thanks are due to Lieut.-Colonel Burt, for twelve views of Niagara, taken by himself.

9. *Chemistry.*—The laboratory has been in constant use by the Advanced Class, and also by officers working independently.

10. *Instruments.*—The instruments are in working order, and have been in constant use by the Advanced Class, and also by officers preparing for examination.

The maximum and minimum temperature of the atmosphere, together with the direction of the wind, is taken daily, and a register of the same is kept in the reading room.

11. *Model room.*—Since the last meeting, a large number of service projectiles and other stores have been deposited in the model room, and many now obsolete returned into store. A catalogue of these stores has been carefully compiled, so that members can now without any difficulty make themselves acquainted with them.

The following cases have also been re-arranged :—

(1) Boxer small-arm breech-loading ammunition, showing construction and progressive stages of manufacture.
(2) The different fuzes at present in use in the service, arranged by gauge of fuze hole.
(3) Tubes.
(4) Rockets, long lights, &c.

12. *Workshop.*—The turning lathes and carpenter's tools for the use of members in this shop are in good working order.

13. *Lectures.*—Lectures have been delivered weekly in the Theatre of the Institution by Mr. Bloxam, F.C.S., on General Chemistry, and by Dr. Percy, F.R.S., on Metallurgy.

The following list contains a statement of Evening Lectures which have been given during the past winter; and the Committee has to express its thanks to Mr. S. Brandram, Professor Maclean, Mr. W. H. Preece, Dr. Ruskin, and especially to Mr. C. L. Bloxam, for devoting so much of his valuable time to the Institution.

Dr. Ruskin	The Future of England.
S. Brandram, Esq., M.A.	Readings from various authors.
Rev. H. Martyn Hart, M.A.	"Wave Motion:" as illustrated in Tides, Sound, Light, and Earthquakes.
W. H. Preece, Esq., C.E.	The Application of Electricity to Railway Purposes.
Professor Maclean	British Rule in India.
C. L. Bloxam, Esq., F.C.S.	Chemical Lecture.—"The Breath of Life."

14. *Afternoon Meetings.*—These meetings, for some time discontinued, have been resumed with every promise of continuance, and some interesting discussions have taken place.

The thanks of the Committee are due to the undermentioned officers for the papers read by them:—

Colonel J. M. Adye, C.B.	Central Asia, and our Military Position on the North-West Frontier of India.
Colonel H. H. Maxwell	The Field Gun for India.
Captain C. O. Browne	Our Rifled Projectiles and Fuzes.
Captain J. P. Nolan	Measuring Distances, as applied to Military Purposes.
Lieut. J. A. S. M. Davies, B.A., F.R.A.S.	On a New Method for rendering Turret Ships Sea-going Vessels.

Colonel Adye's paper has been published in No. 11, Vol. VI. of the "Proceedings."

In compliance with Rule V., the following officers retire from the Committee, and are not eligible for re-election:—

Colonel G. T. Field.
Captain F. A. Whinyates.
Captain C. Orde Browne.
" J. C. J. Lowry.
Lieut. A. B. Brown.

The following members have left the Garrison, and the vacancies thus occasioned have been filled up by the Committee:—

Colonel J. M. Adye,	by	Colonel W. J. Smythe.
Lieut.-Colonel H. T. FitzHugh,	"	" G. H. Vesey.
Captain J. S. Stirling,	"	Lieut.-Colonel G. A. Milman.
" C. E. S. Scott,	"	Captain F. de Winton.
Lieut. O. F. T. Annesley,	"	Lieut. E. Kensington.

The members of the Committee cannot allow Colonel Adye's retirement to pass without some record of their appreciation of his devotion to the welfare of the Institution, and of the great assistance he rendered them in the performance of their duties.

The following resolutions were passed :—

1. *Proposed by Captain Morgan, seconded by Major Geary,*—

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

2. *Due notice having been given, in accordance with Rule XVIII., the following alterations and additions in Rule II. were submitted by the Committee :—*

(1) "That paragraph 2 be struck out, and paragraph 3 become paragraph 2."

(2) "'The Director of Naval Ordnance to be an honorary member, *ex-officio*,' to be inserted after paragraph 2."

(3) "'The naval and military *attachés* at the different embassies in London, may be elected honorary members at the discretion of the Committee, during the time they are thus employed,' to be inserted after paragraph 3."

(4) "Paragraph 4 to become paragraph 5, and to read as follows :—

'The Committee may submit to the annual meeting the names of gentlemen, whether officers in the army or navy, or civilians, for election as special honorary members of the Institution, *the names of these gentlemen having been exhibited at the Institution for fourteen days previous to the meeting.* Gentlemen thus elected, may receive the periodical *publications* of the Institution without any payment. The total number of special honorary members shall not at any time exceed 20.'"

3. *Due notice having been given, in accordance with Rule XVIII., the following addition to Rule III. was submitted by the Committee :—*

"and Veterinary" to be inserted after "Medical."

4. *Due notice having been given, in accordance with Rule XVIII., the following alterations in Rule V. were submitted by the Committee :—*

(1) "That the 'Director of Artillery and Stores' be substituted for 'Director-General of Ordnance.'"

(2) "That the 'Secretary, Department of the Director of Artillery and Stores,' be substituted for 'Secretary, Committee on Inventions.'"

5. *Due notice having been given, in accordance with Rule XVIII., the following addition was submitted by the Committee:—*

"That the following rule be inserted as Rule XVIII.—

'At the discretion of the Committee, assistance will be afforded from the general funds in support of all voluntary classes at the Institution; such assistance not to exceed one-third of the whole amount.

'Members wishing to join any class, are to give notice in writing to the Secretary.

'Any officer who may be prevented, by duty or sickness, from attending any class, is to intimate the same in writing to the Secretary. He will otherwise be charged as if present.'"

6. *Due notice having been given, in accordance with Rule XVIII., the following addition was submitted by the Committee:—*

"That the following rule be inserted as Rule XIX.—

'The Institution will bear a share of the expense of a class at any out-station at which as many as three of its members will combine for the purpose.

'The share of the expense borne by the Institution shall not exceed one-third of the whole expense of the class.

'The number of lessons to which the Institution will contribute shall not exceed one per week.

'The class to designate one of their number, who will engage to furnish a return of the members present at each attendance of the master, and to manage the payments. An account to be sent quarterly to the Secretary of the Institution.'"

"That Rule XVIII. and the remainder of the rules be re-numbered consecutively to XX."

7. The following officers were elected to serve on the Committee, viz.:—

Lieut.-Colonel O'B. B. Woolsey.	Captain J. P. Morgan.
" C. H. Owen.	" M. C. Newall.

Lieut. J. Sladen.

8. *Proposed by Lieut.-Colonel Young, and seconded by Colonel Field:—*

"That the thanks of the meeting be voted to the Chairman."

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 of the Garrison, Woolwich.
The Director of Artillery and Stores.
The Deputy Adjutant-General.

MEMBERS:

The Assistant Adjutant-General.
The Director of Artillery Studies.
The Brigade Major.
The Secretary, Department of Director of Artillery and Stores.

Colonel W. J. Smythe.
〃 G. H. Vesey.
〃 G. Rotton.
Lieut.-Colonel O'B. B. Woolsey.
〃 G. A. Milman.
〃 C. H. Owen.
Major H. V. Timbrell.

Captain T. B. Strange.
〃 F. de Winton.
〃 J. P. Morgan.
〃 F. Duncan.
〃 M. C. Newall.
Lieut. J. Sladen.
〃 E. Kensington.

Asst.-Surgeon F. R. Hogg, M.D.

Captain A. D. Burnaby, *Secretary and Treasurer.*

(Signed) C. J. WRIGHT, Colonel, R.A.,
in the Chair.

18th May, 1870.

ERRATA.

Page 60, note 2, *omit* "Russian."
,, 62, note 2, should read "The exact weight is 14650 kilogrammes = 14 tons, 8 cwt. 2 qrs."
,, 71, 20th line from top, *for* "powder," *read* "power."
,, 71, 11th line from bottom, after "greater" *insert* "than."
,, 79, 2nd line from top, *for* "Redsdale," *read* "Ridsdale."
,, 98, note 5, *for* "almost exactly 9 ins. (9·1735 ins.)," *read* "almost exactly $8\frac{3}{4}$ ins. (8·779 ins.)"

OUR

RIFLED PROJECTILES AND FUZES;

PRESENT CONSTRUCTION AND PROBABLE EFFICIENCY ON SERVICE.

A PAPER READ AT THE R.A. INSTITUTION, WOOLWICH, MARCH 8, 1870,

BY

CAPTAIN C. ORDE BROWNE, R.A.,

CAPTAIN INSTRUCTOR, ROYAL LABORATORY.

COLONEL J. M. ADYE, C.B., R.A. IN THE CHAIR.

It will be my aim to-day, without going into details, to bring before you a short summary of the actual condition of our service rifled projectiles, in order that officers who may not have time and opportunity themselves, may, without waste of labour, have them brought before them, and so may be induced to give us the benefit of opinions rendered specially valuable by being based on actual experience.

Were it the practice, from time to time, for officers engaged in any special branch of work to do this, without necessarily pretending to anything beyond that knowledge of facts which their work must give them; and were this really taken up by you, I say, soberly, that I see no reason why discussions here might not be the best of their kind in the world.

I hold our artillery *matériel* to be, at all events, inferior to none. In ancient times we were the first European nation to use cannon; the very name of Congreve rockets and Shrapnel shell—well known in all civilized armies—prove that we have in modern times also taken the lead; while recently, when allied with the French in the Crimea, we may recall the fact of their borrowing our iron guns when their own bronze pieces failed; and when, in answer to a request for fuzes, we sent them some about as good as and much like their own, some of us may remember their bringing them back and throwing them down, saying, "*Nous ne voulons pas ces choses, nous voulons la fuzée de Boxer.*" I naturally have pleasure in calling to mind an incident like this, when the retirement of General Boxer from the head of my Department enables me to notice such things without any feeling of awkwardness.

At the present time, England has been manufacturing *matériel* so largely for Sweden, Russia, Italy, Denmark, Turkey, Egypt, America, &c., that she has become a sort of arsenal to the world. Certainly, in Woolwich, if we cannot discuss these matters well, we ought to be ashamed of ourselves.

To commence my summary, the systems we have will group themselves very fairly under the three heads of—1. Projectiles for heavy guns. 2. Those for siege guns and guns of position. 3. Those for field guns.

To commence with

Heavy Guns.

These are 13″, 12″, 9″, 8″, and 7″—all Woolwich guns.

Now with these, and indeed all rifled ordnance, it will be found, speaking generally, that shells will, in the long run, supersede solid shot, and probably all shot (case excepted), and the reasons are obvious.

With smooth-bores, shot had certain peculiar advantages which enabled them to hold their own—viz., from the fact that all spherical projectiles were of one form, and all fired from the same gun were one size instead of one weight, it followed that the momentum of solid shot was greater than that of shell; and hence they kept up their velocity better, and had a flatter trajectory. Besides this, there was something to be said for the ricochet of a round shot as compared with the bursting of a shell. But neither of these advantages hold in the case of rifled projectiles; for by increasing the length, the shell may be made up to the same weight, and so given the same momentum and trajectory as the shot. This power of bringing all projectiles for each gun to the same weight, is one of the numerous advantages possessed by rifled guns over smooth-bores; but it is also obviously a great advantage for the shell as compared with the shot. The ricochet of rifled projectiles in all cases being nearly worthless, deprives the shot of the other advantage; and, in addition to this, the weight of the shell being distributed round the outside, gives it a longer radius of gyration, and hence a more powerful rotation and increased accuracy. May we not, therefore, conclude that such unequal competition must eventually end in favour of the shell, where it has not already so terminated.

I may further notice, with reference to the Woolwich guns, that the calibre, charge, and pitch of rifling are such that the length for accurate shooting necessitates a hollow in the projectile; for a solid projectile properly proportioned for shooting with these guns—that is, from two to three calibres in length—would exceed the weight intended for them, and would strain them.

The projectiles for these guns at present stand as follows:—

Common shell,
Double shell,
Boxer shrapnel shell,

Palliser shell,
" cored shot,
Case shot.

The double shell is simply a common shell prolonged so as to take an increased bursting charge. Being too long for good shooting, it is intended chiefly for firing at wooden ships at short ranges. It exists only for the 7″ calibre, weighs nearly 160 lbs., and contains about 12¾ lbs. of powder. I mention it first in order to be able to consider its power and effects together with those of common shell; the main feature to notice in both cases being the very great explosive power, especially great when compared with smooth-bore shell, which always were under the weight that would seem to belong to their name.

To give some comparison. The 13″ shell contained nearly 11 lbs., while the Woolwich 12″ shell will take 35 lbs.; the 68-pr., or 8″ shell, has a bursting charge of 2 lbs. 9 ozs., and the 7″ rifled shell 8¼ lbs. of powder.

The exact effects of these shells in bursting has never been thoroughly investigated; but Admiral Key, on February 2nd, 1866, reports on 7″ double shell fired at the "America" to test its effects. One burst 6 ft. inboard the lower deck, entirely destroying one-half of a main-deck beam, with about 8 ft. square of planking, and cutting severely into the planks and beams of the lower deck. Another struck the chain cable on starboard quarter, and burst before passing through, making a clear hole inside about 26 ins. square, and laying eight planks on the side open to the extent of 28 ft. by 8 ft.; the damage in this case was very close to the water-line. These shells have been fired up to more than 2000 yds., the committee report, with satisfactory accuracy.

Such being the power of 12¾ lbs. of powder, what may we expect from 35 lbs.? To this I cannot give an answer; for I know of no experiments to quote, either as to breaching of masonry, earth, or the destruction of ships' sides.

Next, as to incendiary power—although targets and backings are sometimes ignited with the double shell—Admiral Key remarks:—"In no instance did they set the ships on fire." This being so, I may call attention to the fact that, though a comparatively recent order extended the application of carcasses to all calibres of smooth-bore guns down to the 12-pr., there exists no kind of incendiary projectile for rifled ordnance of any calibre; which is the more remarkable, because, for obvious reasons, as to studs, coats, &c., red hot projectiles could not be fired; and further, carcass rockets have ceased to exist, and even shell rockets have been made into shot by having the head plugged up with wood.

There is a curious fact connected with the strain on a shell in the bore of the gun that I should notice—viz. the great pressure of the gas escaping past the shell, on its sides. The specimen on the table is a comparatively mild example of the effects of this. It will be seen that in that shell the diameter in the middle is only 8·55 ins., while that at the base is 8·92 ins., and close to the head 8·9 ins.; this is due to the pressure of the gas in the gun having told more on the part of the shell furthest from the support afforded by the metal at the head and base. I need hardly say before firing, the shell was of one diameter throughout; from this the value of the longitudinal flanges or ribs in the interior of the double shell may be seen. I may also call attention to the curious nature of the action of the flash of exploded gas firing a shell by entering at a porous place through a tortuous hole. I believe some remarkable results might be quoted by officers who have experimented as to this at Shoeburyness, but I would only notice the singular conditions of the question. You have gas at a great heat forced through a mass of metal whose conducting power is so great that it might be expected to act with the cooling effect of a system of gauze burners, and, on the Davy safety lamp principle, only allow the flame to enter in the form of a rush of cool gas, effective only as to its pressure; but it is probable that the velocity is too great to allow the conducting power of the metal to act, so that the flame enters with heat, as well as enormous pressure.

Common shells are issued filled for sea service, with Pettman general service percussion fuzes in them; they have also Boxer time fuzes, for use if required. For sea-fronts of forts they have these time and percussion fuzes also, but for land-fronts only time fuzes; the Pettman general service fuze being peculiar in its action, and not generally suited for land service rifled guns—for it is constructed not to explode on striking water, even at a high velocity, yet to explode on a ship's side, even at a low velocity, and to act before it crosses the vessel's deck. It is alike available for smooth-bores as well as breech-loading and muzzle-loading rifled guns; it is therefore an efficient fuze, especially for sea service—for it is very necessary that in aiming to hit a ship near the water-line, the accidental contact with a wave should not explode the shell prematurely; but for land service these very conditions rather tell against it—for it will not act on graze unless the falling angle be very great, and the blow consequently more direct than usual. This being so, and the time fuze being driven into the shell, and so made to fire it by direct impact, it follows that there is no use in issuing the Pettman percussion fuze for the land-fronts. It seems unlikely that a fuze to act on graze would be required for the heavy guns, but at all events it is well that its non-existence should be noted.

Boxer Shrapnel.

You see on the table this shell for the 7″ calibre. It is not necessary to discuss its construction further than to say, it has a bursting charge in its base, a wood head lightly attached and easily blown off, and sand shot varying in weight from 4 to 2 ozs., according to the calibre, and numbering 530 in the 12″ and 227 in the 7″.

This description of shell has been preferred to the segment shell beyond question for the large calibres; the effect is good when opened even as much as 500 yds. short of an object. Hence, with the 9 seconds Boxer wood fuze, shrapnel are available for ranges up to about 3000 yds. (nearly a mile and three-quarters). The fuze is used with a primer beneath it to prolong its flash.

It is so important, in the firing of these shells, to watch and understand the indications of the effects that are being produced, that, at the risk of being tedious, I would just call attention to them, believing as I do that the disappointment occasionally following the employment of shrapnel, is commonly due to an over sanguine estimate of these results.

It is necessary not only to note the position of the burst of the shell, but also, if possible, the graze of the balls—which on water give splashes, on dry ground puffs of dust, on ice (so I am informed) very distinctly scored marks, but on boggy ground, I fear, no marks whatever. The importance of this is obvious, from the fact that it is impossible to estimate from the firing point the longitudinal position of the burst, which is seen as a cloud in the air.*

We next come to

Palliser Projectiles.

To point out clearly the condition of these projectiles, I must explain generally the principles of manufacture, and must apologise for bringing together some well-known facts. Iron is hardly to be obtained as pure iron—that is, wrought-iron—in the molten condition, but in contact with some form of carbon it is readily melted, the carbon so far combining with the iron as to form cast-iron; the carbon either remains combined with the iron, or separates from it more or less in cooling, according to its nature. In very white iron it is nearly, if not all, in the combined state of some form of carbide of iron; in very grey iron it is an intimate mixture of particles of carbon—termed graphite—and particles of iron, and intermediate irons range between these extremes. Further, it is found that the carbon has a better opportunity of separating when the iron is cooled slowly than when quickly cooled; hence, iron which might be mottled if cooled slowly, is obtained as a species of white iron when cooled suddenly, or chilled. This, in the case of Palliser projectiles, is effected by running it into metal moulds, or chills, which, by their great power of conducting heat, carry off that of the molten metal so rapidly as to cause it to solidify before the carbon can separate from the iron; hence we get the chilled form of white iron.

I have called it the *chilled form of white iron,* because it is not exactly in the same condition as iron which, from its own tendencies, became white, even when cast in sand. If the specimens on the table be examined, it will be seen that the chilled specimen is close and more silky in its texture than the harsher looking white iron proper; it is believed that it exceeds white iron in the degree in which it exhibits qualities common no doubt to both, to some extent; these are—*intense hardness, great crushing strength, and density.* Both chilled and white iron are brittle, being deficient in tenacity.

Examined chemically by Eggertz' test, with nitric acid, the carbon would probably be found in much the same condition in both.

To bring all these matters to practical results: the crushing strength and hardness are found to be exactly what is required to pierce armour-plates, with such a form given to the head by Major Palliser as to prevent the ill effects of the want of tenacity.

The action of piercing armour-plates may be compared to the ordinary work of punching sheet-iron with a steel punch; when, if enough force is used, something must give way. The punch itself may crush, but the crushing or flattening of the sheet-iron is not sufficient to give relief; it is necessary that the part in front of the punch should come away from the rest, and so let the punch through. Hence the two forces opposed to each other are the crushing strength of the punch, and the tensile strength of the plate. In piercing armour, the work is done

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* *Vide* paper by Major-General Gardner, Vol. VI. p. 33.

suddenly, and the conditions are altered, but still there is much resemblance; so that we find crushing strength a great desideratum in the projectile, and tensile strength equally important in the plate.

I have mentioned hardness and crushing strength as distinct properties. They may at first appear to be the same; but while the former expresses rigidity in each projectile, the latter refers to rapid connection of a mass of particles. Thus glass is harder than iron, and will scratch it; but iron has greater crushing strength than glass, and may be made to crush it.

We naturally look for proofs, or at all events indications, of the projectiles having exhibited the qualities we ascribe to them in the act of performing their work.

In picking up fragments of Palliser shot after impact against armour, two things may be specially observed; one, that the point, however much broken, is never flattened, owing to its intense hardness; the other, that the fragments are most remarkably cool as compared with those of other projectiles, and this seems to prove that its structure has been less crushed—for almost all material becomes heated when pressed out of shape, or set up.

There is, however, a disadvantage in having metal in the constrained or unnatural condition produced by chilling. I made experiments to ascertain the respective densities of shot from the same ladle of metal, in chill and in sand, and found the former to be perhaps as much as 3½ per cent. the denser of the two. Now, the power of molecular forces —that is, of the tendencies of particles of any substance to assume any condition that circumstances encourage—is gigantic. Thus we know shells may be split by water freezing in them, so a Palliser shell may be split by filling it with molten iron and allowing it to solidify in the shell.

Hence it is not very surprising that chilled metal should, under some circumstances, assert its right to so far take a more natural form as to split or crack the projectile. This frequently occurred with solid shot formerly made, and it occurs with shell also. The specimen on the table is a shot found cracked so as to be hardly visible until it was split open, when the extent of the injury became manifest. Hence it is not surprising that shot and shell should occasionally have broken in the guns—the shot, of the two, being perhaps the more likely to wedge in the bore and do serious injury.

For this reason chiefly, it has been found an improvement to chill only the head, and form the body of the mould in which the shot is cast of sand. This was, I believe, suggested some considerable time ago, both by General Boxer and Mr. Davidson, the manager of the Royal Laboratory; and I would especially mention that to Mr. Davidson is due in a great measure the actual efficiency of the Palliser projectiles as they now exist in the service; and I think I may say that Major Palliser is anxious to accord to him the credit of having worked the subject out in a way that, perhaps, could hardly have been done by anyone else.

I am not aware of the relative tendencies of white and chilled iron to split, but I feel confident that mottled bodies cast in sand are less liable to this evil than either.

The projectiles cast with sand bodies are superior in penetration to those entirely chilled; because, as may be seen, while the pressure round the head towards a centre does not test its tenacity, the base is in a very different condition. The metal there, having lent its force to some extent to the head, shivers away to the front, generally indenting the plate round the hole made by the head. Any increase of tenacity in the material at the base, is therefore clearly an advantage.

Palliser shells are fired without any fuze by impact against armour; they would only act as shot against wooden vessels. Hence it was proposed by Lieutenant Boxer, R.N., to use percussion fuzes in them, in case of mistakes as to the character of an adversary in active service; but this has not been adopted.

Penetration of plates at an angle, I will not attempt to discuss here; but I may notice the strong conviction that every one I meet who ought to understand the matter seems to feel, that the Palliser projectiles—on every theoretical and practical ground—are better for this and all purposes than the Whitworth, or any other that is known.

Case Shot.

It will be seen that, far from this being the simple subject many suppose it, it is a very difficult one, if we may judge by the imperfect state of development of case shot. The difficulties are—liability to injure the bore of the gun, and liability of soft metal to conglomerate into masses.

Lieut. Reeves proposed the case first adopted in the service, in which the balls were packed, either in wood discs recessed to hold them, in sawdust, within a wood lining, or in an experimental case shot, in rosin, all interstices being first filled with buck-shot.

General Boxer designed a case shot which carried closer and gave better results on targets, when fired by the Armstrong and Whitworth Committee; this had an iron casing.

The present service case shot contains 8 oz. sand shot for Woolwich projectiles, packed in coal-dust, within a lining of iron segments or curved plates, which, laid inside an envelope of sheet iron, protect the bore.

The Committee have laid down the weight of the case as follows:—For 7″ and under, it is to be two-thirds the weight of any other service projectile; for guns over 7″, it is to be the weight of a solid round shot of the same calibre.

And here I cannot refrain from expressing an opinion—viz: that these case shot are far from being efficient. The sand shot are much too large. At one time they reached the ridiculous size of 2 lbs. weight a-piece in the 9″ case.

Lieut. Reeves, to the last, continually protested against their size; urging that for long ranges shrapnel were more effective, and for short ranges, small shot would both disable men and boats more effectually.

General Boxer wrote that 6 oz. sand shot were as large as would ever be required for any penetration, and protested against the employment of the large balls.

General Wilmot, when Commandant of the School of Gunnery, supported the opinion expressed by Lieut. Reeves; and finally, Capt. Hood, on behalf of the Naval School of Gunnery, recommends smaller balls than those employed, and the Director-General of Naval Ordnance writes to support General Boxer in asking for a decrease in size. One is at a loss to find the individual who really has succeeded—in the teeth of so many authorities on the subject—in keeping these large sand shot in the service; and perhaps one is at just as great a loss to find anything but objections to them.

They are much more liable to injure the gun; therefore the iron linings have to be absurdly heavy, and hence take up a disproportionate share of the very limited weight allowed to case shot. Again, the larger balls do not pack nearly as close; hence the projectile is longer than necessary, and this again increases the weight of the lining and decreases the quantity of the case shot.

It may be urged that, for large guns, the ground in front is generally known to be flat, and suited to ricochet of balls, and hence the range may be extended very greatly; to which it may be replied, that any troops who would leave trenches and expose themselves to the fire of case shot, for a longer distance than 300 yds., would not only be lunatics, but might be considered as nearly harmless lunatics.

But, indeed, while I wish to praise the service projectiles, I cannot say that case shot appear to me to have been satisfactorily worked out yet. I think the actual use of case on active service has been to some extent lost sight of. Surely case may be said to be used only at critical moments, and questions of slight fouling—an objection urged against rosin—hardly deserves consideration, while increase of smoke would be a positive advantage; for the infantry would be at a range at which their fire would be most deadly, and case require little aim and no elevation—in fact, as the committee observe, they graze better and closer to the ground when delivered horizontally.

So, again, expense is a very dubious objection to urge strongly against lead and antimony balls; for the objection amounts to this—we cannot afford to fire the best and heaviest balls against infantry who are within 300 or 400 yds. of us, and perhaps rushing at our guns, because they cost £25 a ton; we must rather fire sand shot, at £14 a ton. I now speak more especially with reference to the smaller calibres, and I would say that of all projectiles—considering the moments when it is used—expense should carry least weight in the matter of case shot.

Then again, why is the weight to be cut down to the limits proposed? Take, for example, the 8″ case. This will weigh 68 lbs. and contains seventy-five 8 oz. sand shot—that is, it fires 37 lbs. weight of balls; the other service projectiles for the same gun weighing 180 lbs. each. In spite, no doubt, of a greatly inferior velocity, I hold the old smooth-bore 42-pr.—which fired exactly nine more of the very same sand shot—just as good a projectile. With a 42-pr. cast-iron gun competing against a 180-pr. rifled gun, I think I am justified in saying that case, for rifled ordnance, are in a very imperfect state of development.

But I may be told that two case shot may be fired at once. Certainly, I have no hesitation in saying many of us would fire three without being told at all. With infantry within 300 yds. of us, we should not carefully consider Army Circulars and Changes in War Stores; but the proportions of stores issued are based on the supposition that one case shot only is used, and the supplies are made accordingly. We are told that, after all, case are hardly required for these guns. If true, that might be a reason for having none, but hardly a good reason either for having a bad case shot, or for acting on the supposition that we have more rounds of case than we really are provided with.

It is true that the segments, or lining, cause the shot to carry close and make better target practice, and also that something is found necessary to protect the bores of the guns; but in the pattern before us this is done at a very great sacrifice.

But to crown all, what is the name of this case shot? It is termed the "Royal Laboratory pattern." This is really very hard. There was once a form of point tried with Palliser shell which we termed the "committee point," but when it began to do badly we took to calling it the "Belgian point;"* and I suggest that this case shot be called the "Belgian case shot." As yet we have not heard it much found fault with; but I am quite satisfied it will do very badly, and think its name ought to be changed at once.

Matériel for Siege Guns and Guns of Position.

Under this head come the 7″, 64-pr., and 40-pr. breech-loading guns, and the muzzle-loading 64-pr. shunt takes the same projectiles, segment shell excepted, and we may therefore consider it at the same time.

The projectiles for siege guns and guns of position are:—

Common shell,
Boxer shrapnel shell,
Segment shell,
Case shot.

Hollow shot have disappeared, and solid are fast following them, though batteries of position still retain the 40-pr. solid shot. Shrapnel have to a great extent superseded segment shell, which are stated by Sir W. Armstrong to have been specially constructed with a view to wooden shipping, &c. We retain them for our siege equipments, although we have no percussion fuze to cause them to act on graze, which we shall see hereafter is their natural associate. It should be observed, with reference to our siege equipment, and still more our guns of position, that we have no means of firing shell to act on graze. The time fuze (Boxer B.L.R.O.) acts on direct impact; hence there would be no advantage in issuing the Pettman G.S. fuze, for, as noticed before, it would not act on graze. There exists a means of firing a small field service percussion fuze from old pattern segment shells; but it is not

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* This, I think, was really due to a similar point having been tried in Belgium; not to any wish to connect bad *matériel* with that country.

intended to do this, and probably there are not a dozen people in the service who know of it, and would think of it, even where they had it.

The shrapnel and case differ only in size and in details from those of the Woolwich guns.

Field Equipment.

This we must look upon as in a state of transition—our breech-loading field equipment having had its foundations thoroughly shaken.

The introduction of the 7-pr. mountain gun has been followed up by the much more important decision in favour of the muzzle-loading gun for India, described to us by Colonel Maxwell.

The Dartmoor Committee declare that we have as yet failed to get any reliable percussion fuze; and on the production of that most desirable store seems to depend the efficiency of the segment shell, once the sole projectile of the system.

However, let us review the equipment exactly as it stands at present—that is, with common shell, segment shell, solid shot still for the 20-pr., and case shot for breech-loading guns; common shell, shrapnel shell, and case shot for the 7-pr. muzzle-loading; and common and shrapnel for the 9-pr. muzzle-loading gun. The case I may briefly dispose of by saying that they are of the Royal Laboratory pattern, lead and antimony balls being grudged even to the poor little 6-pr.—it has got them at present, but a pattern has gone forward in which sand shot are substituted. The 20-pr. contains 9 lbs. 12 ozs. of sand shot; Reeves' pattern—which it superseded—contained 13 lbs. 12 ozs. of the same; the total weight of the two projectiles being 15 lbs. and 14 lbs. 14 ozs. respectively. The common shell are not so powerless as they are generally considered. The 20-pr. contains 1 lb. 2 ozs. of bursting charge, against 1 lb. contained by the 24-pr. howitzer, and 1 lb. 5 ozs. by the 32-pr. howitzer; still the regular field gun shell—the 12-pr.—only contains 9½ ozs. of powder.

Hence the wish for a howitzer.

In Abyssinia, with the 7-pr., a double shell was used for vertical firing—that is, at high angles approaching the conditions of vertical fire; and here I believe a great step in advance was made, if not unconsciously, at all events without perhaps fully realising all the bearings of the question.

It may be observed that vertical fire is in a very crude condition. So little touched has it been by the march of rifled guns, that this is the only point at which a discussion of rifled projectiles even approaches the subject. Rifled mortars have hardly been made experimentally; and so little promise of decided success has appeared, that it seems almost necessary to attempt it, even with the hope of little beyond the improvements that follow the employment of wrought-iron instead of cast.

It appears to me that the difficulties are greatly aggravated by the employment of a charge varying with the range; because this entails a varying velocity, and hence a varying rate of rotation, and to give a pitch abrupt enough to keep the projectile point-first with the smaller charges necessary for short ranges, becomes very difficult. I have gone so far, therefore, as to suggest the trial of some fixed charge, the mortar being laid at angles varying from 45° *upwards*, the greater elevations being thus used with the smaller ranges. I believe this to be worth a trial, because, in addition to the constant velocity so desirable with a rotating projectile, the velocity on impact would become enormously increased at the shorter ranges, and perhaps would be such always as to make it well worth while to fire vertical Boxer shrapnel—which I recommend with the more confidence because it has been proposed both by General Shrapnel and General Boxer, and its power, under the circumstances I describe, would become very much increased. I read that a very crude experiment was made in this direction in the late American war—that is, shrapnel were tried, fired on the regular old mortar system, with good effect.

The advantage of having such a projectile might be very great—certain systems of fortification have depended almost entirely on vertical case; but though the moral effect is considerable, they have faults. They cannot be fired over the heads of one's own troops; they scatter too widely for good effect on any particular spot; the striking velocity is but small, and they cannot be used at long ranges. Even at 260 yds. range I remember a man getting a stiff knee for life from the impact of a vertical sand shot; but at shorter ranges its effects would be less. Vertical shrapnel would be liable to none of these defects. Its range is not limited; it might be fired over the heads of one's own troops; it would not scatter too much, and its striking velocity might be, probably, all that need be desired. Does it not appear—in these days of gun-pits and extended cover—that some effective vertical missile for troops is required? Probably most officers who have been under the vertical fire of mortar shell will confess that their moral effect wears off; and as to the actual effect, it is surprising how many shells will burst harmlessly on the ground, with men stooping or lying within a few feet of them. It requires a little careful thought to see why it is that so many shells may burst in a battery and injure no one at all; and I would put the question to any officer, whether he thinks it likely that if half a dozen of the mortar shell that fell closest to him had been replaced by shrapnel opening near the ground, he could have escaped.

But to pass at once to the last point I have to touch on—

Segment and Shrapnel Shells, and their Fuzes.

The Armstrong and Whitworth, the Ordnance Select, and the Dartmoor Committees have all had this question before them. While Boxer shrapnel have come in for heavy guns and siege guns, and have to a great extent superseded segment shells, with field guns the matter is hotly contested.

The shrapnel has a comparatively close cone of dispersion, and the shower of its bullets is therefore effective for a greatly prolonged distance, and is consequently less affected by slight errors in boring the fuze—hence it offers great advantages as compared with the segment for time fuzes; besides, the momentum and penetration of its bullets are much greater than those of segment. On the other hand, it may be urged that should a shell burst by actual impact on an object, such as a column of infantry, the immediate wide dispersion of the segments tends to distribute them well; and those who advocate the use of segment shells will be found almost invariably to be also advocates for the use of percussion fuzes.

The discussion of the relative advantages of time and percussion fuzes is such, that I do not wish here to attempt it, but rather to keep more closely to the work of bringing facts together for those who have not time to collect them for themselves.

It should be said in favour of the segment, that, under certain circumstances, it has given good results on active service. Capt. Mercer reported its action in bursting into the rifle-pits of the Maories to have been very good; some officers reported well of it in China. The report to lay most stress on is that of Major Hay, describing its action on troops placed behind brick walls. No doubt, also, against wooden ships it would, with percussion fuzes, exhibit a good union of penetration and dispersion.

It will be seen that all these cases are such as favour its action with percussion fuzes, without bringing out the disadvantages of its effects being very local—that is, confined very closely to the bursting spot. This arises from the segments being of comparatively low specific gravity, and of a form unsuited to keeping up their velocity or to ricochet on the ground. Moreover, the bursting charge, from its position, tends to disperse the segments, which are already predisposed to scatter from the centrifugal force due to the rapid twist. This, in the cases above quoted, caused no ill effect, for the ordinary conditions of firing in the open were almost reversed. I believe the Committee on Field Guns for India were interrupted in certain experiments made to investigate carefully the respective cones of dispersion of segment and shrapnel shell.

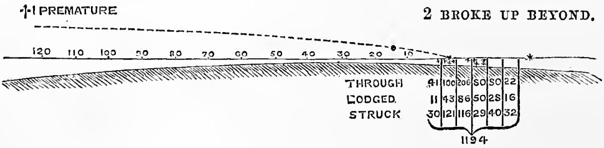
I would now endeavour to illustrate the matter by a few diagrams I have made, to exhibit results of experiments at Dartmoor.

Fig. 1 gives the best result obtained by 12-pr. segment with percussion fuzes acting on targets in column. It is so striking, that before entering into odious comparisons, let us congratulate ourselves that such a result

Fig. 1.

Armstrong Segment.

Percussion Fuze (only). Range 1670 yds.



should be obtained under any circumstances, with our present service ammunition. It is satisfactory to contemplate the possibility, under any circumstances, of striking a column of infantry in anything like 1194 places at nearly a mile range, in firing fifteen rounds.

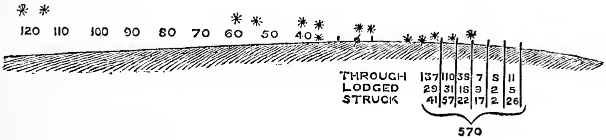
Looking at the exact character of the action, it may be noticed that every single effective shell bursts within five yards of a target, and nearly all burst through one of the targets on to those behind it. Judging from many results, this is the most effective action of the segment shell, but of course it can only be employed on columns.

Fig. 2 is the best result of the same day's firing,* on a column,

Fig. 2.

Segment 9-pr.

Time and Percussion. Range 1000 yds.



with time and percussion fuzes—and these are not fuzes made in the Laboratory, but the genuine article, fresh from Elswick. In this, although ten shells burst and one breaks up within 60 yds. of the front of the targets, the effect is comparatively small, being very nearly the same effect as is produced on the front target by nine shrapnel bursting

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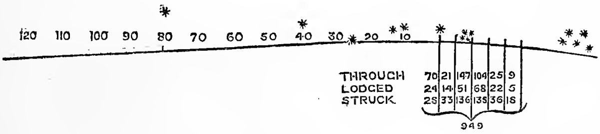
* A better result was obtained with segment shells fired with time and percussion fuzes on another day, but it happened that the chief effect was due to four shells bursting by percussion fuzes through the second row on to the third and fourth rows (*vide* Fig. 3), the first two rows having but few scores on them; and this being so, the result bears out rather than contradicts the principle laid down—viz. that the action of the segment shell requires a percussion fuze to develope it to advantage.

Fig. 3.

Armstrong Segment.

Time and Percussion Fuzes. Range 1700 yds.

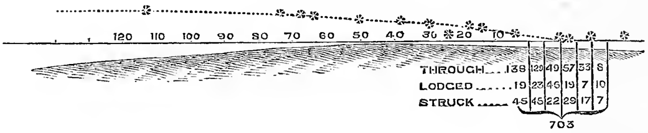


within 70 yds. in front of the column, on Fig. 4. These two last

Fig. 4.

Boxer Shrapnel 9-pr.

Range 1000 yds.



are the results of the 9-pr. shells; but still, making allowance for the difference, both are inferior to the 12-pr. result on Fig. 1; the shrapnel, where time fuzes are used, beating the segment shell decidedly.

Figs. 5 and 6 are the best results obtained with shrapnel and time

Fig. 5.

Shrapnel 9-pr.

Range 1000 yds.

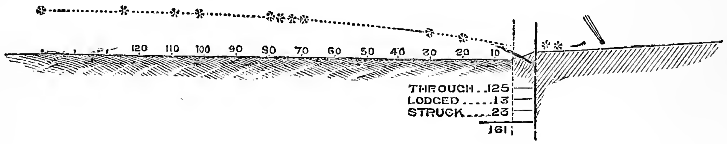
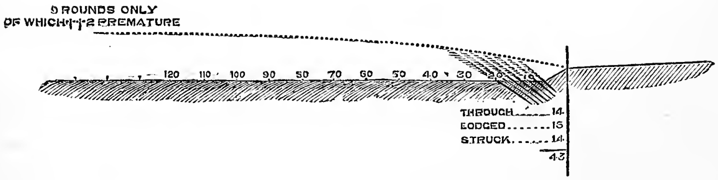


Fig. 6.

Segment 9-pr.

Percussion (only). Range 1450 yds.



fuzes, and segment with percussion fuzes, at a target with a bog in front. The segment here only fired nine rounds, the result being exceedingly bad. It is fair to remember this nature of result, when looking at the action of percussion fuzes at their best; and it is also to be borne in mind that the segment, for the most part, had exactly two trials against each single trial of the shrapnel; so that if the shrapnel stands in an intermediate position, it may be doing quite as well, and have quite as high an average as the segment. Figs. 7 and 8 shew

Fig. 7.

Shrapnel 9-pr.

(Advancing from 1700 to 800 yds.)

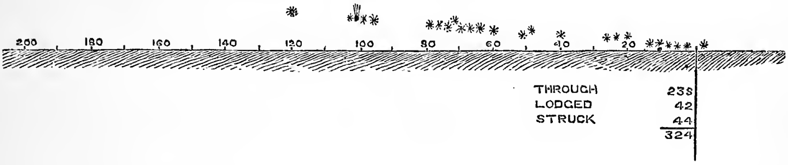
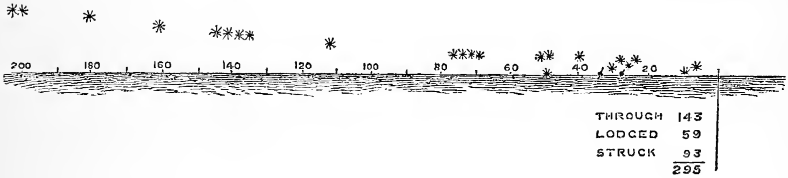


Fig. 8.

Segment 12-pr. (Retiring from 800 to 1300 yds.)

Time and Percussion Fuzes.

† 1 Premature. † 1 Burst beyond.



the best results of independent firing with each nature of shell. This happens again to occur with the 12-pr. in the case of the segment, and the 9-pr. in the case of the shrapnel; nevertheless, the latter is the better result. I would especially notice the wonderfully accurate bursting of the shells with the time fuzes in this independent firing, which was a race against time.

One sometimes hears the idea of time fuzes being properly set in action jeered at by people who claim to take the real practical view of the matter. Now while, as I say, I do not wish to take up the question of time and percussion fuzes, I would just remark that I object to being called upon to believe that the presence of mind of a whole detachment is not sufficient to get a fuze bored. Of course there may be cases where a shell with a percussion fuze already in it might be fired more quickly; but where there is the time, I cannot but believe there will be the presence of mind required to bore the fuze. We need to guard against a sort of slovenly, plausible cry of "rough and ready" things for service; ready of course we want, but why rough?

For greater readiness with time fuzes, General Boxer advocated the lengths being marked with the range which each suited, and this was carried out at Dartmoor.

One word on our fuzes.

"We have no reliable percussion fuze;"* then, after ten years' experience, it seems high time to try something else. For such shells as are fired from our muzzle-loading guns, and are intended to be exploded on graze, a concussion fuze is the natural alternative; that is, a fuze which contains no detonating powder, being lit and burning like a time fuze till impact opens a passage for the flame into the bursting charge of the shell. As you may be aware, there are many fuzes of this class now submitted for trial. In such we avoid the evils which are entailed by the presence of percussion powder, and which render the percussion fuze unreliable. Unreliable because it deteriorates in store, especially in hot climates; and unreliable because it is prone to cause accidents in handling, such as that which blew up our men at Malta.

But where—as in our present breech-loaders—there is no windage, every single fuze is obliged to be lit by percussion, and so every one is liable to deterioration and accident. The condition of some of the field-service percussion fuzes returned from out-stations to the Royal Laboratory, may be understood from the fact that a very simple operation—which effectually prevented the danger of prematures with the Dyer fuze—was suspended because the fuzes did not even seem worth the cost of such a trifling job. Much might be given in detail, but I will conclude a paper, already longer than I originally intended it to be, by observing that although it is probable at this moment our field artillery would, whenever they might be brought to the test, hold their own against all comers, yet it is most desirable that much should be done to simplify their *matériel*, and I believe that this will be rendered far easier whenever the muzzle-loader is introduced generally.

At the conclusion of the reading—

Colonel Adye invited discussion upon the subject of the paper, and said that if any officer wished to ask a question, no doubt the lecturer would have pleasure in answering.

Captain Strange, R.A., said: If his brother officers would have patience with him, he should like to make a few observations; not perhaps on the subject under discussion—for that had been so fully and clearly explained by Captain Browne that he could add nothing to it—but suggested by some observations made in the course of the lecture.

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* Since the date of the lecture, many concussion fuzes have been tried; but all have, as yet, proved too slow in their action. Cap composition, however, which is at all events far more reliable than phosphorus composition, has been substituted for it experimentally.

It was a subject which had been long upon his mind, and upon the minds of other officers of experience, and he hoped that at some future time they would join in placing it before those who had the power to enforce their ideas. During the time he had held the position of instructor, the fact had been forced upon him—and the report of the Dartmoor Committee specially alluded to it—viz. that in gunnery practice, whenever the conditions approached nearest to those of actual warfare—he meant by that, when the range was unknown and the firing rapid—the results were exceedingly indifferent. This ought not to be, considering the general excellence of the projectile they had heard described. How about the animated *matériel?* Of course, as far as instructors were concerned, they were admirably paid—(a laugh)—and had much to be thankful for. He might venture to observe they had seen to-day that some of them did not fail in intelligence, or in an anxious desire to do their duty. (Applause.) The case was different, however, with the people who received instruction. No pay or inducement was held out to the rank and file as a reward for extra intelligence and proficiency *as gunners*. The School of Musketry had exercised an amazing influence on the British infantry, and the study of "Tommy Atkins'" weapon would always be a favourite pursuit with the British soldier, because it was paid for and made honourable. But he had met with great apathy in receiving instruction, especially on the part of the older soldiers of the Royal Artillery; the recruits were more eager, until they found they got no good by it—a circumstance which he attributed to the fact that nothing in the shape of rewards and badges for extra intelligence were held out to the gunner. His promotion, even, did not depend on his knowledge and skill *as a gunner*. To remedy this, he should be put on a level with his red brother in the infantry, and prizes given for extra efficiency. It was not necessary that the prize should be given to the gun detachment, and any attempt in that direction would be a failure. It must be given to the man himself who combined knowledge and skill; and, as a proof that this was practicable, it had been tried in India with very beneficial effect, whenever the commander of the battery was in favour of the system. The plan was one which recommended itself on the ground of economy, and in these days economy was everything; competitive trials in pointing guns could be carried on without ammunition. According to the present system, ammunition was wasted through putting a careless or a short-sighted man to lay the gun—a duty which in the French artillery was entrusted only to certain men called *pointeurs*, detailed for the duty on account of their special aptitude. He believed that the introduction of this plan in the British army would be very beneficial. The want of some improvement in the accuracy of artillery practice, was a subject which had long weighed on his mind. The success of Lieut. Nolan's range-finder made it more than ever necessary we should have picked marksmen skilled in its use. Improvements in artillery, when not accompanied by skill in their use, were simply a disadvantage; and he trusted that he should be pardoned for introducing the subject on this occasion. (Applause.)

Captain J. P. Morgan said that some of Captain Browne's suggestions came very near his own experience, and he could confirm many of his excellent observations. He referred to the very high estimation in which the productions of the Royal Arsenal were held in foreign countries, quoting the observation he had heard of by a foreign officer, that if an angel from Heaven came down to say that a certain projectile was good, he would not believe it unless the article had been adopted at Woolwich. (Laughter.) Captain Morgan also confirmed the observations of Captain Browne as to the density of white metal as compared with grey, having himself had to examine shells of French pattern at Elswick, which he found to be heavier than others of similar bulk—a fact explained by the metal being whiter and denser. He referred, also, to the manufacture of chilled shells of the new pattern, expressing an opinion that *the holes near the base are not so readily detected by the men engaged in their manufacture as the holes near the nose, and should be carefully watched, as a possible means of danger.* As to the percussion fuzes made at Elswick, he said that there the manufacturers steadily adhered to Pattern No. 2, and that in proving their own guns, even at sea, he had never seen one fail on striking the water. He concluded by expressing an opinion that the service modifications in percussion fuzes had not been always attended with advantage. (Applause).

Colonel Adye said he was sure the meeting would unanimously agree with him in thanking Captain Browne for his excellent and interesting lecture. (Applause.) They would no doubt also concur with him in the opinion that discussions of this character were very desirable in an institution like that of the Royal Artillery; and that, in these days of scientific advancement, they were much indebted to any officer—especially those employed in the Royal Arsenal—who had the means of gaining information, and was ready to impart it to those who, in the exercise of their regimental duties, had not the same opportunities. They would esteem it a great favour and kindness on the part of any officer similarly situated, who would come forward and tell them of the various improvements and alterations which were taking place in the manufacturing and scientific departments of the service; and he hoped that all present would concur with him in again thanking Captain Browne for his valuable paper. (Applause.) Colonel Adye continued to observe that Captain Browne had spoken upon so many subjects, that he should not attempt to follow him through the whole of his discourse, but he was desirous of asking him for information on one or two points. One was with respect to chilled shell. It was well known that latterly some of these shells had split, and injured the guns from which they were fired. They all knew that the "Hercules" had come home with one out of the very few guns she had on board injured; and he believed there was a projectile now upon the table, the fracture in which must have existed for some time before it was discovered. Now, it was not satisfactory to think that the Palliser shells—in many respects so excellent—were liable to this serious defect, and he should like to know from Captain Browne whether there was a probability of overcoming the difficulty? They had heard a great deal lately of Sir Joseph Whitworth's metal; perhaps the lecturer would tell them whether, by employing that, or some other description of metal, there was a hope of avoiding these premature fractures in future? Again, Captain Browne had given an interesting account of the Dartmoor experiments, where a good deal seemed to hinge on the degree of perfection attained by the fuzes. He would ask the lecturer—than whom no one could speak better on the subject—whether they were likely to overcome the great difficulty they met with in this respect; for it would become a serious question, if they could not get a proper fuze, whether they should not return to the muzzle-loading gun. Captain Strange had spoken with regard to promoting accuracy of firing by giving prizes for good shooting in the artillery, as in the infantry. To some extent he (Colonel Adye) agreed with the suggestion, but he did not think the plan so easy as his gallant friend seemed to suppose. They had tried it in India, and the late Sir George Barker had written to him on the subject, but they had found it very difficult of operation. In the infantry one man fired a musket, but in the artillery there were half-a-dozen to a gun. It was very easy to say that the prize should be given to the man who laid the gun; but that would be a very expensive affair, because it would require many shots each to test the ability of each individual. The plan had been tried in India and given up, probably on financial grounds. If Captain Browne would now offer a few observations on the questions he had put, he should feel obliged.

Captain Browne expressed himself much pleased at the complimentary remarks made respecting his paper, the chief aim of which was simply to submit a few facts, in the hope that those who had practical experience would form their own opinion thereon. Colonel Adye had spoken of the advantage possessed by officers engaged in the Arsenal; but there was another side to the question. The other day, Captain Majendie was remarking that any officer attached to the Laboratory was under a great disadvantage as to the designing fuzes and the like, because they were out of the way of actual experience; though no doubt it was true that many persons, possessing a thorough acquaintance with gunnery in the field, might fall into some mistake for want of practical knowledge of the manufacture. As an instance of this, he stated that an officer (Major Dyer) had invented a fuze which acted upon graze, but failed from a simple defect, which produced a fatal rebound, and frequently caused premature explosion; a defect which Mr Pettman—a practical mechanic—stopped by merely inserting a small piece of lead behind the pellet; Mr Pettman having—like Sir William Armstrong—a manufacturing experience, and well knowing the great value of lead for such a purpose, owing to its total absence of elasticity—a little bit of working experience unknown to most officers. On the other hand, however, there was a converse to this exhibited in the mistake made by Sir William Armstrong, in the employment of lead, not only as a cushion, but as a support to the pellet; the practical test of service showing that he had not calculated on the result produced on his fuzes by vibration and jarring in the limber boxes. With reference to the unsatisfactory condition of the percussion fuze, Captain Browne said the difficulty was in enabling detonating powder to stand climate. Pettman's general service fuze was on the whole a good fuze, but those hitherto issued had failed to stand the climate; an operation was, however, now being carried out with the object of sealing up these fuzes so as to render them water-proof, and if this was successful, there was no reason why the same plan should not be carried out with any other percussion fuze that might be adopted. But the danger in handling all percussion fuzes must to a certain extent remain, simply from the fact of their containing detonating powder. As for concussion fuzes, which were only adapted to muzzle-loading guns, being lit by the flash, there was no reason why they should not be as safe and reliable as any time fuze.

Colonel Adye said his question referred to fuzes for breech-loaders.

Captain Browne said the question in that case was more difficult, and he thought that for the present they must await the result of the improvement in the Pettman fuze, that was in the operation designed to ensure its security from damage by damp. Captain Morgan had stated that the people at Elswick had great confidence in their percussion fuze, and they had at all events this reason for their opinion—viz. that in the Dartmoor experiments, not one of the Elswick shells exploded prematurely, though many more broke up on touching the ground than those of the Laboratory pattern. The best result of all was made with the Laboratory fuzes; but there were a number of premature explosions —so many that the fuzes were considered unreliable. He thought, in the case of the independent firing, in which by far the largest number of prematures occurred, this may have been frequently caused by the time fuzes not being screwed home, so as to come in contact with the percussion fuze and prevent rebound. There were, however, still a large number of prematures which could not be so accounted for; and, in explanation of the different behaviour of the Freeth fuze, made in the Royal Laboratory, and the Elswick fuzes, he would note the fact that in the former the detonating powder was only covered by thin paper, while in the latter it was protected by sheet brass. Hence it was not difficult to see that the former, being much more readily fired by the needle, was more liable to premature explosion; while the same thing told in its favour, in enabling it to act upon graze—for it appears to have allowed the shell to burst properly on hard rocky ground, when the shells with the Elswick fuzes were split in half. As to the splitting of Palliser shell from cracks developed in store, he observed that these cracks may have not been noticed, because they would not be looked for; a shell which was sound yesterday, would not be expected to be found split to-day. This defect had, however, he hoped been remedied to a great extent, if not entirely, by casting the bodies of the shell in sand, and chilling only their heads. When metal was "coaxed," as it were, by chilling to solidify in an unnatural, or rather a delicately balanced state, it was only reasonable to suppose that it might seize any opportunity of making an effort to re-adjust itself. By having only the head chilled, there was therefore much less danger of the shell breaking up in store or in the gun. Respecting the shells referred to by Colonel Adye as having actually burst on board the "Hercules," he added that the issue of those shells had been under exceptional circumstances; in fact, the question had been raised by the Department whether they should be issued at all, owing to their having been constructed in conformity with an order which had been regarded as overstepping the limits ensuring safety, and the pattern approved for future manufacture had been altered accordingly. With regard to these individual shells, it had been ruled that they should be issued, and it was thought that they would stand; but the result showed the evil of allowing any questionable projectile to get into the service, and it was satisfactory to know that no more would be manufactured. (Applause.) He hoped, therefore, he had shewn, with regard to the chilled shot at present in the service, that they were not all fairly represented by those in question; and with reference to those which would be manufactured for the future, that they stood altogether on different ground, for they would have their bodies cast in sand; and this, it was confidently hoped, would fully meet the difficulty. (Applause.)

Colonel ADYE thanked the lecturer for his explanations, and the proceedings terminated.

REMARKS ON

CAPTAIN NOLAN'S RANGE-FINDING APPARATUS.

BY

LIEUT. C. E. B. LEACOCK, R.A.

Captain Nolan's range-finding apparatus consists of two angle-finders, a measuring tape, and a calculating roller.

The angle-finders are identical in general construction, but inverted in details, one instrument being right, and the other left-handed.

Each angle-finder consists of a long telescope, round each end of which is a band, turned truly round. The bands rest on two Y's fixed on the outer side of the barrel of the gun, so that when the telescope is laid in them, the axis of the telescope is parallel to that of the gun; above the telescope is an index plate, graduated in a manner which will be hereafter described; at the rear of the index plate is a pivot, on which a steel limb revolves. Above the steel limb at the pivot, is fixed a short telescope, which revolves with the limb, and remains constantly at right angles to it. The limb and short telescope receive their motion from a screw fixed to the index plate, and working through a nut on the steel limb. The short telescope is protected by means of a tin case, to the inner lip of which is pasted a white paper ring. This case does not revolve, but is fixed at right angles to the index plate, a hole being cut in its side so as not to interfere with the index bar.

The tape is an ordinary measuring tape, working on a reel. At the loose end is a hook, which, when the tape is used, is hooked to the inner trail-handle of one gun, and the reel is then carried over to the trail of the other.

To measure the range by means of the instrument, two guns are used. They are drawn up at an interval of about 40 yds., and dressed so that the object will be directly in front of some point in the interval. Each gun is then laid on the object, and the interval from inner trail-handle to inner trail-handle measured. The short telescope of each finder is then turned on the vertical axis of the white ring on the lip of the case of the other. This axis is marked by a red spot on the highest and lowest points of the circumference of the ring. The angles between the long and short telescopes will consequently be the base angles of the triangle ABC, formed by the object and the two guns, and their sum will be the supplement of the angle BAC. (See Diagram I.)

Now, as we may fairly assume our range over 500 yds., AB and AC are very large in proportion to BC; and as the point A is directly opposite some point in the base BC, the length of the sides BA, CA, will be much the same for any particular magnitude of the angle BAC, whether the triangle BAC be isosceles or not; and we may therefore treat the triangle BAC as an isosceles triangle of known base and known angles, of which it is required to find the sides. (The error resulting from this assumption, will hereafter be proved too small to matter in practice).

Our formula will be

$$r = b\frac{\sin\frac{\pi - a}{2}}{\sin a}$$

$$= b\frac{\cos\frac{a}{2}}{\sin(\beta + \gamma)}$$

$r =$ range $= AB = AC$,
$b =$ base $= BC$,
$a = \angle BAC$.

Now, as a is very small—for it cannot exceed 5°, as an isosceles triangle with base 40 yds. and apex 5° will have sides only 456 yds. in length—we shall, as will hereafter be proved, incur but slight error from making $\sin\frac{\pi - a}{2}$ or $\cos\frac{a}{2}$ equal to one, and writing our formula

$$r = \frac{b}{\sin(\beta + \gamma)}.$$

We shall hereafter see that from this formula is derived the principle on which the calculating roller is constructed.

We now proceed to read the base angles by means of the index plates of the angle-finders.

On these plates the circle is divided into 144 divisions (of 2° 30′ each), which are again subdivided into 100 subdivisions (of 1′ 30″ each). The actual portion of the circle graduated on the index plate is only about eight divisions, or 20°. Tenths of divisions only are graduated on the plate, but the angles may, by means of a vernier on the steel limb, be read to as little as half a subdivision. At each of the divisional graduations is 0, the subdivisional graduations being marked from 1 to 99—the numbers running from left to right on left-handed instruments, from right to left on right-handed ones. The instruments will consequently show, not the exact magnitude of the angles ABC and BCA, but merely their excess over the next lowest round number of divisions. Thus, if the steel limb EB, be immediately over the long telescope, the lines EB and AB will coincide, and therefore the angle ABC coinciding with the angle EBC, will be a right angle, or 36,00 (thirty-six divisions no subdivisions). A zero must therefore be marked on the index plate, immediately above the axis of the long telescope, to serve as a starting point, from which the plate is graduated right and left. If we turn the short telescope so as to diminish the angle *ABC* to say 35,71, the arrow-head *E* will point to 71, and if we diminish *ABC* to 35,00, the arrow-head *E* will again point to a zero. (See Diagram I.)

Now, let us suppose that, having laid our instruments in the manner above described, we have read 60 at *B*, and 80 at *C*; adding these two together, we have 140. This being more than a division, we cut off the first figure, and read 40. We now know that the sum of the base angles exceeds some exact number of divisions by 40 subdivisions, or to use a symbolical expression, that

$$\beta + \gamma = 100\,m + 40.$$

Now, we may assume that α lies between 20 and 2,00; for with the latter of these values a base of 40 would give a range of 456 yards, and with the former a range of 4560. Hence m must be either 70 or 71—the latter value being rejected when the readings add up to more than 80. Readings below 80 render possible two different values of m, and consequently two apices of different magnitude, and two ranges. The two ranges, however, will be so different that it will be impossible to fail to distinguish the true from the false; for let us have read n subdivisions, then our two ranges will be

$$r = \frac{b}{\sin(70{,}00 + n)} = \frac{b}{\sin(2{,}00 - n)},$$

$$R = \frac{b}{\sin(71{,}00 + n)} = \frac{b}{\sin(1{,}00 - n)}.$$

But $2{,}00 - n$ is more than double $1{,}00 - n$, and small angles vary almost as their sines; therefore the greater of the two ranges will at least be double the less.

We now proceed to describe the calculating roller, and shew how, by its means, the formula

$$r = \frac{b}{\sin(\beta + \gamma)}$$

may be solved, and the sides of the triangle *BAC* obtained without actual computation.

The roller is a built-up cylinder consisting of a body and two rings, these rings being free to rotate round the axis of the cylinder. The lower rim of the body and the upper rim of the lower ring are marked from left to right with 100 equal graduations, corresponding to the number of subdivisions in a division; by means of these rims the readings at *B* and *C* may be added together, and if their sum exceed 100, the first figure will be cut off. At the zero point of the lower ring is marked the word "BREECH." This is brought opposite the reading of the first angle-finder (60), when the reading (80) of the second angle-finder on the lower ring will come under (40) —the sum of the two readings less 100—on the body.

This will be seen in Diagram II., where the two rims are represented as if in one plane, in order that all parts of them may be visible at once.

On the lower edge of the upper ring is graduated from left to right a scale giving the differences of logarithms of all numbers between 400 and 4000, each logarithm being marked with the number to which it belongs. The size of the graduations is so proportioned to the size of the roller that log 4000 — log 400 or unity is exactly one circumference of the circle, and the points 4000 and 400 consequently coincide; while, as all powers of ten have logarithms free from fractions, the point at which 1000 is marked will be the true zero point of the logarithmic scale.

On the upper edge of the body is graduated from right to left a scale giving the differences of logarithms for the sines of all angles between 71,80 and 70,00, which are the greatest and least values the sum of the base angles can have. As the sines of very small angles are proportional to the angles themselves,

$$\sin 2{,}00 = 10 \sin 20\,;$$
$$\therefore\ \sin 70{,}00 = 10 \sin 71{,}80.$$

Hence the difference between their logarithms will be unity, or one circumference.

Each logarithmic graduation in this scale is marked with the number of subdivisions in the angle to whose sine it belongs.

As sin 71,77·18 = ·01, log sin 71,77·18 = — 2, and it is at 77·18 that the zero point of the lower logarithmic rim will fall, an arrow-head is marked here, and the word "TAPE" written beneath it.

From the figures on the lower rim of the body to the corresponding figures of the upper rim, diagonal lines are drawn. These in no way affect the principle of the instrument, and serve only to guide the eye.

We will now describe the use of the roller.

As soon as the number of yards in the base is known, the upper ring is turned round until that number comes opposite the arrow-head marked "TAPE." The two readings of the angle-finders are then added together, as already described, by means of the lower ring. The number representing their sum on the upper rim of the body will be opposite the range on the upper ring.

For by the formula,

$$r = \frac{b}{\sin(\beta + \gamma)}\,;$$
$$\therefore\ \log r - \log b = -\log \sin(\beta + \gamma).$$

But log r — log b is the distance from the point on the upper ring graduated r to that graduated b; and — log sin $(\beta + \gamma)$ is the distance from the arrow-head to the point on the upper rim of the body graduated $(\beta + \gamma)$; the difference in sign corresponding to the contrary directions in which the two logarithmic scales are graduated. Therefore these two distances must be equal.

But the graduation b coincides with the arrow-head; therefore the graduations r and $(\beta + \gamma)$ must also coincide.

We have already stated that for readings less than 80 two values of $(\beta + \gamma)$ are possible, and that we have consequently two ranges given; but that one being more than double the other, they were easily distinguished. A reference to Diagram II. fig. 2, will show this to be the case.

We now proceed to the method by which the range is ascertained with one finder only.

The guns are dressed so as to be in line with some object to the right or left, and laid on the object aimed at. The angle-finder is then placed first on one gun and then on the other, and the short telescope is each time laid on the object to the flank, the long one on the object aimed at. We thus read the angles β and δ (Diagram I.)

$$\text{Let } \beta = 100\,m + p,$$
$$\delta = 100\,n + q.$$

Then

$$\begin{aligned}\beta + \gamma &= 72{,}00 - \alpha,\\ &= 72{,}00 - (\delta - \beta),\\ &= 72{,}00 - \{(100\,n + q) - (100\,m + p)\},\\ &= (72 + m - n)\,.\,100 - (q - p).\end{aligned}$$

Hence we have the rule—

"From the gun-number of the gun nearest the square object, take the gun-number of the gun furthest from the square object, and subtract the difference from 100."

In working without a tape, we have to lay one angle-finder first on the breech and then on the muzzle of the other gun; then taking the triangle *BCH* as an isosceles triangle of very small apex, we calculate b, knowing the length of our gun, from the formula

$$b = \frac{l}{\sin\theta} = \frac{l}{\sin(\gamma - \phi)}.$$

There is a special scale for solving this formula on the top of the roller. Its general principle is similar to that of the scale on the body of the roller.

We have, in the course of the foregoing demonstration, made use of four assumptions, none of which are strictly true, and from each of which an error will consequently result.

These are:—

(1) That when in a triangle *BAC*, the apex *A* is directly opposite some point in base, and the angle α is small, the length of the side *AB* will be much the same, whether the triangle be isosceles or not.

(2) That when α is small

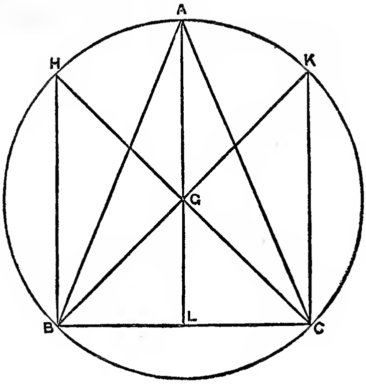
$$\sin\frac{\pi - \alpha}{2} = 1.$$

(3) That $\sin 2{,}00 = 10 \sin 20$.

(4) That the angles read by finders are the true base angles of the triangle *BAC*.

We will first examine the errors produced by each of these assumptions separately, and afterwards see how their combined result affects the range in practice.

With regard to the first assumption, since the points at which the angle α is subtended by the base BC all lie in the arc $BHAKC$, therefore if



perpendiculars be drawn from B and C to meet the circumference again in H and K, all points directly opposite the base BC, at which that base will subtend an angle α, lie in the arc HAK.

Join BK, HC; then their intersection will be G, the centre of the circle. Join AG and produce it to L. Then BL is equal to LC, and the angles at L are right angles.

By our method of working, our actual range taken is AB, and our shortest possible range is HB, our longest KB; for it may be easily shewn that H and K are the points in the arc HAK nearest to and furthest from B.

Hence the greatest error in excess we can have will be

$$
\begin{aligned}
E &= AB - HB \\
&= \frac{BC}{2}\cdot\frac{1}{\sin\frac{\alpha}{2}} - BC\frac{\cos\alpha}{\sin\alpha} \\
&= \frac{BC}{\sin\alpha}\left(\cos\frac{\alpha}{2} - \cos\alpha\right) \\
&= \frac{BC}{2}\cdot\frac{1 + \cos\frac{\alpha}{2} - 2\cos^2\frac{\alpha}{2}}{\cos\frac{\alpha}{2}\cdot\sqrt{1 - \cos^2\frac{\alpha}{2}}} \\
&= \frac{BC}{2}\cdot\frac{\left(1 + 2\cos\frac{\alpha}{2}\right)\left(1 - \cos\frac{\alpha}{2}\right)}{\cos\frac{\alpha}{2}\cdot\sqrt{1 - \cos^2\frac{\alpha}{2}}} \\
&= \frac{BC}{2}\cdot\left(2 + \frac{1}{\cos\frac{\alpha}{2}}\right)\sqrt{\frac{1 - \cos\frac{\alpha}{2}}{1 + \cos\frac{\alpha}{2}}}.
\end{aligned}
$$

Now, this error will be greatest when $\cos\frac{a}{2}$ is least; that is, when $\frac{a}{2} = 100$, its greatest value. Taking $BC = 40$ yds. $\frac{a}{2} = 100$, we have $e = 1{\cdot}31$ yds., which is not sufficient to affect our elevation.

For our greatest error in defect we have

$$\begin{aligned} e &= BK - AB, \\ &= \frac{BC}{\sin a} - \frac{1}{2}\frac{BC}{\sin\frac{a}{2}} \\ &= \frac{BC}{2} \cdot \frac{1 - \cos\frac{a}{2}}{\cos\frac{a}{2}\sqrt{1 - \cos^2\frac{a}{2}}} \\ &= \frac{BC}{2} \cdot \frac{1}{\cos\frac{a}{2}} \cdot \sqrt{\frac{1 - \cos\frac{a}{2}}{1 + \cos\frac{a}{2}}}. \end{aligned}$$

This also is greatest when $\frac{a}{2} = 100$.

Taking $BC = 40$ yds. $\frac{a}{2} = 100$, we have $e = {\cdot}44$ yds., which is not sufficient to affect our elevation.

We now proceed to consider the second cause of error.

In solving an isosceles triangle of known base and apex, the formula to use is

$$r = b\frac{\sin\frac{\pi - a}{2}}{\sin a} = \frac{b}{2\sin\frac{a}{2}}.$$

Instead of this, we made $\sin\frac{\pi - a}{2} = 1$, and used the formula

$$r = \frac{b}{\sin a}.$$

This will give us an error,

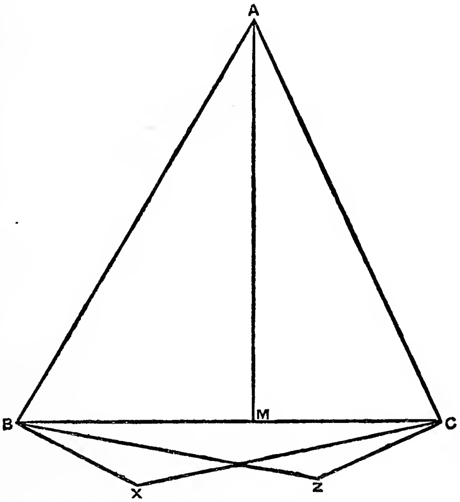
$$\begin{aligned} e &= b\left(\frac{1}{\sin a} - \frac{1}{2\sin\frac{a}{2}}\right) \\ &= \frac{b}{2}\frac{1 - \cos\frac{a}{2}}{\cos\frac{a}{2}\sqrt{1 - \cos^2\frac{a}{2}}} \\ &= \frac{b}{2} \cdot \frac{1}{\cos\frac{a}{2}} \cdot \sqrt{\frac{1 - \cos\frac{a}{2}}{1 + \cos\frac{a}{2}}}. \end{aligned}$$

This is greatest when $\frac{a}{2} = 100$.

Making $b = 40$ yds. $\frac{a}{2} = 100$, we have $e = \cdot 43678$ yds.

This error is too small to affect our elevation.

With regard to the third error, we find by actual reference to the tables, that $\sin 200 = 9 \cdot 99 \sin 20$; so that we should only have an error of 1 per 1000 if our roller could be graduated with perfect accuracy.



Our fourth error is that of assuming that the angles read by the finders are the true base angles. This error is not at first sight very apparent, but may be seen by reference to the above exaggerated diagram. When the long telescopes are laid in the directions *BA* and *CA*, the red spots on the paper discs will be at *X* and *Z*, *ABX* and *ACZ* being right angles. Our short telescopes will consequently be laid in the directions *BZ* and *CX*, and we shall have read the angles *ABZ* and *ACX*, giving us respectively as errors *CBZ* and *BCX*, which we may call ϕ and ψ.

Draw *AM* perpendicular to *BC*. Let $BAM = \frac{a}{2} + \theta$, $CAM = \frac{a}{2} - \theta$.

Then

$$BCZ = \frac{a}{2} - \theta;$$

$$CBX = \frac{a}{2} + \theta;$$

$$\sin \phi = \frac{CZ}{BZ} \sin \left(\frac{a}{2} + \theta \right);$$

$$\sin \psi = \frac{BX}{CX} \sin \left(\frac{a}{2} - \theta \right).$$

Now, CX and BZ are the distances from the face of one angle-finder to the pivot of the other, and this may be taken in practice as equal to the base, or 40 yds., or 1440 ins. CZ and BX are the distance from the faces of the angle-finders to their own pivots, equal to 3 ins.

Hence,

$$\begin{aligned}\sin\phi &= \frac{3}{1440}\sin\left(\frac{a}{2}+\theta\right)\\ &= \frac{1}{480}\sin\left(\frac{a}{2}+\theta\right);\end{aligned}$$

and therefore, as small angles vary as their sines,

$$\phi = \frac{1}{480}\left(\frac{a}{2}+\theta\right).$$

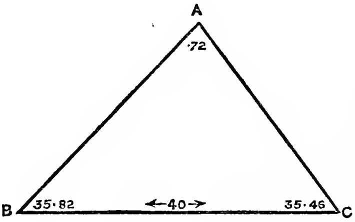
Similarly,

$$\psi = \frac{1}{480}\left(\frac{a}{2}-\theta\right);$$

$$\therefore\ \phi+\psi = \frac{1}{480}a;$$

or we shall have an error of about two per thousand in our apex, and consequently in our range. This, again, is too little to affect our elevation.

Let us now assume a case, and see what will be the difference between the sides of the triangle, as obtained by the calculating roller, and as obtained by the ordinary method.



Let $BC = 40$ yds.

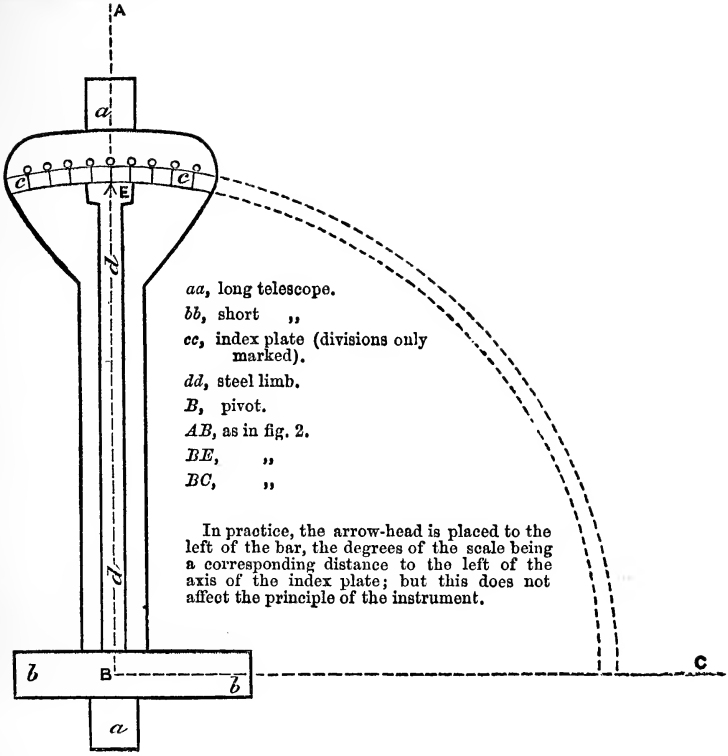
$$\begin{aligned} ABC &= 35{,}82 = 89^\circ\ 33' \\ ACB &= 35{,}46 = 88^\circ\ 39' \\ &\quad \overline{71{,}28}\quad \overline{178^\circ\ 12'} \\ \therefore\ BAC &= \quad 72 = \quad 1^\circ\ 48' \end{aligned}$$

and will be read by the angle-finders

$$72 - \frac{72}{480}\ \text{or}\ 71{\cdot}85 = 1^\circ\ 47'\ 46{\cdot}5''.$$

DIAGRAM I.

Fig. 1.



aa, long telescope.
bb, short „
cc, index plate (divisions only marked).
dd, steel limb.
B, pivot.
AB, as in fig. 2.
BE, „
BC, „

In practice, the arrow-head is placed to the left of the bar, the degrees of the scale being a corresponding distance to the left of the axis of the index plate; but this does not affect the principle of the instrument.

Fig. 2.

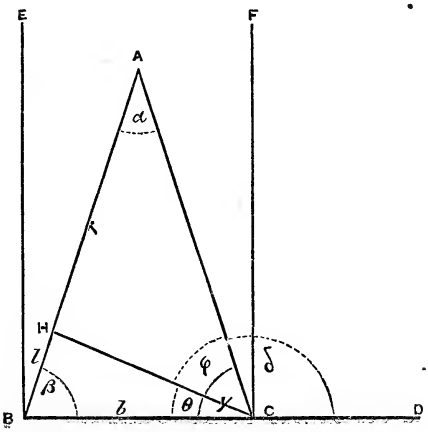


DIAGRAM II.

Fig. 3.

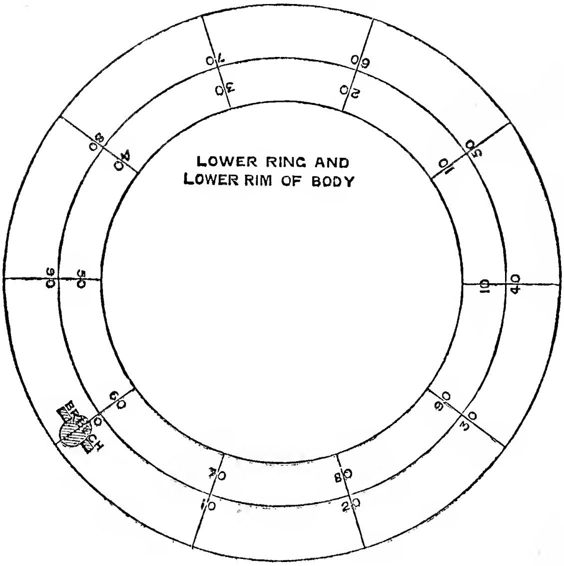
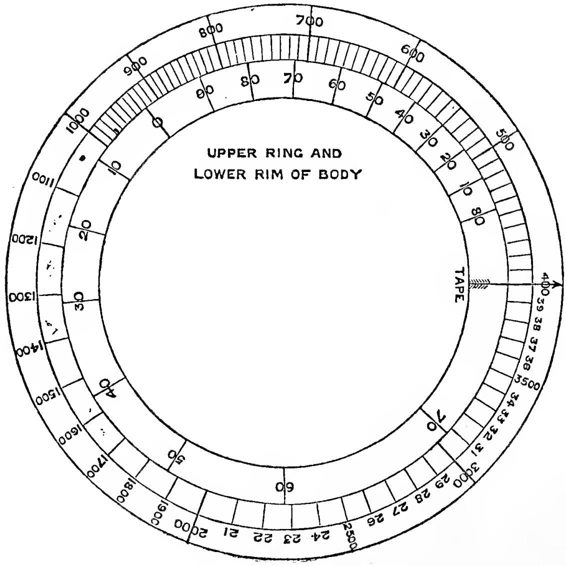


Fig. 4.



From the method employed by the finders we shall have

$$\begin{aligned} AC = AB &= \frac{40}{\sin 71\cdot85} \\ &= \frac{40}{\frac{71\cdot85}{20}\sin 20} \\ &= \frac{800}{71\cdot85}\,114\cdot593 \\ &= 1275\cdot9. \end{aligned}$$

By the ordinary method we have

$$\begin{aligned} AB &= BC\frac{\sin C}{\sin A} \\ &= 40\,\frac{\sin 35{,}46}{\sin 72} = 1273\cdot1\,; \\ AC &= BC\frac{\sin B}{\sin A} \\ &= 40\,\frac{\sin 35{,}82}{\sin 72} = 1273\cdot4. \end{aligned}$$

Here we see our error is less than 3 yds., but we cannot change our elevation less than one minute, which, at 1275 yds., gives $6\frac{1}{4}$ yds.; hence our range is practically exact.

It may often happen in the field that, owing to bad ground, the guns cannot be drawn up so that the object is directly in front of the interval; but as long as the object is not much to the flank, the ranges obtained by the angle-finder will be sufficiently accurate for all practical purposes.

If the dressing of the guns is much oblique, it will be at once detected by the steel limb of one finder running off the index.

THE

EXAMINATION AND PROOF OF GUNPOWDER,

AS CARRIED ON AT THE ROYAL GUNPOWDER FACTORY, WALTHAM ABBEY.

BY

CAPTAIN F. M. SMITH, R.A.

ASSISTANT SUPERINTENDENT.

The examination and proof of new gunpowder, as now carried on at Waltham Abbey, has for its object to ascertain :—

(1) If the powder have a proper colour; a proper amount of glaze; a sufficiently hard and crisp texture; and if it be free from dust and perfectly clean.
(2) If it has been properly incorporated.
(3) If the grains be of the proper size and shape, and if the different sizes of grains present be in the proper proportion.
(4) If the powder be of the proper density.
(5) If the action of the powder, when fired, be uniform and up to a fixed standard.
(6) If it contain the proper proportion of the three ingredients; and
(7) If it possess a sufficient power to withstand the absorption of moisture.

The two latter points have hitherto been determined in the Chemical Department, Royal Arsenal.

Each stoving of powder is proved separately. The stoving—that is, the total amount taken out of the stoves each morning—is taken as the unit, as it is the result of one day's work. The powder, therefore, of which it is composed, has not only been made under exactly the same conditions, but has been to a great extent intermixed throughout in the granulating, dusting, and glazing processes, and is therefore practically uniform.

Taking the various divisions of the proof *seriatim* :—

I. COLOUR; GLAZE; HARDNESS AND CRISPNESS; AND FREEDOM FROM DUST AND FOREIGN MATTERS.—In the case of powder made at Waltham Abbey, the above points would of course be well attended to in the course of manufacture, and any variations in them would be checked at the time, so that the finished powder would not be subjected to proof till quite up to the standard in such particulars. But in the case of powder supplied by contract, some description must be given of the way such points are judged. The qualities enumerated can be judged by eye and hand alone, and require of course a considerable amount of experience to enable an observer to come to a trustworthy opinion.

(*a.*) *Colour.*—The colour of finished powder depends on two points principally—viz. first, the colour of the charcoal of which the powder has been made; and secondly, the amount of moisture that has been added to the charges before leaving the incorporating mills. The more underburnt the charcoal is, the browner will be the powder. Some powders made with very slack-burnt charcoal, have a very decidedly red tint, which is easily detected on crushing the grains to dust. It is needless to say that, as regards colour, the powder under examination must be the same as the standard powder of the particular class to which it belongs. Any great variations in the charcoal would no doubt be detected in the subsequent processes of proof; for powder made with under-burnt charcoal will give a decidedly higher velocity to a bullet than that made with a more highly burnt, and consequently denser charcoal; and it will absorb moisture more readily than the latter. Nevertheless, under-burnt charcoal appears to offer certain advantages in small-arm powders; so that the reader must remember that there is no *absolute* rule to lay down—all examinations of the colour of powder must be *comparative.* As regards the other point—the amount of moisture which has been added to the charges in the mills—it is found that when the charges are taken off the mill-beds with an excess of moisture in them, and are subjected to pressure soon afterwards, the resulting powder is harder and of a blacker colour than if made otherwise. If two powders, therefore, be found to be of equal density, and if the one be *blacker in colour* and *harder* than the other, it has been worked *heavier;* that is, it has been taken off the mill-bed with a greater amount of moisture in it. There is no test for hardness, which can only be estimated by crushing the grain between the finger and the thumb. A powder which has been worked with a great amount of moisture, may be expected to give indifferent results when flashed; but, practically, the differences which powders present in this respect are seldom of any consequence.

(*b.*) *Glaze.*—Examination as to this point must also be comparative, as must also be that for

(*c.*) *Crispness and hardness of grain.*—In these matters, experience is the only safe guide. It must be remembered that it is not the province of the manufacturer to decide what is the best description of powder to turn out, to what extent it shall be glazed, or what is the proper amount of hardness that the grains should have. Such matters are decided by the experimental committees, who, after trying various powders submitted to them by the manufacturer, make choice of a powder which fulfils best all that is required of it. Once the pattern of powder—so to speak—has been settled, it is the manufacturer's duty to make all future issues as nearly identical in all points with the pattern sample as possible. Therefore, as before remarked, all examination of powder should be mainly a matter of comparison.

(*d.*) *The quality of freedom from dust or foreign matters* can be more easily tested. All powders should be absolutely free from dust. The only way to make sure of this, is to pour rapidly a quantity of the powder from a bowl held two or three feet above the barrel, in a good strong light. Even this simple operation requires a little practice to do it dexterously, without spilling the powder over the floor of the examining-room. If there be any loose dust, it will be readily detected. Powder that is glazed with black-lead, should be perfectly free from loose particles of the black-lead, and should in no case soil the fingers. The presence of other foreign substances in powder, need not be alluded to here, as none such could occur in new powder; they are of common enough occurrence, however, in returned powder.

II. INCORPORATION.—This is tested by "flashing;" that is, by burning a small quantity of the powder on a thick plate of glass. 8 ozs. of the powder are generally flashed. This quantity is put into a small copper cylinder, resembling a thimble in shape, and the cylinder is then inverted on the flashing plate. This provides for the particles of the powder being always arranged in pretty nearly the same way—which is an all-important point in flashing. The decomposition of the powder will be more thorough if it be thrown together in a small conical heap, than if it be spread out in a thin layer on the plate; hence, when comparing two powders, they should be placed on the flashing plates as nearly as possible under the same conditions.

If the powder be thoroughly and effectually incorporated, the small charge placed on the plate will "flash" or puff-off when touched with a hot iron, leaving only some smoke marks on the plate. A badly incorporated powder will, on the other hand, leave specks of undecomposed saltpetre and sulphur, and will therefore leave a dirty residue. But the flashing test, though apparently most simple, is one which, like the examination by eye and hand, requires experience to enable an observer to form accurate judgments. Though a very badly incorporated powder may be detected easily enough, it is by no means easy to judge between two powders, both tolerably good, as to which has been most thoroughly incorporated. Flashing should therefore be constantly practised with all classes of powder; and it is useful to keep some samples of specially bad powders (there are few foreign powders which will not afford plenty of samples), to flash occasionally for comparison. Powder which has once been subjected to damp, will be found to flash very badly, no matter how carefully its incorporation may have been performed. This arises from a partial solution of the saltpetre having taken place, causing a consequent disturbance of incorporation.

III. SIZE, SHAPE, AND PROPORTION OF THE GRAINS.—The *shape* of the grains can, of course, be judged by the eye alone. The principal point to observe is whether there be many elongated flat scales amongst them. If this be the case, the powder will be rapid in its action, from the much greater surface exposed to ignition, and therefore injurious to all calibres of our modern artillery. The grains should be as compact in shape as possible, approaching as nearly to the cube or sphere as granulated powder can be expected to come.

The *size* and *proportion* of grain can be readily ascertained with the sieve. The limits of size of each powder being known, all that is required to decide if the powder be of the proper size, is to sift it on the two sieves which define its size; it must all pass the one, and all be retained on the other. For example, if the powder be R.L.G.—the size of which is between a 4 and an 8 mesh—the powder, when sifted on a 4 mesh sieve,* must all pass through it, and when placed on an 8 mesh sieve, must all remain on it. We say *all* retained on it, but practically a small quantity will always pass the lower size of sieve. This arises from the fact that, in the granulating machines, the powders are separated on *sloping* sieves, which do not allow the smaller particles to pass through so easily as horizontal ones would. The quantity, however, which passes should be very small; in the R.L.G., for instance, it must not exceed one-sixteenth of the whole.

The sifting we have described, though it shows that the powder is within the limits fixed for its size, does not however convey any information as to the *proportion of different sized grains* contained in the powder. To explain what is meant:—A sample of R.L.G. must pass a 4 mesh and be retained on an 8; but the sample may either consist entirely of grains *just small enough to pass the* 4; or, again, of grains *just large enough to be retained on the* 8. In the first case, the sample would consist entirely of *large* grains; in the second, entirely of *small*, the effect of which would be very different when fired. Powder made in the granulating machine, generally presents a tolerably regular gradation of sizes in the grain; and it is the object of the proof officer to discover if this gradation of grain be properly preserved in the sample before him; for too great a proportion of small grains may have been either accidentally or purposely introduced. The sample must therefore be sifted into the different sizes of grains of which it is composed. Thus, R.L.G. is sifted on a 4 mesh, a 6 mesh, and an 8 mesh; and the proportion of grain retained on them should be as follows:—

$\frac{3}{4}$ should be retained on the 6 mesh.
$\frac{1}{4}$ " " 8 "

But, as said above, a small quantity will generally pass the 8 mesh, which must not however exceed $\frac{1}{16}$ of the whole quantity sifted.

If 1 lb. be sifted, it should therefore be distributed nearly as follows:—

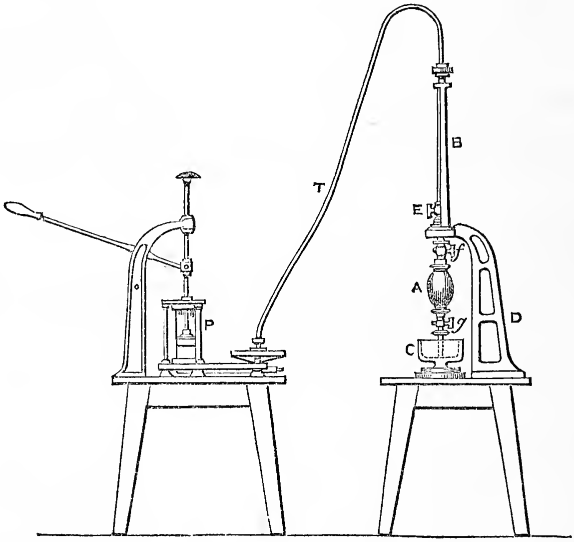
	ozs.
4 mesh to 6 mesh........................	12
6 " 8 "	3
Pass 8 "	1
Total............	16

---

* It is perhaps hardly necessary to say, that by a 4, an 8, a 16 mesh, &c. sieve, is intended a sieve with 4, 8, or 16 *divisions to the inch linear;* not 4, 8, or 16 openings in the square inch. Thus, a 4 mesh sieve has 16 openings in the square inch; an 8, 64; a 16, 256; and so on.

It will not be necessary to describe the siftings of all powders. The above will sufficiently explain the system followed.

IV. Density.—This is the most important quality of gunpowder, and must therefore be accurately determined, which can only be done by means of the mercury densimeter. The old gravimetric test—that is, "cubing" or weighing a cubic foot of the powder—gives a fair indication of considerable variations in density, but may mislead, from differences in shape and size of grain. It is, moreover, perfectly useless to attempt to detect slight variations in density—variations which, though slight in degree, yet exercise immense effect on the qualities of the powder—by means of it. The cube-box is therefore no longer used at Waltham Abbey, being entirely replaced by the densimeter, with which the density of every pressing is ascertained before the manufacture of the powder is carried further.



The Densimeter.

The densimeter consists of a barometer-tube *B*, supported on a stout metal stand *D*, and having a cock *E* at the bottom, by means of which it can be closed or opened. Attached to the top of it is a flexible tube *T*, leading to the air-pump *P*, by means of which the air can be rapidly exhausted from the barometer-tube. A glass globe, fitted at each end with metal collars, on which again are screwed other collars provided with stop-cocks *f* and *g*, can be attached to the bottom of the barometer-tube, by means of a closely fitting screw. The lower collar of the globe is provided with a nozzle, which dips into an iron bowl *C*, filled with mercury. If then the lower cock *g* be kept closed, and the other ones opened, the air can be exhausted from the barometer-tube and globe; and the lower cock being then opened, the mercury will rush in and fill the globe, and continue to rise in the tube till it has attained the same height from the surface of the mercury left in the bowl as the column in an ordinary barometer stands at the same time.

The process of taking the density of a sample of powder, is as follows:—The air is first exhausted from the tube and globe, and the mercury allowed to fill them. The upper and lower cocks of the globe are then closed, the nozzle is screwed off, and the globe then unscrewed from the tube and weighed. This weight—the weight of the globe full of mercury, which will of course vary with the specific gravity of the mercury, which again varies with the temperature—is registered.

The globe is then emptied, and a definite weight of the powder (generally 100 grammes), is introduced into it. It is then attached to the barometer-tube, the air is exhausted, and the mercury allowed to enter and to rise in the tube as before. The stop-cocks at each end of the globe are provided with diaphragms—the lower one of wire gauze, the upper one of chamois leather—which allow a free passage for the mercury, but prevent any particle of powder being carried out of the globe. As soon as the mercury has risen to the proper height, the stop-cocks are again closed, the nozzle unscrewed, and the globe taken off and again weighed. This second weight—that of the globe full of mercury, *plus* the weight of the powder, and *less* the weight of the volume of mercury displaced by it—is also registered.

The density of the powder is then calculated by the following formula:—

$$\text{Density} = \frac{D \times 100}{(P' - P) + 100};$$

where D = specific gravity of mercury at the time of experiment,

P = weight of globe, full of mercury and powder,

P' = weight of globe, full of mercury alone,

100 = weight of powder employed.

The specific gravity of mercury is—

At 50° Fahr.	13·57
60°	13·56
70°	13·54
80°	13·53
90°	13·52

An actual example worked out is subjoined.

	Grammes.
Weight of globe, full of mercury	4138 = P'
" " mercury and powder	3434 = P
Difference	704

Temperature at time of experiment 60°; consequent specific gravity of mercury 13·56 = D. Then

$$D \times 100 = 1356{\cdot}00$$

$$(P' - P) + 100 = 804.$$

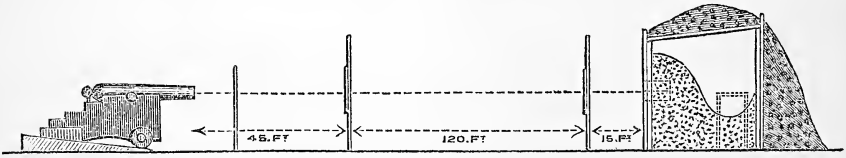
$$804)\,1356\,(1{\cdot}686 = \text{Density required.}$$

V. Action of the gunpowder when fired.—This is decided by the firing proof. It is of course impossible to predict, from observations made with one gun, what the action of different charges of powder will be in different calibres of guns. But this does not in any way affect the accuracy of the firing proof now employed; the only object of which is to ascertain whether certain samples of powder, when fired in equal charges and under the same conditions from the proof-gun, produce the same effects as have been previously obtained with standard powder of the same class. The present firing proof is not intended, and could not be employed to decide what nature and charges of powder are suitable for all arms, but is merely a means of *comparing samples of powder with the standard fixed by previous experiment.* The powders made must be not only identical in physical qualities, but must produce the same results, when fired in equal charges and under the same conditions.

The firing proof now employed affords a very perfect means of comparing the action of different powders. The old proof consisted in firing a 68-pr. shot with a charge of 2 ozs. (3 ozs. in the case of R.L.G.) from an 8-inch mortar, and comparing the ranges obtained. So much abuse has recently been heaped on the old proof mortar, that it is perhaps unnecessary to say anything on the subject. But it must be remembered that its advocates did not intend it to be used for the purpose of comparing the effects of *different descriptions* of powder, any more than the supporters of the new proof make use of the perfect appliance at their command for the same purpose; but only for comparing *various samples of the same powder* with a standard. A proof mortar, if properly used, would probably afford a rude but tolerably exact means of comparing the strength of different samples of the same kind of powder. We say probably; because there are so many disturbing elements in the mortar-proof, which were never properly eliminated, that it never received a fair trial. Now, of course, such a trial would be useless, as far more accurate and delicate means of proof are at our command.

The firing proof now in use at the Royal Gunpowder Factory, consists in measuring the velocity imparted to a projectile fired from a gun by a fixed charge of the powder under examination. The two different classes of powder—that is, powder for cannon and powder for small-arms—are tested as nearly as possible under the conditions under which they would be used; powders of the first class being tested in a 12-pr. gun, those of the latter in a Snider-Enfield or Henry rifle.

The arrangements of the proof range are shown in the accompanying figure.



The muzzle of the gun is 180 ft. from the face of the butt. The latter is filled with loose sand, and has an opening at the side, to admit of the 12 lb. projectiles being dug out. The first wire screen or target is 45 ft. from the gun, there being a screen of wood between them, with a hole for the passage of the shot. The second wire screen or target is 120 ft. from the first, and therefore 165 ft. from the muzzle of the gun, and 15 ft. from the face of the butt. The gun used for proving powder of the R.L.G. class, is a 12-pr. M.L. wrought-iron gun, with Whitworth steel tube, rifled in three grooves; rifling (1 turn in 25 calibres) and vent special. It is used with 12-pr. shot (sometimes shot turned down 9 lbs. have been employed), and a 1 lb. charge.

The small-arms used are a Snider-Enfield and a Henry rifle; both fired with the service ammunition.

The chronoscope used is one of Le Boulengé's, and has recently been so fully described in a separate pamphlet by Lieut. Charles Jones, R.A., Instructor in the Royal Gun Factories, that it is unnecessary to say more on the instrument here. The results obtained with it are excellent. Three shots are fired from each sample of cannon powder subjected to proof, and from five to ten from each sample of small-arm powder. The observations of velocity agree very closely. Indeed, it may be predicted with tolerable safety, that if the powders fired have been made of the same materials (particularly of the same description of charcoal), under the same conditions, and are of equal density and of equal size of grain, they will give very nearly the same velocities. Any variation in density will tell at once.

VI. Analysis.—This is generally conducted under the superintendence of the Chemist of the War Department, in the Royal Arsenal. Generally, a mixed sample from a number of stovings is submitted for analysis, as it is unnecessary to analyse the work of every day. It would be out of place here to enter into the details of the analysis, which will be found fully discussed in various chemical works.

The quantity of moisture in the sample submitted is first of all ascertained, and the powder is then analysed. The process is a very simple one, and may be readily performed by any one—first, by dissolving out the saltpetre, keeping up the process till the water which passes through the residue shows no trace of a deposit when evaporated, and taking special precaution against loss of charcoal in filtering; and secondly, by dissolving out the sulphur from the dried residue with bi-sulphide of carbon. The three ingredients can thus be separated and weighed.

The proportion of ingredients which should be found in the gunpowder made at Waltham Abbey, is nearly—

Saltpetre........................	75·248
Charcoal........................	14·850
Sulphur	9·900

The excess of saltpetre is due to the fact that it has been for many years the practice to put in ½ lb. extra to every 50 lb. charge which goes to the incorporating mill, to guard against loss in manufacture.

But in almost every instance, the charcoal will be found a little below, and the sulphur a little above the figures given; probably caused by the fact that charcoal always contains a certain quantity of moisture, for which no allowance is made when weighing out the ingredients. The question as to the best proportion of the ingredients, is one which cannot be too soon taken up by the Committee on Explosives.

VII. Hygroscopic test.—This, like the analysis, has recently been conducted in the Chemical Department. It consists merely in subjecting dried specimens of powder to a damp atmosphere, in a closed box, kept at a uniform temperature, and weighing them at regular intervals, to ascertain the rapidity with which they absorb moisture. Powders are found to vary very much in this respect. Generally speaking, a hard texture is unfavourable to absorption; a highly burnt charcoal also renders the powder less absorbent of moisture than a less burnt, and consequently less dense one. As a rule, contract powder—of which the charcoal is generally under-burnt—absorbs about twice as much as Waltham Abbey powder. The density of the powder affects the results to a considerable extent—at least with black charcoal powder, the absorbing power of which is diminished as its density is increased; but the comparatively high absorbing power imparted to the powder by red charcoal, is little if at all reduced by an increase of density. The quality of non-absorption of moisture, is of course a most important one for powders to possess.

Having now gone over all the proofs to which gunpowder is subjected, it may be as well to show the form in which the results of examination and proof are recorded at Waltham Abbey.

The following is a copy of the heading of the proof-book of R.L.G. powder, with an entry. Similar books are kept for all other powders:—

Proof of R.L.G., manufactured at Waltham Abbey.

Date of stoving.	No. of barrels in stoving.	Remarks on flashing.	Sifting of 16 lbs.			Density.	Analysis.			
							In 100 parts of dry powder.			Moisture.
			4 to 6	6 to 8	pass 8		Saltpetre.	Sulphur.	Charcoal.	
			lb. oz.	lb. oz.	lb. oz.					
—	35	very clean	12 2	3 10	0 4	1·680	75·51	10·01	14·48	0·90

(*Continued.*)

Date of firing proof.	Barometer.	Thermometer.		Velocity of 12 lb. shot at 105′. Charge 1 lb.				Muzzle velocity.	Remarks.
		Dry bulb.	Wet bulb.	1	2	3	Mean.		
				ft.	ft.	ft.	ft.		
—	30′·12	60°	50°	1002	1000	1007	1003	1007·8	

As all new powder has the date of stoving painted on the barrel heads, and as *every barrel* in a stoving is also numbered, it follows that the fullest information can at any moment be had respecting any barrel of powder issued from Waltham Abbey, about which any complaint or correspondence may arise. But, from the great care now taken to manufacture powder of uniform density, and owing to the severe and searching tests to which it is subjected, there is little chance of any complaint being made as to the quality of the powder which will in future be issued from the Royal Gunpowder Factory.

ENGLISH GUNS AND FOREIGN CRITICS.[1]

BY

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Du choc des opinions jaillit la lumière.

I.

INTRODUCTORY.

IN 1868 some interesting gunnery experiments took place at Tegel, near Berlin. The object of these experiments was ostensibly to determine on the pattern of heavy rifled gun to be adopted for the Prussian iron-clads. They were, however, undertaken and conducted under peculiar circumstances. The Prussian Artillery Committee, which, like our own Director of Artillery's Department, is charged with the experimental trial and final selection of the

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[1] 1. "A critical Comparison of the Prussian cast-steel Breech-loading Rifled Guns of large calibre, and the English 'Woolwich' Muzzle-loading Rifled Guns," on the basis of the experiments at Tegel in the year 1868. By C. von Doppelmair, Captain in the Imperial Russian Horse Guard Artillery. From the 2nd No. of the "Russian Artillery Journal" for 1869. Translated by G. H. Penton. London: Read, Brooks, & Co. 1870.

2. "A comparison of Krupp's Breech-loaders with the Armstrong Muzzle-loaders, with reference to their use at sea." By W. Wilhelmi, Lt.-Col. in the Imperial Russian-Austrian Marine Ordnance Corps. London: Read, Brooks, & Co. 1868.

3. "Comparative Gunnery Experiments with heavy Muzzle and Breech-loaders at Berlin, 1868." Fried. Krupp, Essen, Prussia, and 11 New Broad Street, London. London: Read, Brooks, & Co. 1868.

4. "On the trials in the Prussian Artillery in the course of the Summer and Autumn of 1868 with the 9-inch Armstrong gun, and with the 96-pr. and 72-pr. steel guns by Krupp." Article in "Invalide Russe," January 30, 1869.

5. "Remarks of the firm Krupp, in Essen, regarding the bursting of a steel 72-pr. at the trials in Berlin."

6. "Krupp and Armstrong." Translated from "Archiv fur Seewesen." Vienna, Feb. 1869.

7. "A criticism of Col. Wilhelmi's 'Comparison of Krupp and Armstrong.'" Translation of articles in "Neue Militar Zeitung," February and May, 1869.

8. "The North German Navy, &c." Translation of article in the "Wehr Zeitung" of Feb. 20, 1869.

9. "Bursting of a Krupp cast-steel 72-pr." Translation of article in the "Wehr Zeitung" of Feb. 17, 1869.

10. "From the age of Iron into the age of Bronze." Translation of article in "Neue freie Presse" of Jan. 22, 1869.

11. "Canons de Marine et de Côtes." Paris: Broise, Rue de Dunkerque, No. 43.

12. "Trial of an 11-inch Krupp's Cast-steel Breech-loading Gun, fired against the Hercules' shield in Russia." Translated from the "Russian Artillery Journal," No. 12, 1869. London: Read, Brooks, & Co.

13. "Report of a trial with a 9-inch Breech-loading Cast-steel Cannon, made by Fried. Krupp, Essen." London: Read, Brooks, & Co.

14. "Recent experiments with Heavy Rifled Guns in Russia." Translated from the "Russian Military Journal," in "Proceedings Royal Artillery Institution," Vol. V. p. 59.

naval guns, as well as of those for land service, had already expressed themselves strongly in favour of Krupp's breech-loaders. This was not surprising. The name of Krupp stands deservedly high all over Europe as a manufacturer of steel, including steel guns, of great excellence; in Prussia it is more than a name—it is a power. National prejudices, national vanity, and material interests of various descriptions all enlist themselves on the side of the great steel manufacturer of Essen. An instinctive preference on the part of Prussian officers for Prussian guns to those of English production is natural, and it is unnecessary to seek for more recondite explanations of the bias in favour of the Krupp system, which, at the outset of the Tegel trials undoubtedly prevailed in the War Ministry of Berlin. But in Prussia, as in England, the Admiralty and War Office are not always in perfect agreement on the question of naval ordnance; and it happened that in this instance the Prussian Marine Department were desirous of seeing the efficiency of the Krupp guns established upon some more substantial basis than was afforded by the mere expressed preference of the Prussian War Ministry, or by the comparatively limited practical experience of these weapons to which those who favoured them were able to appeal.

With regard to the preference of the Prussian War Ministry for Krupp guns, it is to be noticed that the experiments with these weapons as armour-piercing guns had up to that time been limited to the penetration of iron plates 4½ ins. thick, and as Captain von Doppelmair observes, "The question of guns intended to attack iron-clads was not solved by this result."[1] Of the nature and extent of the practical experience of Krupp's guns then available, we shall speak more fully hereafter. It will be sufficient for the moment to observe that at the time when the Prussian naval authorities were pressing for a trial of some other system of ordnance in comparison with the Krupp, no European nation, except the Russians, had adopted the Krupp system on a large scale. Austria had a few 8-inch Krupp guns; she had four times as many Armstrong 7-inch guns. The Spanish iron-clads were armed with Armstrong guns. Italy had English guns; France had French guns; Sweden had Swedish guns; Norway, Denmark, and Holland had Armstrong guns; Turkey, Egypt, and Greece were fast arming with English guns. Finally, even Prussia herself had not ventured upon the formal adoption of Krupp's guns. Two or three breech-loading Krupps had been placed on board the Prussian men-of-war, with this result—that the Prussian navy were crying out for muzzle-loaders and another system. Under these circumstances, the anxiety of the Prussian naval authorities to obtain some more complete and satisfactory assurance of the suitability of Krupp's ordnance for the Prussian iron-clads appears intelligible.

Intelligible or not, that anxiety existed and was expressed to the extent of inducing the Prussian War Ministry to sanction a full trial of some Krupp guns, and to pit against these guns a representative of the "Woolwich muzzle-loading system." A 9-inch 12½-ton "Woolwich" gun, made by Sir William Armstrong, was purchased of the Elswick firm for the purposes of this trial, for £1500. A supply of projectiles and English powder was purchased, and the gun was to be required to adhere

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[1] Doppelmair, p. 1.

rigidly to the English service conditions; that is to say, to fire 250 lb. Palliser projectiles, with 43 lb. battering charges of "rifle large grain" powder.

It is hardly necessary to observe that for a competitive trial between two systems of ordnance, the object of which is the selection of one of those systems, the weights and calibres of the guns should be exactly the same; and whatever variation is permitted to one gun in respect of those elements which go to make up ballistic conditions—such as weight of shot and charge, description of powder, nature and form of projectiles—the same variations should be permitted to, and in certain cases imposed upon, the other. If, however, the object be to discover whether a given service system furnishes as powerful and useful a weapon as another given service system, it is permissible, of course, to place two dissimilar guns in competition. If it is desired, for example, to measure the relative merits of the armament of a particular English and the armament of a particular Russian iron-clad, it is proper to take from each ship one representative gun as it stands, with its charges, projectiles, carriages, and fittings.

In this case, no departure from, or slightest variation of, the service conditions should be permitted.

We recognise, therefore, two distinct classes of experiments :—

(1) Competitive trials, which have for their object the determination of the relative merits of abstract systems; the determination, for example, of the relative merits for naval purposes of wrought-iron muzzle-loading rifled guns and steel breech-loading rifled guns. For the purposes of such trials, the competing guns should obviously be placed throughout the competition on exactly equal terms in respect of weight, calibre, charge, &c.

(2) Comparative trials between definite embodiments of particular systems, such as trials between any two given service guns, the details of which are fixed and fully adopted.

In both classes of experiments, two things should be observed. First, if the trial is to be complete and conclusive, the comparison must be made at all points, as to range, accuracy, ballistic power, shell power, handiness, endurance, safety, price. Secondly, if the results are to carry weight and conviction, the trial must be conducted by an impartial body—a body impartial either in the sense of being composed of men absolutely free from bias and judicially disposed, or of men confessedly partisans, and representing the contending interests with equal force on opposite sides.

The object of the Prussian trials having been stated to be the selection of a heavy rifled gun to be supplied to the Prussian iron-clads, these experiments obviously belong to the first of the above classes, and should therefore have been made with two guns, which in weight, calibre, charge, &c., were equal. As a matter of fact, however, the Prussians brought against the English muzzle-loading 9-inch 12½-ton gun, a Krupp breech-loader of 9¼ ins.[1] calibre, which weighed 14½ tons,[2] and was 32 ins.[3] longer in the

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[1] The exact figures are 235·4 millimètres = 9·26 ins.

[2] The exact weight is 14,700 kilogrammes = 14 tons, 9 cwt. 7 qrs.

[3] The exact measurements are: Krupp, 4·002 mètres = 157·56 ins.; Woolwich, 3·188 mètres = 125·51 ins.

bore than the English gun. The price of the Prussian gun was £3450; that of the English gun, as before stated, was £1500. With regard to the charge and projectile, the same inequality prevailed. Against the 250 lb. Palliser projectiles, and 43 lb. charges, the Prussian gun fired projectiles which weighed variously from 211 lbs. up to 336 lbs., with charges from 43 lbs. to 53 lbs.—principally the latter; against chilled iron shot, were brought into competition both chilled iron and steel; while the English test for endurance was carried out with the *brisante* R.L.G. powder, the Prussian test was made with the mild Russian prismatic powder.[1] Further, this powder strain was largely increased by the use in the English gun of a forward vent, as against the Prussian rear vent.[2]

The English gun was placed at an important disadvantage in another respect. While the Krupp was allowed repeatedly to vary not merely its charge and its shot, but even the details, the form and the method of lead attachment; while we find it raising its charge from 43.lbs. to 49½ lbs., and again to 53 lbs.; reducing its projectiles from 336 lbs. to 292 lbs., and again to 279 lbs.; reducing the lead coating from 63 lbs. to 28 lbs.; removing the lead coating altogether, and substituting lead rings; abandoning the rings, and reverting to a lead jacket attached by the English service process; abandoning Prussian powder for Russian prismatic powder; altering the length and diameter of the head of the shot; increasing the initial velocity by a combination of these various devices from 1115·3 to 1413 ft. per second; substituting a new breech wedge for one which had become injured when a few rounds of English powder were fired, and twice cutting out incipient fissures which had appeared about the vent—no change whatever was permitted in the English gun.

In fact, while we find the Prussian gun feeling its way during the trials, step by step, to the successful development of its full power, taking advantage of and applying on the spot the experience which the experiments afforded, and making any change which might be deemed likely to prove favourable to its efficiency, the English weapon was rigidly pinned down to its one charge of 43 lbs. of "poudre brutale," its 250 lb. Palliser projectile,

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[1] The strain exerted by R.L.G. has been estimated by the Prussians at about 6000 atmospheres, and that exerted by Russian prismatic at only about 3000 atmospheres.

The following table gives the figures deduced by the Prussians from some trials which were made at Essen:—

Nature of gun.	Charge.	Shot.	Velocity.	Pressure in atmospheres	Nature of powder.
	lbs.	lbs.	ft.		
Russian 9-in. gun.—Calibre, 9 ins.; length of powder space, 30·25 ins.; diameter of powder space, 9·33 ins.; length of rifling, 112 ins.; length of twist, 540 ins.	43	275	1160	3170	Prussian gunpowder.
	43	275	1172	3160	" "
	43	275	1270	3070	Ritter prismatic.
	43	275	1250	5950	English R.L.G.
	46	275	1230	2050	Belgian powder.
	46	275	1320	3070	Russian prismatic.

Whatever may be the exact figures which represent the relative destructiveness of the English powder as compared with the prismatic, the far greater violence of action of the former is fully admitted by artillerists of every nation.

[2] Everyone acquainted with the subject will readily appreciate this difference.

its one forward vent, and subjected to no repair or renewal of any description. Indeed, so numerous were the alterations in the Prussian gun, that in the course of the trials almost every feature of the original combination became altered, and from firing a heavy, thickly-leaded, obtuse-headed shot with a low charge of comparatively rapid powder, the gun came to fire light thinly-leaded sharp-pointed projectiles with high charges of superior powder; the breech arrangement and system of venting having meanwhile also undergone reconstruction and repair.

If under these circumstances the Prussian gun had largely surpassed the English gun in penetrative effect and other qualities, such a result would hardly have afforded justification for any very marked expression of satisfaction on the part of those who were favourable to the Prussian system. If one gun is pitted against another which is bigger and longer and one-sixth heavier, which fires charges nearly one-fourth heavier, and projectiles generally from one-eighth to one-third heavier, and which, according to the estimates of its own maker, has a resulting theoretical superiority of power of from 30 to 33 per cent.,[1] and if the heavy gun beats the lighter gun, does that prove that the system which the heavy gun represents is superior to the system which the light gun represents? But if, in the event, the heavy gun barely succeeds in holding its own against the lighter gun, what shall then be said of attempts to deduce from the trials a conclusion favourable to the heavier weapon?

And this is exactly what happened. The relations of the two competing guns at Tegel were as we have stated them. The result, broadly expressed, was—as will presently appear—that the Krupp gun barely held its own—if indeed it did that—against the English gun. And yet, since the Tegel trials, pamphlet after pamphlet, article after article have appeared, setting forth, on the basis of those trials, the superiority, not merely of a particular Krupp gun to a particular English gun, but of the Krupp steel breech-loaders generally to the English wrought-iron muzzle-loaders. The "Woolwich" system has been tried at Tegel and found inferior to the Prussian system; muzzle-loaders are inferior to breech-loaders; wrought-iron is inferior to steel; English projectiles are inferior to Krupp's steel shell; English chilled iron is inferior to Gruson's; English powder is inferior to Russian; the English system of venting is inferior to the Prussian system of venting. In fact, on the basis of these Tegel trials, the English system of heavy rifled ordnance has been subjected, comprehensively and in detail, to an amount of destructive foreign criticism which is probably unexampled. That it should have suggested itself to so many foreign critics—to Prussians, and Austrians, and Russians—to erect a structure of this character and extent upon such a foundation as the Tegel experiments, is remarkable; that it should have seemed to them possible or probable that when erected it would have any sort of stability, or be otherwise than as a pyramid standing upon its point, is almost inconceivable. But the fact remains—the criticism

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[1] See Mr. Krupp's pamphlet, "Comparative Gunnery Experiments," Table III., where the "energy" or theoretical penetrative power of the two guns is given as 16¼ to 16¾ mètre-tons per centimètre of the shell's circumference for the Prussian guns, against 12·35 mètre-tons for the English gun.

is there;[1] and the phenomenon is sufficiently curious to invite investigation.

On approaching the object of our investigation, a great part of the difficulty disappears; we discover that the effect produced is, in a great measure, an optical illusion, which is obtained on the principle which has been ingeniously applied to the production of a popular toy, known as the "wheel of life," where a number of fixed figures in various postures, or gradations of the same posture, become blended by rapid revolution, when seen through openings prepared for the purpose, into an appearance of a single figure, accomplishing a definite result. And those who would have us believe, on the evidence of the Tegel trials, that the English system of heavy rifled ordnance is inferior to the Prussian, are aware that their only hope lies in skilfully mixing up things which have no necessary connection with one another—in confusedly blending together metal and breech mechanisms, long bores and prismatic powder, steel projectiles and steel guns, and thus producing an appearance of certain results accomplished by a definite system of ordnance, which has been elaborated into a symmetrical whole by Krupp of Essen; a system so homogeneous that no separation of its component parts is possible. When all the points which tell in favour of the English guns—such as the destructive character of the powder which they fire, their less weight, as well as that of their charges and projectiles, to say nothing of the less cost of the system—are artfully kept in the background, or shown, if at all, only in shadow, it is not difficult to understand how, even from the Tegel trials, it may be possible to deduce conclusions apparently destructive of the English system of ordnance.

It follows from the above, that if we would assess the true value of this foreign criticism of our English guns, we must examine it in close and critical detail. The very circumstance that, unless so examined, it is liable to produce an erroneous impression and to lead to conclusions opposed to the fact, renders it desirable that some one should undertake the task. Pamphlets such as those of Captain von Doppelmair, and Lt.-Col. Wilhelmi —officers of the Russian and Austrian services—and published with a certain parade of professional, if not official sanction, carry weight with those who only read them superficially, or who are not familiar with the facts which furnish an effective answer to the various conclusions which the writers have endeavoured to establish. Without inquiring how many of those who read these pamphlets belong to this class, we may reasonably assume that a large proportion of professional readers will want the time necessary to read these pamphlets critically, while non-professional and foreign readers can hardly be expected to have that intimate acquaintance with the details of the question without which an intelligent examination of those criticisms is impossible. The pamphlet of Captain von Doppelmair appears on several accounts to be the one which it is most important to consider. In the first place, the paper is a more recent, a more comprehensive, and a far more able pamphlet than that of Lt.-Col. Wilhelmi; in the second place, Lt.-Col. Wilhelmi's pamphlet has been very effectively and completely answered by a writer in the "Neue Militar Zeitung;" lastly, Captain von Doppelmair's

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[1] The extent and variety of this criticism are in some degree indicated by the names of the pamphlets and articles of which it is in part composed, which are printed at the beginning of this paper.

pamphlet is perhaps the most remarkable example which could be selected of that system of skilfully blending together things not necessarily connected, so as to produce an appearance which is wholly artificial, of keeping out of sight inconvenient facts and considerations, and of assigning undue prominence to others, which is characteristic, more or less, of the whole of the foreign remarks on these trials which we have read. It is also a good example of the insufficiency of the information out of which men may be tempted to construct a theory favourable to a particular view. We shall, therefore, proceed to examine the account of the Tegel trials as given by Captain von Doppelmair, supplying, as we proceed, such comments and omissions as may occur to us; rectifying such errors as we may observe; disentangling, as far as may be possible, the issues which Captain von Doppelmair has contrived to confuse; and, finally, observing how far the facts warrant the conclusions at which that officer has arrived.

II.

Comparative Penetrative Power of the Woolwich and Krupp Guns.

Captain von Doppelmair commences his pamphlet with a description of the competing Krupp and Woolwich guns. We have already given the principal weights and dimensions of these weapons; but the more detailed information contained in Captain von Doppelmair's pamphlet may be useful.[1]

Krupp's $9\frac{1}{4}$*-inch Gun.*

Calibre	235·4 millimètres	=	9·26 ins.
Length of bore	4·002 mètres	=	157·56 〃
〃 rifled part	2·929 〃	=	115·40 〃
Total length of gun	4·708 〃	=	185·31 〃
Number of grooves	32		
Greatest outside diameter	1020 millimètres	=	40·18 〃
Weight of gun[2]	14650 kilos.	=	$14\frac{937}{2240}$ tons.

Woolwich 9-inch Gun.

Calibre	228·6 millimètres	=	9·0 ins.
Length of bore	3·188 mètres	=	125·51 〃
〃 rifled part	2·642 〃	=	103·98 〃
Total length of gun[3]	3·962 〃	=	154·23 〃
Number of grooves	6		
Greatest outside diameter	991 millimètres	=	39·016 〃
Weight of gun	13100 kilos.	=	$12\frac{2000}{2240}$ tons.

It will be observed that the maximum battering charge adopted for the Krupp guns at the outset was 46·30 lbs. of Prussian powder; and it is important to notice this, because it will hereafter become necessary to observe how far this condition was departed from when the inability of the Krupp gun to hold its own became apparent. With this charge and a

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[1] Doppelmair, pp. 2, 14.

[2] With breech-piece (weight of breech-piece, 600 kilos.)

[3] With cascable.

projectile of 336 lbs., an initial velocity of 1140 ft. per second was obtained. The English maximum charge was 43 lbs. of R.L.G. powder, and this charge was never increased or varied during the trials.

Three shields, the plates for which had been obtained from Sir J. Brown, of Sheffield, had been erected for the purpose of the experiment, representing ships' broadsides covered with 5, 6, 7, 8, and 9-inch plates. No. 1 shield, which represented the broadside of the Prussian "Friedrich Karl," consisted of 6-inch plates upon a backing similar in general features to the well-known composite, Chalmers' backing. Over the upper part of the target a 5-inch plate was substituted for the 6-inch. No. 3 target, which represented the broadside of the "König Wilhelm," was similar to No. 1, but stronger, the lower plate being 9 ins. and the two top plates 8 ins. thick. Both shields had a stout iron skin at back. No. 2 target consisted of 7-inch armour upon 30 inches of wood backing, without any iron struts or strengthening.

The practice against the shields was commenced on March 31, 1868, by the Krupp gun firing 46·30 lb. charges, and both Gruson's and Krupp's steel projectiles. Out of 7 rounds, only 4 struck the target without ricochetting;[1] a result which, at ranges of 1028 and 782 yds., is hardly compatible with Captain von Doppelmair's statement, that the Krupp gun had "a very satisfactory accuracy."[2] The result of this trial, as far as penetration went, was very unsatisfactory. Even the 6-inch shield was not completely penetrated—a failure which is attributed to the shot having "struck on a particularly strong place."[3] However this may be, Captain von Doppelmair frankly admits that the Prussian gun "would have proved too weak against ships with 7, 8, and 9-inch plating, not only at great but also at smaller distances. The result of the trial consequently was, that the gun was not sufficiently powerful to fulfil the conditions under which the trial was held, and therefore could not satisfy the requirements of coast and marine artillery."[4] This result occasioned, as may easily be understood, the keenest mortification in Prussia. The established power of the English guns was already well known to be largely in excess of that which the representative Prussian gun had exhibited.

Something must be done—and three expedients were proposed. The charge might be increased; some of the lead coating might be removed, so as to facilitate the passage of the shot through the bore; or a quicker powder might be employed. So we find the Prussians increasing their charge from 46 lbs. to 49½ lbs., then to 53 lbs., and again to 55 lbs. of Prussian powder; the velocities being thus increased to 1151·6, 1170·9, and 1184·7 ft. per second. But with heavier charges than 49½ lbs. the accuracy, fortunately perhaps for the endurance of the guns, began to diminish, and it was therefore decided to continue the trials with this charge as a maximum.[5] The proposed reduction in the lead coating was not attended with advantage, either as regards velocity or accuracy, and it was not adopted.[6] Then came an experiment which is worthy of particular attention. An attempt was made to improve the velocity by employing

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[1] Doppelmair, pp. 7, 8.

[2] Ibid. p. 6.

[3] Ibid. p. 8.

[4] Ibid. p. 9.

[5] Ibid. p. 11.

[6] Ibid. p. 12

English powder. A few rounds were fired of R.L.G. powder in charges of 43 lbs., and with this result—that the breech mechanism was broken,[1] and the use of English powder was hurriedly abandoned. The breech action was renewed, and the construction improved.[2] The significance of this effect of a few rounds of English powder upon the Prussian gun, we shall have occasion again to refer to.

At this point the English gun came upon the scene, and, in the trial which followed, it is admitted that it "evinced a considerable superiority over the Prussian gun for use against armour plates;"[3] while the comparison of the Prussian and English projectiles led to "several necessary alterations in the previous construction" of the former.[4]

Before proceeding to record the results of these trials, it is necessary to correct one or two errors into which Captain von Doppelmair has fallen at this part of his narrative. Exception might be taken to the expression that the escape-hole in the Woolwich guns is provided "to prevent unexpected bursting," as tending to convey an erroneous impression of the general behaviour of the guns. But a more decided objection must be made to the statement that "the selection of this energetic powder (R.L.G.) for the English 9-inch gun was necessary in order to obtain high initial velocities with the comparatively short length of the gun."[5] This passage is incorrect in two important particulars. It is incorrect because it implies that this powder was deliberately selected for use with our heavy rifled guns; it is also incorrect because it states that such a powder is "necessary" for those guns. This double error will be found running all through Captain von Doppelmair's pamphlet.[6] The same error underlies the remarks of other critics,[7] and it is important to correct it, because if admitted, it points to this conclusion—that whatever advantages the Prussian guns may derive from the use of a slower and milder powder, in respect of decreased strain upon the gun with increased charges and initial velocities, reduced scoring of the bore, &c., those advantages cannot be enjoyed by the English guns, which are too short to use a slow powder effectively. In fact, we have here a good illustration of the system on which we have remarked of blending together things not necessarily connected, in a way to produce an effect favourable to the Krupp and unfavourable to the Woolwich gun. Moreover, as will presently appear, while our system gets the discredit of employing a *brisante* powder, it nowhere gets the credit which attaches to

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[1] This result may be best given in Captain von Doppelmair's own words:—"After the termination of this firing, two cracks appeared in the hollow turned out in the wedge for the obturating plate. Whether these cracks had been already started by the previous firing, or were exclusively the effect of employing the English powder, could not be decided. But these cracks, as well as a crack that had previously appeared in the female screw of the breech of the Prussian gun, the bending of the obturating plate, and of the metal of the wedge behind it, induced the determination to renounce the use of descriptions of powder of rapid combustion and more destructive effect."—Doppelmair, p. 13.

[2] Doppelmair, p. 13, note.

[3] Ibid. p. 13.

[4] Doppelmair, p. 13. Compare this statement with that at p. 79, that Gruson's works "had determined the shape and construction of these projectiles on which their depth of penetration depends."

[5] Doppelmair, p. 15.

[6] See, for example, Doppelmair pp. 24, 62.

[7] See Krupp's pamphlet, p. 3.

its use, as in the endurance of the increased strain which this powder imposes, and in the less uniformity of the granulated powder.[1] To avoid, however, breaking the narrative of the Tegel trials, we reserve the full discussion of this important subject; contenting ourselves with recording, in passing, an emphatic contradiction of the correctness of the statement quoted above, which seeks to establish the existence of a necessary and indissoluble connection between English guns and a violently destructive powder.

Further, we must object incidentally to Captain von Doppelmair's convenient desire to disregard the trials which were made at this time for accuracy with the "Woolwich" gun, and which he admits were "perfectly satisfactory,"[2] on the grounds that, "as only four rounds were fired, we cannot draw from them a conclusion as to the accuracy of the Woolwich system."[3]

We now come to the account of the trials of June 2, 1868. Four rounds were fired from the Woolwich gun—one at the 6-inch plates, two at the 7-inch plates, and one at the 8-inch plates. "These projectiles struck the targets at undamaged places, and went right through them."[4]

Two rounds were fired from the Krupp—both with Gruson's projectiles, and 46·30 lb. charges. One of these projectiles struck and penetrated the 5-inch target, though why it was fired at this target at all is not very clear. The other struck the 8-inch plate, pierced the plate, and went 190 millimètres (Krupp says 229 millimètres) into the wood backing,[5] and remained sticking in the target. "The result of this trial, as well as that of March 31, was, therefore, that the English 9-inch Woolwich rifled muzzle-loader gun was considerably superior to the Prussian 9¼-inch[6] rifled breech-loader gun as regards execution done to armour-plated shields. Krupp's and Gruson's 9¼-inch[7] rifled breech-loader projectiles only just pierced the 6-inch target, and were entirely powerless against shields with 7-inch and 8-inch plates. The Palliser shells pierced all the shields completely."[8]

Considering that the Prussian gun was now firing charges 3½ lbs. heavier than those originally assigned to it,[9] with a resulting increase of initial velocity from 1115 to 1130 ft. per second, and that the gun was now therefore decidedly more powerful than it would have been if the Prussian navy had blindly accepted it, as first proposed, without trial; considering also, that, after some months' manipulation, the Prussians had been only able to get the gun up to the point of exhibiting a lamentable inferiority to a

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[1] Captain von Doppelmair's description of the English powder is also incorrect. He asserts that resin is used in glazing it; and elsewhere he tells us that this powder burns more rapidly and is more violent in its action in warm weather, because the resin becomes detached (pp. 14, 25). As a matter of fact no resin is employed.

[2] Doppelmair, p. 15.

[3] Ibid. p. 15.

[4] Ibid. p. 16. We notice, in passing, that Captain von Doppelmair's record of this experiment enables us to correct an error in one of the tables in Mr. Krupp's pamphlet, in which the performance of the English gun is erroneously credited to the Krupp gun.—Krupp, Table II. Round 2, column of effects.

[5] Krupp, Table II. Round 2, column of effects.

[6] In Captain von Doppelmair's pamphlet, this gun is spoken of as a "96-pr.;" but this nomenclature (which is that commonly used in Prussia, and which refers to the size of the bore in relation to the weight of *spherical* shot which it would fire), being liable to confuse, the calibre of the gun has been substituted.

[7] See note next above.

[8] Doppelmair, p. 16.

[9] Ibid. p. 11.

smaller, lighter, cheaper weapon, it is not surprising that the result, while it amply justified the action of the Prussian Naval Department, and saved it from the fate which had overtaken the Russians—who had already embarked largely in these guns—should have occasioned considerable disappointment and annoyance in Prussia. The resignation of the Presidency of the Prussian Artillery Committee by General Neuman—one of the most distinguished of continental artillerists, who had more or less guided the labours of the Committee for thirty years—marks at least his view of the completeness of the failure.

What was the cause of this failure? Captain von Doppelmair answers the question. The initial velocity was too low. The lead jacket was too thick. The form and dimensions of the projectiles were unsatisfactory.[1] These defects must be remedied, and in applying the remedies the Prussians necessarily at each point approximated the main features of their system nearer to those of the English system. With regard to the increase in initial velocity, the passing admission of Captain von Doppelmair, that "high initial velocities had not been looked upon as particularly necessary in experiments with guns intended for firing against iron ships,"[2] implies that the Prussians had a good deal to learn when they entered upon this competition. But the readiness with which they now copied each detail of the English system, relieves them from the reproach of being slow to learn. We have seen that it had been found impossible to obtain any considerable increase in the initial velocity by increasing the charge of Prussian powder without loss of accuracy; we have seen also that the Prussian guns would not stand the English powder. It was therefore wisely determined to try Russian prismatic powder, and the result was—by using a charge of 52 lbs. the velocity, with a chilled shell of 336 lbs., was increased to 1286 ft.; with a shell of 292 lbs., to 1366 ft.; with Krupp's light steel, of 279 lbs., to 1413 ft. per second.[3] The accuracy of the gun with this charge of prismatic powder also proved satisfactory, and superior to that obtained with Prussian powder—a result due, as Captain von Doppelmair explains, and as may be admitted, to the more uniform combustion of this powder.[4] The observation here naturally suggests itself, that whatever advantage in respect of greater accuracy and uniformity may be due to the use of a superior powder, would also accrue to the English gun if the same powder were employed. But the way to this conclusion is blocked by the convenient foreign theory, upon which we have before commented, that the English gun can use no other than English R.L.G. powder. The fallacy of this theory has been already referred to,[5] and will presently be more fully exposed; we now only call attention to it that it may be observed what an important and valuable theory it is for the foreign critics to maintain. In its way, it is almost as useful as another favourite and equally baseless theory of Captain von Doppelmair's, that "it is not possible for the English to make cast steel guns," and that therefore we are "compelled" to employ inferior materials and modes of construction, the use of which renders breech-loading "not available" for England.[6]

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[1] Doppelmair, pp. 16-19.

[2] Ibid. p. 22.

[3] Ibid. pp. 20, 28.

[4] Ibid. p. 22.

[5] See p. 68.

[6] Doppelmair, p. 24.

The charge of 53 lbs. of prismatic powder was now substituted for the 46½ lbs. of Prussian powder[1]—conditions vastly different, we need hardly observe, from those which the guns had been originally designed and proved to meet.[2]

The next point was the reduction of the lead jacket of the shot. Captain von Doppelmair argues at great length, and Mr. Krupp in his pamphlets is very emphatic in the same direction, to prove that the lead jacket of the shot is unfavourable to penetration.[3] We are disposed to admit the soundness of this reasoning, with this qualification—that as the lead coating adds to the weight of the projectile, it increases the *vis viva* of the shot, and must not therefore be altogether thrown out of the account.[4] But that a thick lead coating is to a very large extent unproductive in penetration trials, and actually obstructive of the passage of the shot—an absorbent, so to speak, of the shot's energy, and a bar to its progress through the plate—is indisputable. It was shown conclusively to be so in the Tegel trials,[5] and theory would of course point to the same conclusion. But when we have admitted this, is the admission favourable or unfavourable to the Krupp system of ordnance, with which a lead coating of some sort is indispensable? Is it not an admission of the necessity on Krupp's part to produce a large margin of ballistic powder in order to accomplish the same penetrative results as a gun which is not saddled with this dead weight of projectile? Is it not an admission of an inherent defect in the system, to say that it entails the use of a projectile of which from one-fifth to one-fifteenth (according to the thickness of the lead jacket) is declared by its supporters to be useless for penetrative purposes? Have we not here, indeed, some explanation of the fact which will appear more clearly as we proceed, that with a large theoretical excess of penetrative power, Krupp's gun produced penetrative effects not greater, if so great, as those produced by the English gun? Then, again, there is the question of accuracy, and Captain von Doppelmair is driven to admit that the inferior accuracy of projectiles with a thin coating may have been due to the reduced quantity of lead.[6] Finally, have we any assurance that the thin lead coating, upon which Captain von Doppelmair shows conclusively so much depends, can be applied to the Gruson chilled projectiles at all? On the contrary, it appears that each attempt to apply the new jacket to these projectiles without detriment to the casting was, if not actually a failure, far short of a successful result.[7] And while the importance of this point is fully admitted, and indeed insisted upon with great emphasis by Captain von Doppelmair, he can give

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[1] Doppelmair, p. 27.

[2] It should also be observed that 53 lbs. of prismatic is admitted by Krupp to be more than equivalent to 43 lbs. English, which charge is stated to be equal to 46 lbs. prismatic.—Krupp, p. 5, and Table VI. It is also worth while noting that, although prismatic powder is used in Russia with the Krupp guns, the maximum charge for a 9-inch Krupp, heavier by 4 cwt. than the Tegel gun, and firing a light shot, is only 46 lbs.—Krupp, Table VI.

[3] Doppelmair, pp. 17–19, 25. Krupp, pp. 9, 10.

[4] See Doppelmair, p. 18, where the lead coating *is* altogether thrown out of the calculation.

[5] Doppelmair, pp. 32, 43.

[6] "Perhaps also the absence of the heavier lead jacket lessens the stability of the axis of rotation of the shell, and so influences the accuracy of fire."—Doppelmair, p. 33.

[7] Doppelmair, pp. 29, 36, 40, 49.

us no further information as to its actual accomplishment than a vague note, which states that "Gruson's Works have since executed large orders for chilled shells with thin lead jackets for various Governments."[1]

With respect to the form of the shot, the Palliser form was closely observed and copied[2]—the length of head and its diameter at junction with the body being increased. In fact, the Gruson shot was made externally as like the Palliser as possible. Considering what an important influence the form has upon penetration, this, again, was not an unimportant departure from the original pattern. Before applying these alterations to the large gun, they were tried in an 8-inch ("72-pr.") Krupp gun,[3] which was present on the ground, and which during the trials played the useful part of a pioneer to the heavier weapon.

On July 7, after a month's private experimenting, we find the Prussians prepared once more to enter the lists against the English gun, in which no change of any sort had been made during the interval. The effect of the various experiments and united alterations had been to give to the Krupp gun an initial velocity of from 1286 to 1414 ft. per second, according to whether a 336 lb. or 275 lb. shell was used;[4] and this velocity, according to Mr. Krupp,[5] gave a momentum to the Krupp projectiles of from 16·26 to 16·78 mètre-tons per centimètre of circumference, as against 12·35 mètre-tons for the English shot. In other words, the Krupp resumed the contest with a theoretical ballistic superiority of from 30 to 33 per cent.[6] The Prussian official report also gives a superiority of momentum of about 33 per cent. to the Krupp. If other formulæ and modes of calculation be adopted, the figures representing the relative ballistic powers of the two guns will vary. Thus, Captain von Doppelmair assigns a theoretical superiority of momentum to the Prussian gun of from 17 to 15 per cent., according to whether the heavy or light shell is used.[7] The theoretical superiority of penetrative power will depend upon the range and upon the value assigned to the lead jacket. The Prussian official report on these trials gives the Krupp gun a theoretical penetrative superiority[8] of from 29 to 21 per cent., if calculated by the English formula, and of from 25 to 17½ per cent. if calculated by the Prussian formula. Sir William Armstrong estimated it at about 18 per cent.[9] Without attempting to assign a precise figure to the theoretical

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[1] Doppelmair, p. 49, note.

[2] Ibid. pp. 19, 25.

[3] Ibid. pp. 25, 26, 63.

[4] Ibid. pp. 28–63.

[5] Krupp, Table III.

[6] In a later pamphlet, Mr. Krupp estimates the ballistic power of his 9¼-inch guns at from 15 to 34 per cent. superior to that of the English 9-inch gun, according to whether the Krupp guns are of 14,000 or 15,500 kilos. See "Canons de Marine et des Côtes," Tables I., IV.

[7] Doppelmair, p. 30.

[8] Range not stated.

[9] Captain W. H. Noble, R.A., has kindly furnished the following interesting observations on the subject:—"In any comparison of guns where the conditions are so different, it is very difficult to assign values to different parts of the same projectiles. Thus, the 96-pr. Gruson shot, of 336 lbs., consisted of a lead jacket of 63 lbs. and an iron shot of 273 lbs. It is an open question which weight we should assume in making a comparison of *vis viva*. There cannot be a doubt that the 63 lbs. of lead is less effective than if it were 63 lbs. of iron; but has it no effect whatever? On the whole, the fairest way is to take the absolute weight of projectile which strikes the target. If the Prussian system necessitates the use of 63 lbs. of useless material on a 336 lb. shot, it is a decided disadvantage to the system. In the same manner, we have no data to guide us as to the diameter of the iron part of the Prussian shot. We know the calibre of the gun, and we know also that the shot with its lead jacket must be of the same diameter as the calibre of the gun,

penetrative superiority of the Krupp gun, a superiority due solely to its greater weight and length and higher charge—in fact, to its being a bigger gun—it is clear that that superiority was considerable. Under the stress of defeat, the Prussians had developed the power of their gun, although, we observe in passing, without having satisfied themselves that the gun was capable of doing this increased work for any considerable number of rounds—without, in fact, subjecting it to any trial of endurance with the increased charges. For the matter of that, it could hardly be worse to burst the gun than to accept without further effort the defeat which had been endured in the trials of March 31 and June 2. And there was always the hope, as the prismatic powder was mild, that the gun might not burst; while, as the English gun might fail in some way or another—might fall somewhat short in some particular of the Prussian gun—there remained the hope of snatching a victory if the contest were continued; on the other hand, if it were now abandoned, the victory belonged too obviously to the English gun to be disputed.

When the trial recommenced, on July 7, the position was this:—The English gun, having proved its superiority, had been heavily handicapped—to an extent which is estimated at from about 18 to 30 per cent. As that superiority was obviously not inherent in the Prussian system, but had been obtained only by repeated alterations in that system, carried out during the trials, it was necessary for Captain von Doppelmair to explain why no alterations—of weight of charge and nature of powder—and no attempted improvements were permitted to the English gun; and this he does by quietly begging the whole question in a passage to which we have before referred, but which it will be as well here to quote:—"If we consider the English system of guns of large calibre, we must admit that its arrangement is perfectly rational—that the proportion of charge, the construction of bore, the description of powder, are so combined with the material of the guns and the mode of manufacture, that, as a result of the whole, the greatest possible effect of the projectile is obtained as a combination of its accuracy and momentum. The whole arrangement of the English system follows, as a matter of necessity, from the material selected and the mode of manufacture."[1] We do not quote this passage for the purpose of calling attention to the curious contradiction involved in the statement that the "description of powder"—which is admitted by Captain von Doppelmair, in common with the rest of the world, to be of an exceedingly destructive character, and which, on account of the violent strain which it imposes upon the guns, has earned the designation of *poudre brutale*—is a powder which it is "perfectly rational" to employ with guns made of a material which Captain von Doppelmair is anxious above all things to show to be inferior to steel.

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but we do not know the diameter of the iron part irrespective of its lead jacket. We must, therefore, in any comparison, assume that the diameter of all the projectiles are identical with that of the gun from which they are fired. . . . . The English 9-inch gun, 43 lbs. charge, initial velocity 1324 ft., reduced to 1237 ft. on striking" (at 514 yds.), "weight of shot 250 lbs.; total striking energy 2652 foot-tons, or 94 foot-tons per inch of circumference of calibre. The Prussian 96-pr., 53 lbs. charge, weight of shot 336 lbs., velocity (at 51 yds. from muzzle) reduced to 1217 ft. on striking at 514 yds.; total striking energy 3390 foot-tons, or 116 foot-tons per inch of circumference of calibre."

[1] Doppelmair, p. 24.

Nor do we quote the passage with a view to gibbeting the confusion of thought which can thus trace an inevitable connection between the English proportion of charge to calibre and the mode of gun manufacture, and between the metal of our guns and the system of muzzle-loading. Nor is it our immediate object to expose the reckless inaccuracy of statements which follow: that we are unable to make cast-steel guns; that we are unable to make breech-loaders; that we are compelled to employ a powder of rapid combustion, because our guns are short; that we are compelled to use short guns, because we cannot make breech-loaders; that "the uncertain stability of the guns remains as a prejudicial consequence of the selection of the metal;" that our guns are so weak that we are compelled to adopt the increasing twist; that with our guns there is no security against a sudden bursting.[1] These points will call for some remark hereafter; for the present, it is only necessary to observe that they afford so many examples of the worst possible form of begging the question—so many examples of the "wheel of life" system in full play. The passage above has been quoted here, however, rather to show upon what grounds and by what sort of reasoning the indisposition of the Prussians to give the English gun the same opportunities as the Krupp for developing its penetrative power is attempted to be justified.

When the guns were now fired, the following results were obtained:—Round 1, with Krupp, firing a Gruson shell, struck the 8-inch target, but without penetrating it. An explanation of this failure is ready at hand. "The shell was not of the usual excellence."[2] Mr. Krupp ascribes the failure to another cause—the shell struck "obliquely against the plate."[3]

Whichever explanation be accepted, the round was a failure.

Round 2 was a Krupp steel shell, which penetrated the 8-inch target. Both Captain von Doppelmair and Mr. Krupp neglect to state, however, that this shell struck actually on the junction of two plates, and therefore on what is always considered in target experiments a weak place. Indeed, Mr. Krupp ventures to affirm that this round struck on a less favourable place than the Woolwich projectiles. The plans of the practice, and the testimony of an eye-witness in the "Times," clearly contradict this assertion.

Round 3. A fair hit with a Gruson 336 lb. shell, and a fair penetration —a result, however, which it is proper to notice had also been accomplished by the Woolwich gun with Palliser 250 lb. shell and 43 lb. charges.

Round 4 Captain von Doppelmair omits altogether. From Mr. Krupp's pamphlet,[4] we learn that this was a Gruson shell, which stripped its lead coating in the gun, made several ricochets, and struck obliquely—affording an illustration of the difficulty attending the desired alteration of the lead jacket.

Round 5. This round also Captain von Doppelmair omits, which is the more remarkable since Mr. Krupp writes "through" against it. It is, however, clear from Mr. Krupp's detailed record of the effects, that the shot only went "partly through the inner skin."[5] It is not equally clear why Captain von Doppelmair has left this round out altogether, especially as the

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[1] Doppelmair, pp. 24, 25.

[2] Ibid. p. 29.

[3] Krupp, Table IV.

[4] Krupp, Table IV.

[5] Ibid.

projectile was a Gruson of the same construction as had done well in Round 3. Either this round was a failure or a success. If a failure, Mr. Krupp ought not to have recorded it as "through;" whether a failure or a success, Captain von Doppelmair should have included it in his account of the experiments.

Round 6[1] was a Krupp steel shell, against the 9-inch plate. It went over 5 ins.[2] into the wood backing, where it stuck, and was shaken out on the following day by the concussion of a succeeding round. Both Captain von Doppelmair and Mr. Krupp affirm that this shell struck on an exceptionally strong place; whereas, in fact, the unsupported balk of timber at the back would not materially add to the resistance when the target clearly overmatched the gun.

Round 7[3] was fired at the 9-inch target from the Woolwich gun, with a shell made by Gruson in exact imitation of a Palliser,[4] but slightly heavier. The shell did fairly, penetrating about 2½ ins. into the wood backing. At the same time, it is doubtful if this round should be included in the competition, having been supplied by the Prussian Government without the concurrence of Sir William Armstrong.

Round 8[5] was a Palliser shell proper from the Woolwich gun, at the 9-inch target. It penetrated about 4 ins. into the backing—about 1½ in. less than the Krupp steel shell in Round 6. Mr. Krupp states that this shot "struck the 9-inch plate between two bolts and struts (favourable spot)."[6] An eye-witness of the trials, writing in the "Times," says:—"Krupp's pamphlet is incorrect in stating that this shell struck on a favourable spot. It struck on a strut."[7] The same eye-witness comes to a conclusion with regard to these trials which every impartial witness must arrive at, that "no advantage can fairly be claimed for either side." The same conclusion, in point of fact, was arrived at by the Prussian Committee, which reported that no definite superiority had been established on either side.

What, then, had become of the large theoretical penetrative superiority of the Krupp gun—the 18 to 33 per cent. excess of ballistic power? It had become absorbed apparently by the inherent disadvantages of the system; and this result was as distinctly a substantial victory for the Woolwich system, as would be a dead heat between two horses of which the smaller was heavily handicapped.

And this conclusion we reach without any reference to the question that the only Krupp shell which produced results comparable with those obtained by the Palliser was a steel projectile—and steel, Mr. Krupp affirms, is vastly superior to chilled iron for penetrating purposes."[8] If this be so, the victory of the English system becomes still more marked, and Mr. Krupp is on the horns of this dilemma—he must either maintain the superiority of his steel shell, in which case he has a further excess of non-productive penetrative power on the part of the Prussian gun to account for; or he

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[1] No. 4 in Captain von Doppelmair's account.

[2] Mr. Krupp sets it down as 5·9″; another account gives it as 5·3″.

[3] Round 5 in Captain von Doppelmair's pamphlet.

[4] Doppelmair, p. 29.

[5] Round 6 in Doppelmair.

[6] Krupp, Table IV.

[7] "Times," January 23, 1869.

[8] Krupp, p. 9.

must give up the superiority of his steel shell, in which case he must explain why he has recourse to a material at least four times as costly as chilled iron.

Captain von Doppelmair's conclusions from these trials are—First, that the Prussian gun can pierce the 8-inch target "with a surplus of power,"[1]—a conclusion which, in view of the decided failures at rounds 1 and 5, and the circumstance that round 2 was on a weak place, is hardly likely to receive unqualified acceptance; secondly, that the English 9-inch gun also pierces the 8-inch shield, "but that the destruction of the target at the back is much less considerable."[2] This last is rather a strong conclusion to arrive at on the evidence of so few rounds, and we are disposed to doubt if the effect upon the back of the target of a blind Gruson or steel shell, which breaks into few pieces, is at all equal to that of a Palliser shell, which breaks into many pieces. But if we admit it, what does it amount to?—that the Palliser projectile, instead of expending itself in producing comparatively useless destructive effects, enters the ship in a shower of fragments which carry havoc and destruction among the crew. This is a naval question, upon which English opinion has long since pronounced itself. The real object in the attack of iron-clads, as of other ships, is less the disablement of the vessel than of the men and guns which it contains; to destroy the vessel, when we can, if we choose, reach the men and guns, is a tedious and roundabout way of accomplishing our object. "A ship, its guns, and its crew, constitute in combination an active fighting power. Destroy or paralyze one of the elements, and you destroy or paralyze the combination. . . . . In making choice of the direction and nature of attack, it is important to endeavour to effect the object in the shortest time, in the easiest manner, and with the least possible expenditure of men, money, and material. . . . . The ship represents a passive agent in the combination of fighting power. The men are the active and vital agents—the soul of the system; and while the passive agent, constructed as it now is, will stand a vast deal of battering without becoming disabled, comparatively few shells will serve to disorganise and paralyze the best crew ever brought together. . . . . This view, we conceive, embodies the whole merits of the shell system of attack. The great primary advantage of the use of shells is, that they wreak a tremendous destruction *within* the vessel, carrying terror and confusion between decks, creating smoke and wounds, and accomplishing a demoralising effect, such as shot produce, only in a very much less marked degree."[3] This view we hold to be a perfectly sound one, and it is an answer to Captain von Doppelmair's depreciation of the English projectiles on the ground that they break up into a greater number of pieces than the Prussian shells,[4] since these pieces are effective, and serve as so much mitraille among the crew. It is worth while also to point out, in passing, that it is only externally jagged holes—not those which are *internally* jagged—which are difficult to plug, and therefore especially damaging to ships. Externally, the hole produced by the English shell is of the same character as that produced by the Prussian shell.[5]

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[1] Doppelmair, p. 30.

[2] Ibid.

[3] "Pall Mall Gazette," November 6, 1867.

[4] Doppelmair, pp. 30, 62.

[5] We notice, in passing, an apparent contradiction in Captain von Doppelmair's narrative. At

We now reach an important point in the narrative of the Tegel trials. Hitherto, as we have seen, the Prussian gun had proved itself at first inferior to the English gun, and afterwards—when the charge of powder had been largely increased, the projectiles altered, and the initial velocity improved—it had succeeded in equalling the performances of the English gun, but not in surpassing them. And this equality had been obtained at the cost of an expenditure of ballistic power on the part of the breech-loaders, which, as has been explained, left the substantial advantage with the English system.

It was now determined to try the two systems with live shells. But before doing this, the Prussians satisfied themselves, by actual trial against the 8-inch target, that the "large capacity" Palliser shell—*i.e.* a shell containing a bursting charge of 5¾ lbs. instead of 2½ lbs., and having therefore thinner walls—was less effective than the "small capacity" Palliser against a strong target. That this was so, hardly needed an experiment to prove. The large capacity shells were intended to develope high explosive effects when the target was well within the power of the gun. The inferior penetrative power of the large capacity shell had been expressly declared upon the ground by the representatives of the English gun, and the small capacity shell had been expressly prescribed for maximum penetrative effects. It is worth while also to notice that the Prussians themselves fully recognised the value of thick walls for high penetrative effects; because we find presently that when a Krupp steel shell failed, the failure was ascribed to the "thinness of wall consequent on their large chamber for bursting charge,"[1] and Captain von Doppelmair is careful to tell us that this is "not in disfavour of steel for projectiles, but of the construction of this particular shell."[2] That therefore the large capacity Palliser shell should fail when it struck a strong place on the 8-inch target, was only what might have been anticipated; and yet this shell actually, as Captain von Doppelmair admits, did "about the same"[3] as the only round from the Krupp with which it could be compared. This performance is very instructive; because not merely had the Krupp projectile, according to Captain von Doppelmair, a striking momentum of 117 as against 100 for the Palliser shell,[4] but it was a *small capacity* Gruson shell; nay, more, it was a 336 lb. Gruson shell, which had a chamber only large enough to contain as much powder (2¼ lbs.) as a small capacity 250 lb. Palliser.[5] It was, therefore, or should have been, a stronger shell than an English small capacity shell; the comparison is still more in its favour when made, as in this case, with a large capacity English shell adapted for carrying 5 lbs. of powder. And yet the two shells did about the same. Captain von Doppelmair is only able to account for this result by throwing the blame on

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p. 3 he states that "the Krupp steel shells with hardened point and thin lead jacket were excellent." At. p. 32 he says "Both the Krupp steel shells were set up on penetrating into the target." At p. 31 he speaks of the great accuracy of the steel shells with thin lead jacket. At p. 33 he speaks of the inferior accuracy of these shells.

[1] Doppelmair, p. 63.

[2] Ibid. p. 47.

[3] Ibid. p. 34.

[4] Ibid.

[5] Indeed the Prussian shell contained a rather less charge than the small capacity Palliser—viz. 2·420 lbs. against 2·464 lbs.—Doppelmair, p. 35.

the lead jacket. He observes, "The proportion between these two numbers[1] is as 1 to 1·17. These numbers are in contradiction to the results of the trial, which showed that the effect of both guns is about the same. This trial serves thus as a further proof that the momentum of the lead jacket is almost entirely lost as regards the effect desired from the projectile,"[2]—a conclusion, as we have before pointed out, exceedingly unfavourable to the Krupp system, as imposing the necessity for an excess of ballistic power to produce penetrative effects equal to those obtainable with the muzzle-loader.

The comparison obtained in this trial of August 4, if it added nothing to the reputation of the Krupp gun, but rather further marked its inherent inferiority, had for the Prussians one useful result. It showed that the power of the English gun might be minimised against a strong target by using large capacity shells; and this piece of practical information determined the course of the subsequent experiments. We have seen already how the Prussians had opposed themselves to any attempts to increase the power of the English gun by using large charges of other powder, or by other means, such as had been adopted for the Krupp gun. But when it became a question of reducing the power of the English gun, by using against a strong target a shell specially designed for use only against weak targets—a shell designed not for producing great penetrative but great explosive effects—then all hesitation about breaking the rule disappeared. There was no longer a question of strictly adhering to one pattern of English shell.

But, as we shall see, the selection of a large capacity English shell for use on this occasion, in competition with *small* capacity German shells, was not the most remarkable incident of the trials of August 4. The experiments were made against the 7-inch target, at 782 yds. range. Seven rounds were fired in all—viz. five from Krupp, consisting of two Gruson chilled and three Krupp steel shells; two from the Woolwich gun. Three out of the seven rounds were thrown out of the comparison. One of these,[3] a Gruson, struck the wood at the bottom of the target; one Krupp shell[4] struck on the top of an old live shell which was sticking in the target, and exploded it; and one Krupp[5] grazed the edge of a plate and carried it away. Mr. Krupp, we observe, takes credit for both the two latter shells as "through."[6] Captain von Doppelmair most properly throws out these rounds. This leaves us with the four following effective rounds :[7]—

Round 1. There is very conflicting evidence about this round—a Gruson shell. Captain von Doppelmair says that it "made a clean hole right through the target."[8] Krupp's pamphlet does not give it as "through," but states that it stuck in the wood backing, where it exploded—"explosive effect principally in the direction of gun."[9] The "Times" correspondent says the shell "burst backwards in the backing."[10] It seems clear, therefore, that the shell did not act as perfectly as readers of Captain von Doppelmair's pamphlet might be led to suppose.

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[1] About 2·34 mètre-tons per square centimètre of the cross section of the Palliser, and about 2·75 mètre-tons per square centimètre of the Gruson.—Doppelmair, p. 34.

[2] Ibid.

[3] Round 1 in Krupp's pamphlet.

[4] Round 4 in Krupp's pamphlet.

[5] Round 3 in Krupp's pamphlet.

[6] Krupp, Table X.

[7] No. 2 in Krupp's pamphlet.

[8] Doppelmair, p. 35.

[9] Krupp, Table X.

[10] "Times," January 23, 1869.

Round 2.[1] This was an English shell, and a small capacity shell, but it was one which ought not to have been fired. It was made of pure Redsdale iron. Experiments in England had shown that iron to be unsuited for penetrative purposes; and the shell had been, at the request of the representative of the English gun, withdrawn from competition.[2] The shell was painted brown to distinguish it from others; and on account of its having been withdrawn from the penetration trials, it had been ordered by the Prussian Artillery Committee not to be used at all, even for the endurance trials. The firing of this shell was in flat disobedience of this order. It occurred "during the absence of Armstrong's agent from his gun, and it was only on picking up the pieces that the mistake was discovered."[3] The shell, as it happened, produced very much the same effect as the Gruson shell in Round 1. That is to say, it penetrated the plate, lodged in the wood backing, and burst backwards.[4] The circumstances under which this shell was fired gave rise to a good deal of discussion and angry feeling at the time, for which what we have stated of those circumstances affords sufficient justification. It was impossible for anyone in Captain von Doppelmair's position, and with his knowledge of these trials, to be ignorant of all this. And we may therefore fairly ask, why does Captain von Doppelmair omit all mention of the fact that this shell was experimental—that it had been improperly fired? And a further justification is needed of his misleading statement, that the shell was a "small capacity Palliser shell," when it was, as we have seen, not a Palliser shell at all. It is with regret that we observe the grave error which was committed at Tegel, reproduced and apparently sanctioned, in a pamphlet which professes to give an accurate account of those trials. We are afraid, however, that it must be admitted that Captain von Doppelmair's narrative has by this time reached a point at which there is no longer any pretence of impartial criticism. The neutral tints which appeared to prevail for a few pages, soon brightened into the warm colouring of the partisan; and, pressed on all sides by the difficulties which necessarily attended an attempt to evolve conclusions unfavourable to the English gun and favourable to the Krupp out of the Tegel trials, Captain von Doppelmair seems, even before this crucial experiment (as the Prussians chose to consider it) of August 4, to have abandoned in despair the impossible task of keeping up his self-imposed *rôle* of a candid critic, and to have found it necessary, if he would cut his way at all through the difficulties which lay between him and his desired conclusions, to throw off every encumbrance, and to rely upon the ignorance or carelessness of his readers for effecting his escape from a false and inconvenient position.

Passing to Round 3,[5] we find a Palliser "large capacity" shell—which, as has been explained, was not the proper shell to use for this purpose—getting through the plate and into the backing, where it exploded without producing any very great destructive effect.[6]

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[1] Round 6 in Krupp's pamphlet.

[2] The shell had been sent to Berlin confessedly as experimental, pending the result of some trials at Shoeburyness. Those trials showed that shells of this iron were too brittle, and it had therefore been at once formally withdrawn from trial.

[3] "Times," January 23, 1869.

[4] Doppelmair, p. 35.

[5] No. 7 in Krupp's pamphlet.

[6] No. 5. in Krupp's pamphlet.

Round 4 was a Krupp steel shell from the Prussian gun, which did good execution. It penetrated the plate, exploded in the backing, and blew a hole clean through the target. This, without doubt, was the best result obtained on this occasion. At last—when, by the adoption of frequent alterations and improvements in the Prussian gun; when, by the use of 53 lbs. instead of 43 lbs. of powder, of an improved construction of projectiles, and of steel shell, the effective penetrative power of that gun had been brought up to its maximum, while the effective penetrative power of the English gun had, by the use of improper shell, been brought down to a minimum—the former weapon was able to snatch a victory; the only victory which it had scored throughout the trials, and not substantially a victory at all, if we take into account the disparity in the two guns, and in the conditions under which they had been fired. "The case stood thus," says the "Times" correspondent:—"The Gruson chilled shell from the Krupp gun penetrated the plate and burst backwards. Both the Armstrong chilled shell of the wrong pattern did the same. One shell only of the three steel ones struck a sound place. It passed through the target with good effect. This was the first success (so called) of the Prussian system."[1] This was the point at which the Prussian Artillery Committee determined to make their report. The representatives of the English gun pressed, over and over again, for a trial of proper English shells (*i.e.* small capacity Palliser) before any decision was come to. They reminded the Committee that it had been proved in England—not by one or two rounds, but by a long series of experiments—that the bursting charge does not diminish, but rather increases the penetrative power of Palliser shell;[2] they appealed to the results of the trial on June 2 to show that the English gun with empty small capacity shell was capable of penetrating the 8-inch target, and that it followed that the same shell if fired loaded against the 7-inch target, were not likely to fail. Equally cogent were the arguments that the Gruson shell of proper and latest pattern had failed to penetrate both the 8-inch and 7-inch targets; that in England live Palliser 9-inch shell had pierced the 8-inch target at Shoeburyness,[3] and that the failure to penetrate the 7-inch target at Tegel could therefore only have been due to the shell being, as it had been expressly declared to be, too weak. Finally, no argument was needed to show that—considering the previous performances of the Woolwich gun, the advantages which the Krupp gun had enjoyed in the matter of alterations of charges, shell, &c., and the fact that this was the first occasion on which the Prussian gun had succeeded in even slightly passing the English gun, notwithstanding its two tons greater weight, its greater weight of projectile, its greater charge, and its resulting greater ballistic power—it was manifestly improper to bring the contest summarily to a conclusion, and to render a report at this particular stage. But it appears that the Prussian Artillery

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[1] "Times," January 23, 1869.

[2] See "Extracts of Report and Proceedings of O.S.C.," Vol. V. p. 44. "The results of this practice appear to warrant the following practical conclusions:—1. That the bursting charge in a Palliser shell evidently assists the penetration to a certain extent. . . ." And again, Ibid. Vol. V. p. 47:—"The bursting charge in the Palliser shell assists penetration;" so much so, indeed, that we find the Ordnance Select Committee recommending an increase of the bursting charge.

[3] See, *inter alia*, Round 1248. "Extracts of O.S.C.," Vol. IV. p. 374.

Committee considered that the report could be no longer delayed. Political reasons required that an order for the guns for the Prussian iron-clads should be given out. The small capacity shells, it was stated, would be fired hereafter, but a report must now be made.

We do not know whether it will occasion surprise or not when we state that the report was favourable to the Krupp guns. But so it was.

In passing, we would here remark that Captain von Doppelmair's conclusion—derived from the result, be it remarked, of two rounds with shell of improper construction—that "loaded Palliser chilled shell on striking armour plates explode comparatively early," is not in accordance with the results of the extensive trials which have been made in this country, and is another example of the danger of jumping at foregone conclusions on insufficient evidence. Further, Captain von Doppelmair ought to be aware that it is possible to retard the explosion by various special dispositions of the bursting charge; and this objection, if it existed, could not be regarded as a permanent or important one. As a matter of fact, however, it does not exist.[1]

No less than four months were allowed to elapse before the practice against plates was resumed. On November 28, however, the desired trial of small capacity live Palliser shell against the 7-inch target took place. The result was remarkable enough. Captain von Doppelmair, however, omits to record it; just as he omits all reference to the rendering of the report at a time when the trials were incomplete. He merely refers to the trial in general terms, and sums up with the conclusion that "the new Palliser chilled English shell were not better than the previous ones."[2]

Let us see what really happened. The account given by the "Times" correspondent, and which we have verified from other sources, is as follows:—"Then came the long-hoped-for Palliser live shell at the 7-inch target; range the same as in the old experiments. Two rounds were fired. The first struck near the left lower corner of the target and went completely through, bursting as it passed through the backing; the point of the projectile struck 1 ft. from the left of the plate, and 8 ins. from the bottom. The corner was torn off, and a ragged blackened hole would have been made through the ship. The second hit fairly on a very sound spot on the middle 7-inch plate 14½ ins. from the top, and 4 ft. from the left; it penetrated

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[1] It is worth while here to call attention to the fact, that when the Krupp steel shells are found not to explode quite quickly enough—sometimes not at all—Captain von Doppelmair has a specific ready at hand, and promptly proposes to insure and accelerate the explosion by only partially filling the shell, or by roughening the interior.—Doppelmair, p. 36. The suggestion is well meant, no doubt, and the effect of its adoption would be so far successful that explosion would certainly take place. But the explosion would be even more rapid than that complained of in the Palliser shell—since a shell partially filled with powder, or roughened internally, would in a large majority of cases explode in the gun.

[2] Doppelmair, p. 49. But we have not merely an omission, but a contradiction; for while we get this confident condemnation of the new (*i.e.* small capacity) Palliser shell, we get, almost in the same paragraph, the statement that "unfortunately this trial did not give quite decisive answers . . . as all the targets . . . were already so far injured by previous experiments that all the projectiles struck on damaged parts of the shield" (p. 49). Nevertheless we are told, on the evidence of this trial, that the new English shells were as bad as the old. We are further told, that the new Gruson projectiles fired on the occasion gave unsatisfactory results, but "this result does not, however, speak against the new projectiles."

the plate, and exploded on its way through the backing. The plate was split right across, far from any previous holes; a piece 4 ft. 4½ ins. by 3 ft. 3 ins. was torn off and thrown down. Much force was necessarily expended in performing the work, yet there was enough left in the shell to blow in the backing and inner skin, so that a terrible wound would have been inflicted in the side of a ship carrying this armour. Thus, both the Palliser shells from the English gun made holes through the target—a feat which the Krupp gun had failed to perform with chilled shell, and only once with the costly steel shell."[1]

In other words, directly the English gun was fired with the projectile designed for use against strong targets, it not only equalled but surpassed its rival—notwithstanding the advantages, already more than once enumerated, which that rival enjoyed.

This is the experiment of which Captain von Doppelmair thinks it proper to omit all details. It is upon this experiment that he asserts that the small capacity shell were no better than the others. It is with this experiment before him that he ventures still to maintain the superiority of the Krupp system.

III.

Comparative Accuracy of the Woolwich and Krupp Guns.

The Tegel trials, then, if they established anything, plainly established the necessity for the possession of a large margin of power on the part of Krupp's guns to produce penetrative effects comparable with those obtained with English guns. Captain von Doppelmair, having out of such unpromising materials attempted to frame a conclusion favourable to the Krupp guns, proceeds to deal with other points upon which these experiments appeared to him to throw some light.

On the question of accuracy, he observes:—"The superior accuracy of breech-loading guns, firing projectiles with a coating of soft metal, is incontestable. The reason for this is the A B C of artillery service."[2] And he proceeds to give certain figures which show a superiority on the part of the Krupp guns. We have here, therefore, at once an axiom and its application.

With regard to the comparative accuracy of the two guns which were tried at Tegel, we believe the facts to be as follows:—During the 300 rounds of chilled projectiles which were fired at Tegel, on only two occasions was

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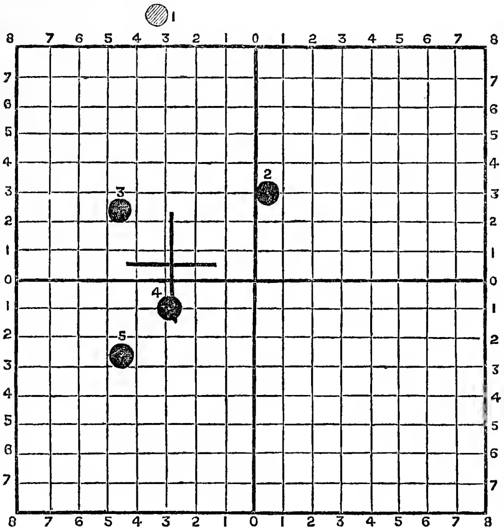
[1] "Times," January 23, 1869.

[2] Doppelmair, p. 57.

the accuracy of the guns compared with any degree of care. The results of this practice are shewn by the annexed diagrams.

Fig. 1.—Range 1200 paces.

Woolwich gun. Palliser shell, filled with sand.



No. 1 round fired with 50′ too much elevation.

Fig. 2.—Range 1200 paces.
Krupp gun. Gruson chilled shot.

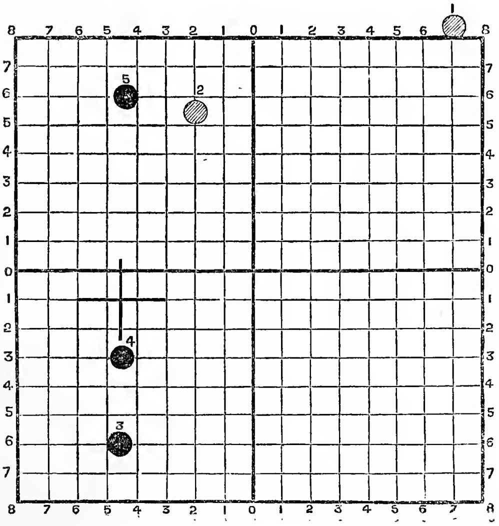
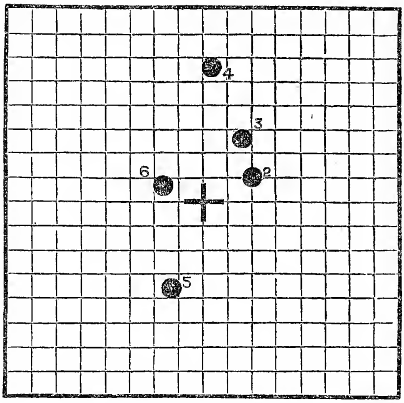


Fig. 3.—Range 1200 paces.

Woolwich gun. Chilled shell.



No. 1 round fired for elevation.

Fig. 4.—Range 1200 paces.

Krupp Gun. Chilled shell.

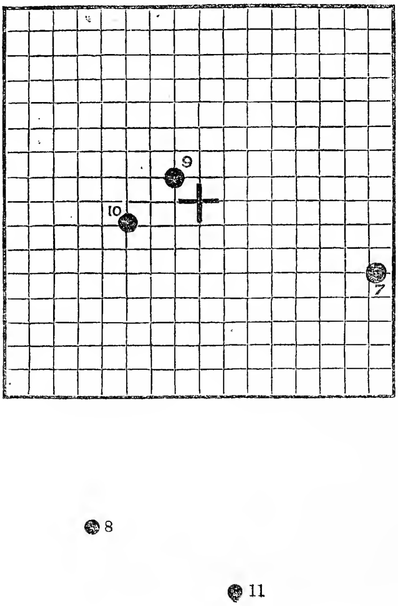


Fig. 5.—Range 1200 paces.

Woolwich gun. Chilled shell.

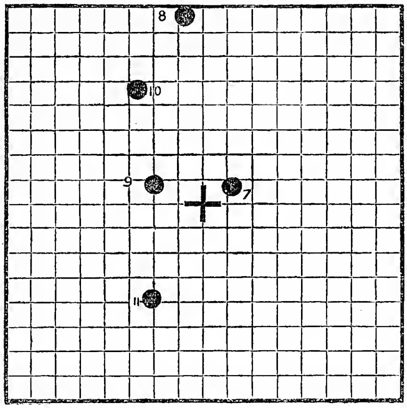
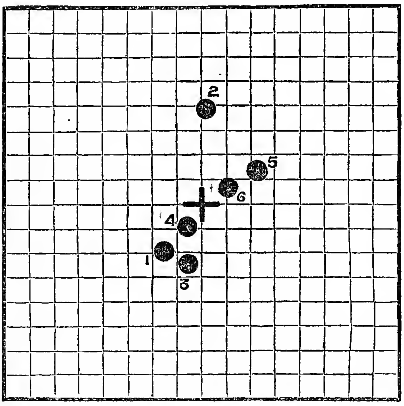


Fig. 6.—Range 1200 paces.

Krupp gun. Steel shell.



It will be observed that in the first instance the practice was in favour of the Woolwich gun. This advantage was attributed by the Prussian Artillery Committee to the use of an inferior powder in the Krupp gun. On the second occasion, the advantage was in favour of the Krupp gun firing steel shell—to an extent, however, which is inconsiderable, but which it is not difficult to explain. It may have been due, for example, in a great degree, to the more accurate make and homogeneity of the carefully tooled steel shell, as compared with the relatively rude cast-iron chilled projectiles; and it may probably in part be accounted for by the greater uniformity of the prismatic powder—a uniformity which Captain von Doppelmair admits, upon which indeed he insists,[1] but on account of which he makes no allowance for the English gun.[2] Here, once again, we find ourselves face to face with the convenient fallacy upon which we have before remarked, that the English gun could not fire prismatic powder, and therefore could not improve its accuracy by this means.

But, independently of this, attention must be called to this attempt to solve the question of accuracy by such a limited trial—a trial which, when compared with the vastly more extensive experiments which have taken place in England on this particular point, is ridiculously insignificant. From these very limited Tegel trials, we appeal confidently to the accumulated results of an extended series of carefully conducted and scrupulously scientific experiments in this country, in proof of the fact that the English guns, when skilfully handled, are capable of an accuracy of fire which leaves nothing to be desired. The following table gives, in a concise form, the results of practice with 7″, 8″, and 9″ Woolwich guns by the late Ordnance Select Committee, who reported, when presenting these tables in 1867, that "the practice of these guns is quite unexampled. It has never, within the Committee's experience, been exceeded by that of guns on any other system of rifling whatever."[3]

This practice therefore surpassed in accuracy not merely all known practice at that date (1867) with muzzle-loading guns, but it also surpassed all practice with breech-loading guns, field and heavy, "on any system of rifling whatever."

Calibre of gun.	Nature of projectile.	Mean range.	Mean difference of range.	Mean reduced deflection.	Remarks.
		yds.	yds.	yds.	
7-inch ……	Common shell	756	13·5	0·3	In each case the figures are the means of ten rounds with R.L.G. powder.
〃	〃	3880	31·4	2·2	
〃	Palliser shell	1129	12·0	0·3	
〃	〃	2240	12·2	0·8	
8-inch ……	Common shell	751	11·3	0·4	
〃	〃	1123	10·7	0·5	
〃	〃	2258	25·7	0·6	
〃	〃	3716	25·8	2·0	
9-inch ……	〃	731	14·7	0·3	
〃	〃	4056	31·1	2·1	
〃	Palliser shot	1110	11·0	0·3	
〃	〃	2326	10·1	0·8	

With regard to the broad question of the "incontestable" superiority of breech-loading to muzzle-loading guns, it is difficult to know how within the limits of courteous discussion to reply to an artillerist who gravely

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[1] Doppelmair, pp. 22, 23.

[2] See text above, where it is stated that the want of accuracy of the Krupp gun was attributed by the Prussian Committee to the inferiority of the powder. If the use of a superior powder made the Krupp gun shoot better, it is reasonable to assume that the English gun would have been benefited to the same extent if it had enjoyed the same advantage.

[3] "Report of Ordnance Select Committee," No. 4443, January 9, 1867. See Parliamentary Papers, "Army Whitworth Guns," June 6, 1867. It may be noticed, in passing, that the Committee show that these results were vastly superior to those obtained with the Whitworth guns, about the accuracy of which much has been said.

advances a statement of this character at the present time. This fallacy, which rests upon purely theoretical considerations, and which can be maintained only by deliberately ignoring the published results of actual practice, has long since been exploded in England; and in England we may at least claim to speak authoritatively on this point, having had an experience of both the breech and muzzle-loading systems unequalled for variety and extent by that of any other country. The remarkable accuracy of the breech-loading Armstrong guns has not been disputed, and yet we find that whenever these breech-loaders have been carefully compared for accuracy with muzzle-loaders, the result has invariably been favourable to the latter. Thus, both the reports of the Armstrong and Whitworth Committee of 1865 show that the superiority in point of accuracy and uniformity of range rested with the muzzle-loading Armstrong shunt and Whitworth guns, as compared with the breech-loading Armstrong guns.[1] The following passages bear upon this point:—12-pr. Report: "The advantage of the Whitworth gun in respect of accuracy with solid shot, as compared with the breech-loading Armstrong gun, is very marked throughout. . . . The muzzle-loading Armstrong gun has a marked superiority over the breech-loading Armstrong gun."[2] "All the three guns may be considered as practically equal as regards accuracy with segment or shrapnel shell."[3] 70-pr. Report: "Up to a range of about 1700 yds., the accuracy of the muzzle-loading Armstrong is superior to that of the other two guns. . . . At a range of about 3500 yds. . . . the accuracy of the breech-loading Armstrong is decidedly inferior to that of both the muzzle-loading guns. At ranges greater than about 3500 yds., the Whitworth gun exhibits a decided superiority over the muzzle-loading Armstrong gun, and this latter a very marked superiority over the breech-loading Armstrong."[4] "Up to a range of about 1600 yds. the breech-loading gun exhibits (with shrapnel and segment shell) a decided superiority over the muzzle-loading guns, which, however, it soon loses, as at 1900 yds., and at all higher ranges, it is far inferior to them both."[5] The probable relative accuracy of the three systems, irrespective of the projectile, is stated by the Committee to be as follows:—"Up to a range of about 1500 yds. the accuracy of the breech-loading Armstrong and the Whitworth guns may be considered as equal, and up to that range the accuracy of the muzzle-loading Armstrong gun is superior to both. At greater ranges than 1500 yds. the accuracy of the breech-loading gun is inferior to that of both the muzzle-loaders."[6]

More recently a comparison has been made between the bronze 9-pr. muzzle-loading gun, recently adopted for India on the recommendation of General Wilmot's Committee, and the breech-loading Armstrong 9-pr. and 12-pr. guns, which has shewn that the breech-loaders have no advantage whatever in point of range, and that they are at a decided disadvantage in respect of flatness of trajectory.[7]

Finally, the 9-pr. muzzle-loading gun above mentioned has given the following results when fired for accuracy:—[8]

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[1] This Committee fired over 1800 rounds to test accuracy.

[2] "Armstrong and Whitworth Report," p. 23.

[3] Ibid. p. 24.

[4] Ibid. p. 57.

[5] Ibid. p. 58.

[6] Ibid. p. 58.

[7] Captain W. H. Noble, R.A., has recently made a full report on this subject to the War Office.

[8] "Report of Special Committee on Field Artillery Equipment for India," p. 22, Appendix.

Date of practice.	No. of rounds.	Charge.	Projectile.	Elevation.	Mean range.	Mean difference of range.	Mean reduced deflection.
		lb. oz.			yds.	yds.	yds.
Jan. 13, 1870	10	1 12	Common shell, plugged	2°	1176	14·2	0·5
Jan. 13, 1870	10	1 12	"	3°	1552	17·1	0·8
Jan. 17, 1870	10	1 12	"	7°	2665	18·9	0·8
Jan. 18, 1870	10	1 12	"	15½°	4221	25·0	3·0

It is unnecessary, in view of the figures which we have quoted, to consider the theoretical side of the question of the assumed superior accuracy of breech-loaders. The question is essentially a practical one; and practically, as we have seen, not only does the advantage remain with the muzzle-loaders, heavy and light, but the accuracy of which good guns of this class have proved themselves capable—even with a powder of admitted comparative irregularity of combustion—is all that the artilleryman could possibly desire; nor is it possible to conceive any real practical advantage resulting from the introduction of a weapon capable of greater precision and uniformity of fire than the English muzzle-loading guns.

IV.

Comparative Rapidity of Fire and Facility of Manipulation of Woolwich and Krupp Guns.

Captain von Doppelmair's mode of dealing with the question of the relative rapidity of fire of the Woolwich muzzle-loading and the Krupp breech-loading guns, is in principle similar to the system which he has adopted in dealing with the question of accuracy. He dissolves his facts in theories.

His theory in this case is, that no comparative trial between the two systems was possible, because the carriages employed were different.[1] The facts which he has to get rid of are, that at Tegel the English muzzle-loader largely surpassed the German breech-loader in rapidity of fire. Having bridged over this difficulty, Captain von Doppelmair proceeds to construct another theory, which he employs as a sort of *tête de pont*. He enumerates the operations required for the two guns, omitting, however, one or two which form part of the manipulation of the breech-loader; he complacently accepts the dressing of the lead-coated projectile with tallow or with wax dissolved in benzine as a serviceable condition; he makes every

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[1] Doppelmair, p. 59.

operation with the breech-loader simple and easy, and with the muzzle-loader long and heavy; he begs the whole question by informing us that the loading of the Prussian gun is "much more convenient;" and he is thus finally "led to assume" that the Prussian gun can be more rapidly and conveniently loaded than the English gun, and with less danger to the gunners.[1] By this means he easily arrives at the conclusion that a gun, which actually proved itself in open competition more rapid in manipulation than its rival, is slower, more difficult, and more dangerous to load. If Captain von Doppelmair's conclusions could be depended upon, it would follow apparently that a 14½-ton gun is generally easier to handle than one of 12½ tons. Further, while up to this point the whole English system had been kept rigorously together—dealt with as a whole, and not permitted to be resolved for the purposes of comparison into its elements—we suddenly find that system broken up into different parts. If the English gun proved rapid in manipulation, the merit did not belong to the gun, but to the carriage. It is no longer a question of a complete system, but of a system composed of many elements. If Captain von Doppelmair had adopted this mode of comparison throughout, there would be no reason to complain—only in this case his pamphlet would probably not have been written. But to refuse on one page to recognise any separation of the parts of the system, and to reserve a right of separation when convenient, is plainly inadmissible.

It is a common error, similar to that which assumes an "incontestable" superiority of accuracy for breech-loaders, to assume an incontestable superiority of rapidity for the same class of guns. This theory is put forward indifferently with regard to breech-loaders of all sizes and calibres. It has been well observed on this point, that "it is forgotten that the strength and skill of men are limited, while the size of guns, and consequently the weight and complexity of the breech mechanism, are comparatively unlimited. Men can work small breech-loaders very quickly; mere men cannot work quickly the mechanism of such breech-loaders as the Krupp 1000-pr. With muzzle-loading guns there is no such wide difference between guns of different size, because the labour peculiar to muzzle-loaders—that is, the labour of sponging and ramming, does not increase in anything like the same ratio as the labour peculiar to breech-loaders—that is, the working of the mechanism. Thus, there may be a point where the muzzle-loader will overtake and pass the breech-loader in rapid fire; and the question is wholly practical."[2]

Turning from theory to fact, what do we find? That the rapidity of fire of the English 9-inch muzzle-loading gun was at Tegel nearly three times as great as that of the Krupp 9¼-inch breech-loading gun; that the former gun has been proved at Shoeburyness to be capable of being fired with accuracy at a rate of 5 rounds in 3 minutes 22 seconds; that the 9-pr. muzzle-loading bronze gun has fired 50 rounds in 7 minutes;[3] and that with the 9-inch Woolwich gun the following practice for rapidity and accuracy is officially recorded:—

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[1] Doppelmair, pp. 60, 61.

[2] "Neue Militar Zeitung."

[3] "Report of Special Committee on Field Artillery for India," p. 10.

"Result of ten rounds fired at Shoeburyness for the Inspector-General of Artillery, February 28, 1868, to test the 9-inch Woolwich muzzle-loading gun, fired at a moving target 5 ft. by 5 ft., distant 1000 yds. The detachment consisted of 1 officer and 18 men. Charge, 30 lbs.; common shell, of 250 lbs. Target moving at the rate of 3½ miles an hour. Elevation 2° 4′—

	Fired in		
Round.	Minutes.	Seconds.	
1	0	0	
2	1	17	
3	1	17	struck target.
4	1	8	
5	1	10	

"Target moving at the rate of 6 to 7 miles an hour. Elevation 2°—

	Fired in		
Round.	Minutes.	Seconds.	
1	0	0	
2	1	2	
3	0	45	
4	0	45	struck target.
5	0	30	

"Every one of these rounds would have struck a ship's launch."

With 12-inch 23-ton Woolwich muzzle-loading gun, firing 600 lb. shell and 60 lb. charges, the result was:—

"Time of fire, rounds taken from 'load' to 'ready'—

	Fired in	
Round.	Minutes.	Seconds.
1	1	40
2	1	36
3	1	25
4	1	33
5	1	25

These results contrast remarkably with the following account by a writer in the "Engineer" newspaper, of the time occupied in opening and closing the breech arrangement of a Krupp breech-loading gun:—"On the 31st October, 1867, three men—being those in charge of the gun at Paris[1]—the writer caused to manœuvre the breech-closing arrangements before him. The result of actual trial—the men being requested to do their utmost as to speed—was that it required a few seconds more than *ten minutes* to withdraw the closing arrangements and to get the gun open ready to receive a projectile and cartridge, and instantly to recommence the movements for closing the

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[1] The great 50-ton "Exhibition" Krupp gun is the one here referred to.

breech again, without waiting a moment, and restore all to place. If we add, then, to the above, three or four minutes more for getting into place through the breech cavity the ponderous and thus awkward-to-handle projectile, and the powder cartridge, we shall not be far wrong in saying that four rounds an hour would be about the best practice that could be expected from this gun; and we think we shall not exaggerate in saying that at least double that number might be loaded and fired from the same length and calibre of gun, if muzzle-loading. There are no less than eleven distinct movements and adjustments to be gone through or made merely to open and close the breech, and half as many more, about, to insert the projectile and charge. It, of course, might possibly be urged that the three men who manœuvred the gun on 31st October were not trained gunners; that was possibly so, but they were trained mechanics, and knew all the parts they handled perfectly."[1]

These facts establish that both with heavy and light muzzle-loading guns a rate of fire has been attained equal, if not superior, to the rapidity yet accomplished with breech-loading guns of corresponding calibre. It is evidently safer, in dealing with questions of this sort, to adopt a system precisely the reverse of Captain von Doppelmair's, and to dissolve, if possible, theories in facts.[2]

It is a relief, after so much special pleading, to find Captain von Doppelmair admitting that, as regards the handling of the guns and projectiles and the training of the gunners, "the preference is due to the Woolwich system,"[3] and that "the breech-piece of the breech-loading gun requires careful handling, preservation from rust, strict training of the gunners, and in certain cases consideration and full knowledge of the movable apparatus of the breech-piece. The lead-coated projectiles require to be more carefully dealt with, and, under some circumstances, to be more carefully stowed than shot with bronze studs. On board ship the shot must be well stowed, in order that the lead jacket may not suffer. The more careful training of the gunners, called for by guns on the breech-loading system, will take time, especially in the case of seamen-gunners, who have to be taught their duties

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[1] "Engineer," April 3, 1868.

[2] It is worth while remarking that, having on purely theoretical grounds established that the Krupp gun can be fired more rapidly than the English gun, Captain von Doppelmair proceeds, by way of adjusting his facts to his theories, to state that the difficulties of muzzle-loading have obliged English artillerists to adopt various devices to overcome them. Thus we are told that "costly turntables 'have been introduced' for greater convenience of loading" (p. 61), and that it has been found necessary to place the studs nearer the centre of gravity, and to experiment with a view to the introduction of one row of studs, for the same reason (p. 61). If this were so, the argument could not be admitted as against the system of muzzle-loading, abstractedly. It is no reproach to a system that those who employ it have recourse to various minor alterations with a view to its improvement. Still less is it a reproach when those minor alterations are distinctly advantageous in other ways. In reality, however, the arguments in favour of turntables and the single row of studs rest upon other considerations. The turntables wholly withdraw the men from the enemy's fire, and their use will assuredly not be limited to muzzle-loading guns. The single row of studs has been proposed on grounds quite independent of facility of loading—such as the greater length of shot-chamber which can be left unrifled, and the convenience which may attend the use of projectiles which can be fired in guns having different twists of rifling.

[3] Doppelmair, p. 56.

as seamen besides those appertaining to gunnery."[1] But having made these important admissions, Captain von Doppelmair hastily explains them away. He does not "attach any particular importance" to these points. These defects are "unimportant;" they "exist in the case of all things of improved construction."[2] In other words, Captain von Doppelmair is forced, by the pressure of his own reasoning, to the admission that in his opinion simplicity is a matter of no practical value, and that no particular credit ought to attach on this account to a system which possesses this characteristic in a pre-eminent degree. How far an officer who holds this view is a trustworthy guide in artillery questions, practical artillerymen will best be able to judge.

V.

Comparative Cost of Woolwich and Krupp Guns.

On one point—the relative cost of the Krupp and Woolwich guns—Captain von Doppelmair is silent. Whether he thought that a difference of 100 per cent. in favour of the English gun was, like the greater simplicity of the weapon, a matter of "no particular importance," and therefore not worth mentioning, or whether he found the fact insoluble by any available theory, he has assigned to this point no place in the comparison of the two systems. And yet the question of price is surely one of great importance. Is it nothing that the English gun should have cost only £1500, as against £3450, which was paid for the Krupp? The subject appears to be one of sufficient interest to make it worth while to supply the details which Captain von Doppelmair has omitted to furnish. The following table gives the prices of the heavier Krupp guns and projectiles. We have included in it other particulars, respecting the calibres, &c., of the Krupp guns, which may be useful.

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[1] Doppelmair, pp. 56, 57.

[2] Ibid. p. 57.

Krupp's Cast-steel Guns.

Description of gun.	Gun.							Projectile.				Charge.		Carriage.*	Remarks.
	Diameter of bore.	Total length.		Length of bore.		Weight.	Price delivered at Essen.	Weight.	Ratio of weight of gun to weight of projectile.	Diameter.	Price at Essen, at £4 15s. 6d. per cwt. (each).	Species of powder employed.	Weight.	Price at Essen, at £4 11s. 5d. large orders, at £4 17s. 6d. small orders, per cwt.	
	ins.	ins.	calibres	ins.	calibres	cwt.	£	lbs.		ins.	£ s. d.		lbs.	£ s. d.	
21 $^{c}/_{m}$ Gun say 8¼-inch	8·236	148·425	18·0	124·803	15·2	167	—	209·44	89·5	8·0315	8 18 4	Prismatic powder.	37·48	—	The data upon the initial velocities are the results of experiments at Berlin, at St. Petersburg, and at Krupp's manufactory.
	8·236	164·566	20·0	140·944	17·2	177	—	209·44	95·0	8·0315	8 18 4		37·48	—	
	8·236	185·432	22·5	161·811	19·7	192	2520	209·44	102·5	8·0315	8 18 4		37·48	—	
24 $^{c}/_{m}$ Gun say 9¼-inch	9·267	166·929	18·0	138·976	15·0	276	—	297·62	102·0	9·0551	12 13 4		52·91	—	
	9·267	185·432	20·0	157·480	17·0	290	3120	297·62	109·0	9·0551	12 13 4		52·91	—	
	9·267	205·905	22·2	177·558	19·2	305	3300	297·62	115·0	9·0551	12 13 4		52·91	—	
28 $^{c}/_{m}$ Gun say 11-inch	11·000	198·031	18·0	164·960	15·0	496	5520	496·04	112·0	10·7874	21 2 6		88·18	1079 13 6	
	11·000	205·905	20·0	187·007	17·0	512	5720	496·04	115·5	10·7874	21 2 6		88·18	to	
	11·000	240·157	21·8	207·086	18·8	541	6040	496·04	122·0	10·7874	21 2 6		88·18	1151 10 6	
30·5 $^{c}/_{m}$ Gun say 12-inch	12·008	216·535	18·0	178·739	14·9	659	7400	645·95	114·5	11·8110	27 10 10		114·64	1417 1 0	
	12·008	240·157	20·0	202·362	16·9	670	7600	645·95	118·0	11·8110	27 10 10		114·64	to	
	12·008	263·779	22·0	225·984	18·9	720	8040	645·95	125·0	11·8110	27 10 10		114·64	1511 6 10	
33 $^{c}/_{m}$ Gun say 13-inch	12·992	233·858	18·0	192·125	14·8	851	9520	815·71	117·0	12·7952	34 15 7		143·30	1844 8 5	
	12·992	259·842	20·0	218·110	16·8	881	9840	815·71	121·0	12·7952	34 15 7		143·30	to	
	12·992	285·826	22·0	244·094	18·8	935	10440	815·71	128·0	12·7952	34 15 7		143·30	1967 3 2	

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* The carriages are, as a rule, exact copies, down to the minutest details, of the carriage supplied by Sir William Armstrong for the Tegel experiments.

With regard to the English guns, carriages, and projectiles, the following table gives the trade prices and other particulars of the principal natures of

Woolwich guns, carriages, and projectiles, as supplied at Sir William Armstrong's Works at Elswick.[1]

English Service Wrought-iron "Woolwich" R.M.L. Guns.

Description of gun.	Gun.							Projectile.					Charge.		Carriage.	Remarks.
	Diameter of bore.	Total length.		Length of bore.		Weight.	Price.	Weight.	Ratio of weight of gun to weight of projectile.	Diameter (over body.)	Price (each).		Species of powder employed.	Weight.	Price.	
											Palliser shell.	Palliser shot.				
	ins.	ins.	calibres	ins.	calibres	cwt.	£	lbs.		ins.	£ s. d.	£ s. d.		lbs.	£	
7-inch	7	126	18	111	15·85	130	—	115	126·6	6·92	1 9 6	1 6 6	Pebble powder.	30	350	
	7	141·5	20·2	126	18	140	830	115	136·3							
8-inch	8	136·5	17	118	14·75	180	1140	180	112	7·92	2 6 6	2 5 0		35	450	
9-inch	9	147	16·3	125	13·89	250	1540	250	104·3	8·92	2 13 0	2 11 0		50	550	
10-inch	10	170·75	17	145·5	14·55	360	2125	400	100·8	9·92	4 6 0	4 2 6		70	750	
11-inch * ...	11	171·5	15·59	145	13·18	500	3218	530	105·66	10·92	5 12 0	5 8 0		85	970	
12-inch † ...	12	171·5	14·29	145	12	500	—	600	93·33	11·92	—	—		85	—	
11·6-inch ...	11·6	191·75	16·5	162·5	14	700	4200	700	112	11·52	7 6 0	7 0 0		120	1250	

* These are guns of 25 tons, originally intended for 12-inch, but afterwards ordered to be completed as 11-inch guns.

† This gun is not, in the highest sense, a plate-piercing gun at all—that is to say, it is not designed for producing maximum penetrative effects. It is a powerful shell gun for use on occasions when the defence is well within the power of the attack.

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[1] The prices at which the Woolwich guns, projectiles, &c. are manufactured in the Government factories are of course considerably less than the Elswick prices, which are here quoted; but it has seemed fairer to put trade prices in comparison with trade prices. It should also be noticed that the trade prices are subject to reduction for discount, and according to the extent of the orders given.

Thus the Krupp guns are more costly than the Woolwich by at least 100 per cent., to say nothing of the far greater cost of the projectiles of the former.[1]

VI.

Comparative Endurance of Woolwich and Krupp Guns.

Hitherto, as we have seen, Captain von Doppelmair has contrived so to confuse the issues as to convey a superficial impression that throughout the contest at Tegel not merely did a particular Krupp gun prove superior to a particular English gun, but that the Prussian system of heavy rifled ordnance established on that occasion a complete superiority at all points to the English system of heavy rifled ordnance. Directly the knot which Captain von Doppelmair has so elaborately tied is disentangled, his argument, as we have seen, falls to pieces. In the same way, when we reach the question of the relative endurance of the English and Prussian guns, Captain von Doppelmair, instead of strictly limiting the comparison to the respective merits of steel and coiled wrought-iron as materials for ordnance, and eliminating as far as possible all conditions foreign to the comparison, proceeds to envelop the subject in so much smoke and darkness, that the difficulty of seeing one's way to a clear and just conclusion becomes greater, if possible, than ever. Captain von Doppelmair's attack at this point, partakes of the character and confusion of a midnight sortie. It ought to have been an essentially plain, philosophical discussion. For it may be said that herein resides the fundamental, the permanent, and characteristic difference between the two systems of ordnance, and here, if anywhere, temperate and judicial criticism was desirable.

The test determined upon for the Tegel guns was 600 rounds, with

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[1] The "Times" correspondent, from whose admirable article on the Tegel experiments we have already made one or two extracts, makes the following calculations with regard to the relative cost of the two systems:—"The question of cost is not to be measured by the difference between that of the projectiles actually fired, but between the cost of the whole quantity of ammunition to be provided for all the guns in a battery. We were informed that by using Siemen's furnaces, and otherwise cheapening the manufacture, M. Krupp can make steel projectiles at the cost of one shilling per pound. A 280 lb. shell would, then, cost £14—or, roughly speaking, about £10 more than the Palliser shell. Let us suppose that the Krupp gun is reduced in price to £3000. We know that the Armstrong can be sold at £1300. Let us further suppose only 200 rounds per gun to be provided. We believe the selling price of Palliser 9-inch chilled shell is £4 10s. each. Against the 10s. we will put the cost of the extra powder used in the Krupp gun and shell, and the necessary renewals of the breech-loading apparatus. Then, a battery of ten Prussian guns will cost £17,000 more than ten Armstrongs of 9-inch calibre, and the difference in the cost of shells will be £20,000—or £37,000 altogether in the battery. To leave no margin for possible exaggeration, the difference may be put at £30,000—or £3000 per gun—enough to provide Moncrieff's carriages and the whole of the magazines and building of the fort. If these considerations have no value in the eyes of the Prussian War Office, it must be rich or extravagant beyond anything we can dream of in England."—"Times," January 23, 1869.

battering charges, viz. 43 lbs. of R.L.G. powder, fired from the forward vent of the English gun; 53 lbs. of Russian prismatic powder, fired from the rear vent of the Prussian gun. No artillerist will need to be told that this comparison was absolutely worthless. The difference in the *force brisante* of the two powders is so great, that the trial was no more comparative than would be a trial of two guns with totally different descriptions of detonating compositions. In what exact relation the destructive action, or maximum pressure, of the English powder stands to that of the prismatic powder, it may be difficult to say positively. The Prussians themselves have estimated it, as already stated, at twice as great.[1] This estimate is probably excessive. At all events, it is unreliable, as it was arrived at by means of an instrument—the Rodman pressure-gauge—which recent experiments in England have shewn to be practically worthless for the purpose for which it is intended.[2] The English estimate of the maximum pressures exerted by the two powders, as determined by the chronograph, is as follows:—

	R.L.G. Tons per square in.	Russian prismatic. Tons per square in.
8-inch gun	29	20
10-inch gun	28	19

Whether we accept these figures as absolutely correct or not, it is certain that the *brisante* character of the English powder is vastly greater than that of any other known powder. Indeed, this fact has been most distinctly and emphatically recognised in general terms by nearly every artillerist—among others by a Prussian officer, whose authority Captain von Doppelmair will hardly dispute. Captain Sallback, "Reporter on Artillery Experiments at the Prussian War Office," states that the English powder is so exceedingly racking and destructive ("*si énormément brisante*") that "no gun in the world can resist it during a long number of discharges."[3] The Russian prismatic powder, on the other hand, has recommended itself on account mainly of its mild character—its progressive inflammation—by which the maximum strain on the gun is immensely reduced. To subject guns to a comparative trial of endurance, with powders differing so widely in their destructive effects upon the gun, was therefore manifestly an absurdity. But this was not all. The English gun was saddled with a still heavier burden: while the Krupp was fired with a rear vent, the English gun was fired throughout with a forward vent. No artilleryman will fail to appreciate the importance of this difference. With the forward vent, the maximum pressure exerted by the R.L.G. powder is of course greatly increased, in consequence of the more rapid inflammation of the whole charge. The increase of pressure due to the position of vent, has been estimated by the Committee on Explosives as:—

	Forward vent.	Rear vent.
R.L.G. powder	28	18

More than this, in computing the number of rounds fired at Tegel, it

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[1] See p. 63, note 1.

[2] This instrument has been entirely discarded on this account by the Committee on Explosives.

[3] "Journal des Armes Spéciale." We have already seen what the effect of only a few rounds of the English powder was on the Prussian gun. (See p. 68).

was assumed, on the evidence of the Rodman pressure-gauge, that 43 lbs. of Prussian cannon-powder was equal in its effect upon the gun to 53 lbs. of prismatic powder; and therefore all the rounds fired with charges of 43 lbs. and upwards of Prussian powder, were included in the test for endurance of the Krupp gun.[1] Now, it is quite possible that 43 lbs. of Prussian powder are equal in pressure to 53 lbs. of prismatic, although we are not prepared to accept the indications afforded by the Rodman gauge as trustworthy evidence upon this point; but if it be so, then, as the English powder is admittedly much more destructive than the Prussian, and as the English gun fired throughout 43 lb. charges, it follows, on the evidence of the Prussian instruments and by the arguments of those who conducted the experiments, that the test advisedly adopted for the English gun was much more severe than that adopted for the Krupp gun.

Finally, the endurance test of the Prussian gun was conducted in, to say the least, a most extraordinary manner. Captain von Doppelmair states that, "after 430 rounds, a guttering, 22 millimètres long, appeared at the bottom of the vent. The metal at the bottom of the vent was on this account removed spherically to a depth of 75 millimètres; but as the guttering again appeared after the subsequent 30 rounds, the metal was further removed to a depth of 25 millimètres.[2] At the 176th round, the breech-piece was also damaged, as before described, by a few rounds of English powder fired experimentally,[3] and had to be replaced with one of "somewhat different construction, and a new Broadwell ring."[4] Captain von Doppelmair also states that some further partial failure of the second Broadwell ring occurred after 445 rounds had been fired from it.[5] Further, after 662 rounds, a serious crack, 267 millimètres long, ultimately appeared in the chamber of the gun,[6] which was developed another 90 millimètres by 14 more rounds.[7] "After this," says Captain von Doppelmair, "the trial of endurance, which the gun had hitherto sustained in the most brilliant manner, was discontinued."[8]

The "Times" correspondent gives a somewhat different account of these proceedings. He says:—"If our information be correct, the wedge, or breech-loading apparatus, had to be changed so long ago as September 29. After the firing on that day, a crack was discovered at the base of the old upper vent. Mr. Krupp's workmen were allowed to cut away the surface of the bore, at the seat of the incipient danger. Part of the breech-loading apparatus was again renewed on October 15. After the practice on the same day, the crack appeared again, and was again cut out. On Nov. 19 there was a considerable escape of gas. Before firing on November 21, the whole breech-loading apparatus was renewed, both Broadwell ring and wedge. On December 3, so serious a crack appeared, that the chief advocates of the gun desired that no further experiments should be made with it."[9]

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[1] Doppelmair, p. 53.
[2] Ibid. p. 53.
[3] Ibid pp. 12, 13.
[4] Ibid. p. 54.
[5] Ibid. p. 54.
[6] Ibid. pp. 54, 55.
[7] Ibid. p. 54.
[8] Ibid. p. 54. The gun subsequently endured thirty-six more rounds with no further increase of the crack, and it was then sent back to the factory for repair, pp. 85, 86.
[9] "Times," January 23, 1869.

It is clear, therefore, whether we take the "Times" account or that given by Captain von Doppelmair, that the Krupp gun was very carefully nursed throughout—that whenever any injury appeared which could be remedied or removed, Mr. Krupp's workmen were at hand with their tools. The removal of an incipient crack is to a gun, what the removal of a speck of decay is to an unsound tooth. It is the proverbial "stitch in time;" and the advantage which Krupp's guns derived in an endurance trial from this treatment is incalculable. This cutting out of the crack, twice repeated, meant nothing less than the rescuing of the patient from destruction by the prompt application of the surgeon's knife. The renewal of the breech-loading apparatus speaks for itself. With regard to the final crack in the Krupp gun, Captain von Doppelmair is careful to assure us that it was occasioned by the bursting of a shell in the bore. In his extreme anxiety to save the reputation of Krupp's steel, he is at this point betrayed into an unfortunate argument. He declares that this serious injury—the splitting of the gun so severely as to necessitate the discontinuance of the endurance test—was occasioned by the explosion within it of a single shell;[1] but he has elsewhere, by way of making a point against the English projectiles, informed us that seven shells[2] broke up in the bore of the English gun,[3] but "no damage was thereby occasioned" to the gun.[4] What grounds Captain von Doppelmair has for so confidently asserting that the Prussian gun was injured by a single shell, while the premature bursting of seven shells in the English gun caused no damage, we do not know; but if his statement be correct, we have only to observe that it tells not for but against the Krupp gun. The premature explosion of a shell is an accident which must be expected to occur sometimes on service, and if the Krupp gun is liable to be put *hors de combat* by one accident of this sort, it is *pro tanto* inferior to a gun which can endure seven such premature explosions without injury.

What conclusions, then, may we draw from this test for endurance of the Prussian gun? These: that with a mild powder, a rear vent, careful nursing, the prompt application of tools to any incipient injury, a single Krupp gun can be made, at an extravagant cost, to exhibit a very fair, but by no means extraordinary, endurance. And behind all this is the significant fact, that the weight and dimensions of the Krupp 9¼-inch gun have, since these Tegel trials, been increased from 14½ to 16½ tons.[5] The weights now adopted for the different calibres of Krupp guns are given in the table at p. 93. Why, we may ask, has this increase of weight been made, if the Tegel trials were wholly satisfactory? Mr. Krupp surely would not add two tons of steel for mere caprice.

Let us now turn to the English gun. This weapon fired 43 lb. battering charges of the severe English powder, with a forward vent. At the

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[1] Doppelmair, p. 54.

[2] We say "shells," although Captain von Doppelmair does not expressly state that they were shells; but as he suggests that the friction of the powder against the insides may have caused the failures (p. 66), it is clear that shells are intended.

[3] Doppelmair, p. 66.

[4] Ibid. p. 53.

[5] In a Krupp gun recently supplied to Belgium for experiment, of which the calibre is only 223 millimètres — almost exactly 9 ins. (9·1735 ins.), the weight is 17,000 kilos., or about 17 tons.

203rd round[1] a crack appeared in the steel tube. Was this crack (which Captain von Doppelmair states expressly was small in the beginning and less than that which first appeared in the Krupp),[2] at once cut away, like the crack which twice appeared in the Krupp gun? Not at all. The firing *was continued for another* 78 *rounds with battering charges, and* 30 *rounds with reduced charges,* until the injury had become developed to such an extent that it was impossible to repair it except by the removal of the gun to the factory for re-tubing. Such removal the Prussian authorities refused to sanction. They informed Sir William Armstrong that he might cut out the crack if he could on the ground, as Mr. Krupp had done; but the permission was worthless, because it came too late. It is important to put this matter in a clear light. What had happened, then, was this: a crack appeared in the English gun, which could, like the crack in the Krupp gun, have been readily removed at first, but, after the existence of the injury was well known to the Commission, it was developed by continued firing to an extent beyond the possibility of repair, except with larger mechanical appliances than were available on a practice ground. When a similar crack appeared in the Krupp gun, its removal was at once authorised—a proceeding, as we have seen, which was also successfully repeated on a second occasion. The flaw in the Krupp gun was precisely similar to that in the English gun, and originated, as did that in the latter, at the vent. The treatment of the two guns under these circumstances should have been exactly the same. It was, however, as different as possible. The Krupp gun was promptly and efficiently repaired; the English gun was not repaired at all, but subjected to about 100 more rounds of heavy charges, and with a severe powder, after which repair *on the ground*—the only repair permitted—had become impossible.

But this treatment, although it placed the English gun at a serious and improper disadvantage in the competition, did, in fact, and perhaps contrary to the anticipations of its opponents, establish an important merit of the construction. It showed that even after the steel tube has cracked, the gun might still be fired a considerable number of rounds without danger. Is there anything in the Tegel or any other trial of the Krupp guns which will enable Captain von Doppelmair to affirm the same of those weapons?[3] We may here state, also, that the English gun has since been re-lined and re-proved, and is at this moment in the service of a foreign Government, which, knowing its history, purchased it at the same price as if it had been a new gun.

There is another circumstance about the cracking of the English gun to which, as bearing upon the question at issue, attention must be called, viz. that the part of the gun which failed—the part which behaved, when com-

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[1] Captain von Doppelmair says, at the 138th round a guttering, 20 millimètres long, appeared (pp. 50, 51).

[2] See note above, where the guttering in the English gun is given as 20 millimètres; while at p. 53, the original Krupp crack is stated to have been 25 millimètres.

[3] It is not beside the subject to compare this behaviour with that of the 8-inch Krupp gun which burst explosively, at Tegel, into many pieces (see Doppelmair, pp. 84, 85). Captain von Doppelmair will say that this was a *solid* gun; to which we reply, that the solid guns were originally advocated by Mr. Krupp just as confidently as his hooped guns are now.

pared with the performances of scores of similar guns, abnormally and treacherously, was the steel, and not the wrought-iron. Captain von Doppelmair will easily believe us when we state that no pains had been spared in the selection for this gun of a perfectly sound steel tube of superior quality; and the material exhibited what we may call its characteristic defect—the defect of uncertainty. Whereas the tube ought, according to the evidence of former experiments, to have stood the test, severe as it was, of 600 rounds of battering charges of English powder, with a forward vent, it failed after a comparatively small number of rounds. But surely, as the tube was of steel, this can hardly be used as an argument in favour of that material. The conclusion to be derived from this experience would be not, as Captain von Doppelmair would argue, to make the whole of your gun of steel, but, on the contrary, to employ as little of that treacherous and uncertain material as possible. On the other hand, the wrought-iron portion of the gun acquitted itself well and loyally. With a split steel tube, it resisted about 100 rounds, of which the greater part were with battering charges. In this portion of the gun—the portion which is peculiar to the English system of gun-making—there was no failure whatever.[1]

Such results as these obviously afforded too insecure and insufficient basis on which to attempt to establish the superior resistance of the Krupp to the Woolwich gun; and this consideration presented itself to Captain von Doppelmair with so much force, that he immediately set to work to collect from the highways and byeways of controversy, facts and fictions wherewith to eke out the slender means at his immediate command. With an appearance of great pomp and circumstance, he proceeds to consider the relative durability of the cast-steel and coiled wrought-iron systems of ordnance, and their liability to burst. But Captain von Doppelmair can never travel far without a theory; and the theory which he adopts on this occasion consists of two terms. It is as follows:—With regard to wrought-iron guns, he says, "From the trials of one gun, a conclusion cannot be come to as to all guns of the same description;" as to steel guns, he says, "From the trial of one specimen, a judgment can be formed as to all guns of the same description."[2] It is hardly necessary to observe that this, for a writer who has undertaken

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[1] The gun as a whole, if we except the steel portion, acquitted itself so well, that it is hardly necessary to press into the argument the consideration—notwithstanding that it is an important and legitimate one—that the gun which was tried at Tegel was not of the present service construction, which is believed to afford double the resistance tangentially to the exterior of the tube. If we were so disposed, we might with perfect fairness throw overboard the endurance test of this gun altogether, in the same way as Captain von Doppelmair gets rid of the original (solid) construction of Krupp's guns when it serves his purpose to do so (p. 74), although elsewhere we find him including some of these solid guns among his examples of the successes of Krupp (pp. 72–74). The Woolwich gun tested at Tegel was really no more a representative of the *existing* English service system, than was the Krupp 8-inch solid gun which burst, a representative of Krupp's present service system. But, happily, we are not under the necessity of playing fast and loose with our different types of gun manufacture in this way. The performance of the English gun at Tegel, in firing 100 rounds after its steel interior had failed, was, we repeat, exceedingly good, and will compare advantageously with any result obtained with Krupp's guns—whether solid or hooped—that we are acquainted with.

[2] Doppelmair, p. 69.

to defend steel guns and to disparage wrought-iron guns, is an exceedingly convenient theory. Having got one steel gun to exhibit, under the exceptional circumstances above described, a fair amount of endurance, it is of course important to make the most of this result; and in no way can this be more conveniently done than by laying down as an axiom that "from the trial of one specimen, a judgment can be formed as to all guns of the same description."

The application of this theory must immensely facilitate the introduction of the Krupp guns. Prove one Krupp gun, and you have proved all. There is no occasion for going to the expense and trouble of a number of tests to destruction—which, looking to the enormous cost of Krupp guns, is an advantage. Nurse one steel gun carefully, minimise the strain to which it is exposed by the employment of a mild powder and a rear vent, promptly cut away any incipient injury, renew the breech mechanism whenever it requires it, and if a crack appear which cannot be repaired, explain it, if possible, by the explosion of a shell within the bore; and in this way you may establish not merely the endurance of a single specimen, but of all steel guns of the same description. That is, in fact, the method which Captain von Doppelmair recommends when we have to deal with Krupp guns. Nor is the method peculiar to Captain von Doppelmair, although to him is due the credit of thus bluntly enunciating it. It is the method which, more or less, has governed the introduction of Krupp's system of heavy artillery, and against which we desire strenuously to expostulate. If we seek for the source of that system, we always find ourselves referred back to some one single performance. An 11-inch Krupp gun has done well; therefore all 11-inch Krupp guns must do well. The 9-inch Krupp gun gave satisfaction at Tegel; therefore all 9-inch Krupp guns must give satisfaction. If we enquire in Belgium for their warrant for the purchase of a few heavy Krupp guns, we are referred to the Prussian experience; and the Prussian warrant for the adoption of these guns, if we except a few isolated and partial trials, is the Russian experience; and the Russian experience, to which we always come back, is so remarkable as to be worth relating in some detail.

In 1865, a report was made by a Russian Artillery Commission which had been appointed to inquire into the provision of ordnance for fortresses and naval service.[1] A most important point must be noticed in connection with this report—viz. that a large order for steel ingots, out of which guns were to be carved, had been given to Krupp by the Russian Government before the trials which the Committee were required to conduct had commenced. This circumstance is stated to have been due to the political exigencies of the moment ("the political aspect of the moment called for immediate armament, and did not allow of loss of time,")[2] and Cronstadt had suddenly in 1864 to be placed "in a condition to oppose the attack of an armour-plated squadron."[3]

However unavoidable this order for a material for making guns before its suitability for the purpose had been established, the circumstance can

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[1] A translation of this report will be found in the "Proceedings of the Royal Artillery Institution," Vol. V. pp. 59–73.

[2] "Proceedings of the Royal Artillery Institution," Vol. V. p. 63.

[3] Ibid. Vol. V. p. 64.

hardly fail to have hampered the officers who were called upon to report upon the merits of this class of ordnance. Supposing the guns to fail in the experiments, what was to be done with all these costly steel blocks? The order had been given—an order, like everything else Russian, on a large scale. As a matter of fact the guns did fail, and this is what the Committee did:—When they found that the steel ingots would not stand as rifled guns with heavy charges, they tried them as rifled guns with light charges; and when they failed under these conditions, they tried them as smooth-bores; and when in their smooth-bore state they stood a test, which certainly did not err on the side of severity, the Committee gravely reported "that Krupp's cast-steel cannon are of very great resistance."[1] As, however, they declare in the same breath that "rifled guns possess very important advantages over smooth-bored guns . . . as regards their effect upon armour-plates,"[2] and as the Cronstadt armament was expressly required "to oppose the attack of an armour-plated squadron," this was not a conclusion which could be accepted as final or satisfactory. Even as a *pièce justicatif*, the report was incomplete. So further trials were made, and at last one breech-loading 8½-inch Krupp gun fired 400 rounds of 27½ lbs. of prismatic powder and 200 lb. shot, and 25 rounds of 22 lb. charges of "common" powder; upon which the Committee reported that the 8½-inch breech-loader gun was "perfectly suitable for the armament of coast batteries."[3] In this way the great order to Krupp was sanctioned.

To anticipate a possible objection that this account of the proceedings of the Russian Committee is deficient in detailed information, it may be well to state somewhat more precisely what occurred, observing that the weights given are in Russian pounds, which are 10 per cent. less than ours, and that the charges were of comparatively mild Russian powder.

The Committee selected from the steel gun-blocks ordered to be supplied by Mr. Krupp, eight, with which to experiment. The first block was tried as a 9½-inch muzzle-loading rifled gun. It was fired with 45 lbs. of prismatic powder and 269 lb. shot. It burst badly at the 66th round. No. 2 block was bored out to 8½ ins., and fired with 33 lbs. of powder and 220 lb. shot. This gun burst at the 109th round. That these bursts, notwithstanding the Committee's suggestion that they were perhaps due to the jamming of the projectiles in the bore, were really in the Committee's opinion attributable to the simple fact that the guns were unequal to the strain imposed by these charges,[4] seems to be proved by the circumstance that the next step was to effect a further reduction in the charge and weight of shot.

Nos. 3 and 4 blocks were bored out to 8½ ins., and fired with 27½ lb. charges[5] and 200 lb. shot. After 169 rounds with No. 3, and 240 rounds

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[1] "Proceedings of the Royal Artillery Institution," Vol. V. p. 68.

[2] Ibid. Vol. V. p. 68.

[3] Ibid. Vol. V. p. 72.

[4] "The reasons assigned for the bursting of the guns, seem prompted by a needless desire to save the reputation of Krupp's steel. They evidently burst from over-work, and the misgivings of those unnamed persons who conceived thereupon doubts as to the resistance of large steel guns, cannot be regarded as altogether unreasonable."—Proceedings of the Royal Artillery Institution, Vol. V. p. 60.

[5] One of these guns fired 46 rounds with 33 lb. charges.

with No. 4 gun, it was deemed prudent to discontinue the experiment, on account of the erosion of the bore, "due to the mechanical action of the gas;" and the Committee express their opinion that the service of muzzle-loading steel rifled guns of large calibre "cannot be rated higher than 250 rounds without danger;"[1] this conclusion having been arrived at, be it observed, with an extremely mild powder. By this time half the experimental blocks had been expended, with results which it was impossible to regard as satisfactory. At this point, it appears to have struck the Committee that the endurance of the guns could be more conveniently established if they were smooth-bored merely. Blocks Nos. 5 and 6 were therefore bored out to 8½ and 11 ins. The first fired 1025 rounds of 27½ lb. charges and 80 lb. round shot, the second fired 790 rounds with 44 lb. charges and 198 lb. shot. This test the Committee chose to accept as establishing the "great resistance" of Krupp's steel guns. Two blocks remained; No. 7 was tried as an 8½-inch muzzle-loading rifled gun, with a Parrott cup to stop windage. After 50 rounds the practice was stopped, the results having been unsatisfactory. No. 8 block was tried as an 8½-inch breech-loading gun. After, as has been stated, 400 rounds of 27½ lbs. powder and 200 lb. shot, and 25 rounds of 22 lb. charges, the Committee reported that guns of this description were "perfectly suitable for the armament of coast batteries;" they decided upon the immediate introduction of this class and calibre of gun, and upon converting all the 8½-inch guns already made, and all those which remained to be delivered, into breech-loaders.

This is how the Krupp guns came to be introduced into Russia. Upon this evidence the reputation of that class of ordnance may be said really to rest. How far the foundation is equal to the support of the superstructure which has been imposed upon it, we leave to competent judges to determine.

It might be supposed that Captain von Doppelmair would be embarrassed by the circumstance that the Russian trials, upon which the whole fabric of the reputation of Krupp's heavy ordnance rests, were conducted with solid steel guns—a construction which is now abandoned as admittedly unreliable. It might also be supposed that the circumstance of one or two of these solid guns having in the first instance given results which were deemed satisfactory, while subsequent trials have so far contradicted the earlier experience as to show the necessity for abandoning that construction, scarcely dovetails into the theory that "from the trial of one specimen (of steel guns), a judgment can be formed as to all guns of the same description." But Captain von Doppelmair does not for a moment allow difficulties of this sort to obstruct his progress. Nay, he even boldly takes credit for the performances of these solid guns,[2] and he trusts here, as he has trusted elsewhere, to the carelessness of his readers to overlook this inconsistency, and to overlook also the disastrous failure of a solid 8-inch Krupp gun at Tegel, when he is pressing upon them his theory that from the behaviour of one specimen the behaviour of all steel guns of the same sort may be safely inferred. Captain von Doppelmair conducts his arguments on the turret system of warfare. It is no inconvenience to him to swing round and fire

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[1] "De crainte que si l'on continuait le tir, les projectiles ne produissent une obturation dans l'âme du canon."—Proceedings of the Royal Artillery Institution, Vol. V. p. 67.

[2] Doppelmair, pp. 72–74.

in the opposite direction, leaving his theory for the time to take care of itself as best it may. Thus we find that out of seven Krupp steel guns of large calibre, which is all that he can enumerate in testimony of the endurance of this ordnance,[1] no less than four are of the solid construction —the construction which is admitted to have failed, and which is now abandoned.[2]

This leaves us, on Captain von Doppelmair's own showing, with only three heavy Krupp guns of which the endurance test has been in his opinion markedly satisfactory. One of these was the Tegel gun, and in what manner the endurance of that weapon was established, and how far the gunmakers themselves are satisfied with the performance, we have already seen. The second was another 9¼-inch 14½-ton gun, which fired no charges heavier than 43 lbs. of prismatic powder[3]—a charge which it was proved at Tegel left the gun far behind its lighter and smaller English rival in penetrative effect. The third was the Krupp 11-inch gun, which has fired 400 rounds of heavy charges of prismatic powder.[4] It is therefore easy to understand why Captain von Doppelmair insists so emphatically upon his convenient theory that "from the trial of one specimen, a judgment can be formed as to all guns of the same description." We shall presently consider from another point of view how far this principle may properly be applied to steel guns.

With regard to the English guns, Captain von Doppelmair lays down a totally different axiom, viz. that "from the trial of one gun, a conclusion cannot be come to as to all guns of the same description." With this view we so heartily concur, that we do not care to trouble ourselves with commenting on the unfairness of applying to the English guns a touchstone which is rejected when we are dealing with steel guns.

Taken by itself, then, we have no sort of objection to make to the principle here enunciated, beyond the obvious objection that it is one of universal application, and that it is not open to Captain von Doppelmair to except from its operation the guns which he has made it his business to extol. The principle of basing our confidence in any system of gun, on the trials, not of isolated specimens, but of a large number of guns, and feeling our way by repeated and careful experiments until our confidence is fully and fairly established, is the only sound, the only safe and rational system upon which to proceed. It is to the application of this very principle that we are ever anxious to appeal, for evidence of the superior character of the English guns. It is at this point that we are most distinctly at issue with partisans like Captain von Doppelmair, who desire us to recognise the safety and durability of guns, whether of steel or any other material, upon exceptional trials of a few specimens, and who enunciate the extraordinary theory that the particular class of guns which they advocate needs no extended trials. We shall presently show that steel guns, more than any others, require to be subjected to the test of extended experience, before they

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[1] Doppelmair, pp. 72–74.

[2] "The Prussian artillery are having hoops added to the solid steel guns in stock."—Doppelmair, p. 85.

[3] Doppelmair, p. 73.

[4] Ibid. Also, pamphlet giving result of trial of the 11-inch gun.

can be accepted as satisfactory. But, for the moment, we are concerned with our English weapons, and with observing how far they have satisfied the test which Captain von Doppelmair very properly desires to impose upon them. That officer, it is perhaps hardly necessary to observe, conscientiously believes that the English guns have failed to satisfy such a test. He states this, indeed, in express terms, and labours through several pages to prove it. He assures his readers that "the English artillery can only bring forward two guns" which have stood a satisfactory endurance test;[1] he gives us a table of twelve English guns, which he says have failed;[2] he quotes seven passages from the reports of the Ordnance Select Committee to prove how frequent have been the failures, and how numerous the difficulties with the English guns;[3] and, finally, he condemns the whole English system of gun-making, stating that, "in the English guns there is no scientific arrangement of metal;"[4] that "the scientific arrangement may be there, but it is only accidental;"[5] that "the tension of the wrought-iron in the coils, according to their different diameters, is left entirely undetermined;"[6] that "great accuracy in making the coils is not observed, and no trouble is taken to fulfil any of the requirements of the theory of the resistance of guns;"[7] that the durability of wrought-iron guns depends "on the conscientious and technical knowledge of the individual workman."[8]

It is hardly necessary to inform anyone who knows anything about the subject that, if the case were as Captain von Doppelmair represents it, no defence of the English heavy guns would be possible. If we really had for all these years been blindly groping our way by rule of thumb—making guns on no definite or scientific arrangements, bursting one specimen after another, adopting innumerable and hap-hazard modifications of construction, and in the result producing only two guns of satisfactory endurance—we should deserve not merely all the hard things which Captain von Doppelmair says of us, but many besides, and our heavy artillery would be simply a disgrace to our service. Indeed, assuming, as we are bound to do, that Captain von Doppelmair sincerely believes what he tells us, we must render a tribute to his comparative moderation of language, and esteem it in some sort an honour that he has thought it worth while seriously to discuss an artillery which is in so deplorable a condition.

But let us examine the several statements upon which this lively attack upon our heavy guns rests.

1st. "The English artillery can only bring forward two guns" of any considerable endurance.[9]

We do not remember to have met, in any work on artillery, a statement at once so broad and so inexact as this. Only two English guns which have stood severe endurance tests! If Captain von Doppelmair's information

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[1] Doppelmair, p. 74.
[2] Ibid. p. 69.
[3] Ibid. pp. 75-77.
[4] Ibid. p. 71.
[5] Ibid. p. 71.
[6] Ibid. p. 71.
[7] Ibid. p. 72.
[8] Ibid. p. 69.
[9] Ibid. p. 74. This extraordinary passage is as follows:—"Against these seven Krupp guns of large calibre which have stood the test in the most brilliant manner" (see *ante*, p. 103, where it is shown that four of these were *solid* guns), "the English artillery can only bring forward two guns, one of which, of only 7-inch calibre, cannot strictly be reckoned as belonging to guns of large calibre."

respecting the English artillery on so important a point be so limited and incorrect as would appear from this statement, we cannot be surprised at the opinions which he has formed; we can only be surprised that he has ventured on such data to form an opinion at all. For what are the facts? Without insisting too emphatically on the circumstance that over six thousand guns have been made for the English service on the system which Captain von Doppelmair so strenuously condemns, without a single explosive burst after the guns have been admitted into the service, notwithstanding that they have all been fired with the severe English powder which a Prussian officer declares no gun can resist for many rounds,[1] we would pass at once and confidently to the performances of the heavy rifled guns.

Of these guns, we find that the following had been made and passed into the service up to October 31, 1870:—[2]

13-inch	23 tons	2
12 〃	25 and 23 tons	19
10 〃	18 tons	60
9 〃	12 〃	494
8 〃	9 〃	119
7 〃	7 〃	113
7 〃	6½ 〃	576
		1383

And what have been the results obtained with these weapons? There is, in the first place, the important result which we have already mentioned, that no single instance has occurred of a gun bursting after its admission into the service; and, with regard to the number of rounds which have been fired, while it is of course impossible for us to give the exact endurance of each of the 1383 guns, the following table will furnish a sufficient contradiction of Captain von Doppelmair's statement that only two English heavy rifled guns have exhibited a satisfactory endurance.

Number of Rounds fired by Woolwich Guns of different calibres.

MUZZLE-LOADING GUNS.

Nature of gun.		Nature of gun.	
12-inch	1 gun has fired 262 rounds.	9-inch	1 gun has fired 500 rounds.
	1 〃 〃 200 〃		1 〃 〃 500 〃
11-inch	1 〃 〃 119 〃		1 〃 〃 370 〃
	1[3] 〃 〃 304 〃	8-inch	1 〃 〃 433 〃
10-inch	1 〃 〃 534 〃		1 〃 〃 408 〃
	1 〃 〃 163 〃	7-inch	1 〃 〃 1729 〃
9-inch	1 〃 〃 1107 〃		1 〃 〃 1061 〃
	1 〃 〃 1070 〃		1 〃 〃 1009 〃
	1 〃 〃 1049 〃		1 〃 〃 986 〃
	1 〃 〃 945 〃		1 〃 〃 637 〃
	1 〃 〃 600 〃		1 〃 〃 636 〃
	1 〃 〃 500 〃		

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[1] See *ante*, p. 96.

[2] In addition to these, there have been made 457 64-prs., which are hardly entitled to rank as "*heavy* rifled guns."

[3] A 10$\frac{2}{3}$-inch gun.

7-INCH BREECH-LOADING GUNS.

1 gun has fired 1949 rounds.
1 〃 〃 1457 〃
1 〃 〃 1296 〃
1 〃 〃 1246 〃
1 〃 〃 942 〃
1 〃 〃 918 〃
1 〃 〃 918 〃
1 〃 〃 860 〃
1 〃 〃 836 〃

1 gun has fired 792 rounds.
1 〃 〃 756 〃
1 〃 〃 751 〃
1 〃 〃 700 〃
1 〃 〃 687 〃
1 〃 〃 647 〃
1 〃 〃 636 〃
1 〃 〃 630 〃

It may further be added, that "the experimental firing at Shoeburyness has, in a great measure, consisted of trials of the service guns; and it may give some idea of the extent of these trials to state that more than 50 tons of gunpowder have been expended there annually in this manner."[1] How far the above table bears out or contradicts Captain von Doppelmair's statement about the "two English guns," our readers will be able to judge.

2nd. Captain von Doppelmair gives a table[2] of twelve English guns which have failed. With one exception, these were all experimental guns, tested for the purpose of ascertaining particular points in their respective structures; to say nothing of the fact that, without a single exception, these guns are all of a construction which has long been obsolete, the trials having fulfilled their object.[3]

3rd. We next come to several passages from the Reports of the late Ordnance Select Committee, which Captain von Doppelmair cites to show how numerous have been the failures and difficulties with the Woolwich guns.[4] The only way of dealing satisfactorily with these extracts is to reprint them seriatim, with such comments as suggest themselves.

Extracts from the Reports and Proceedings of the Ordnance Select Committee, Vol. IV.	*Remarks.*
CAPTAIN VON DOPPELMAIR'S PARAPHRASE. "Page 133.—The Committee reports that the 9·22-inch gun, No. 222, rifled on the shunt system, burst on May 19, 1866, after 402 rounds with shot of 100 to 118 kilos. (220·46 lbs. and 260·14 lbs.); of these 402 rounds, 266 were fired with charges	Instead of "assuming" that the steel tube had received damage, the Committee state distinctly that "from the appearance of some fragments of the steel tube, it would appear the latter had given way some rounds before the explosion."[5] Captain von Doppelmair omits also to quote the statement of the Committee that the iron used was "of a quality which has since been discontinued, and as such the gun

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[1] Captain Haig's paper in "Proceedings, R.A. Institution," Vol. VI. p. 468. Fuller details of the trials of the Woolwich guns are given in Captain Stoney's admirable paper on "The Construction of our Heavy Guns."—Proceedings, R.A. Institution, Vol. VI. p. 406.

[2] Doppelmair, p. 69.

[3] Captain von Doppelmair does not hesitate to state, nevertheless, "The material and the mode of manufacture of English guns have not been altered since that time" (p. 69).

[4] Doppelmair, pp. 75–77.

[5] Extracts, Ordnance Select Committee, Vol. IV. p. 134.

of 19·5 kilos. (43·0 lbs.) of rifle large-grained powder, and the rest with smaller charges. The gun was made on the Armstrong system, and had a steel inside tube. The gun burst into forty-two pieces. The Committee assumes that after the first few rounds before the explosion, the inside steel tube had received damage. Nothing is said of the possibility of the shot having got jammed."[1]

can hardly be considered a fair type of the present service gun of 9-inch calibre."[3]

He omits also to quote the statement that "the gun was known to be considerably scored, and had been ordered up for re-tubing; but as there was an urgent programme to be completed, to try the possibility of dispensing with a pivot in mounting 12-ton guns, the Committee directed fifty more rounds to be fired from it before sending it up. It was at the thirteenth of these rounds that it burst."[4]

"Page 136 to 138.—Particulars are here given of the bursting of the 13-inch gun, No. 300, which is included in the table at page 69. The gun burst on March 27, 1866. Of the fifty-two rounds fired from the gun, twenty-four were with charges of 31·8 kilos. (70·10 lbs.), fifteen with charges of 27·2 kilos. (59·96 lbs.), and the rest with smaller charges; the shot, 259 to 304 kilos."[2]

It appears, on reference to the Committee's report, that the charges which Captain von Doppelmair states were all "smaller" than 60 lbs. and 70 lbs., were, on the contrary, every one of them, in excess of 70 lbs., viz. two of 87½ lbs., one of 80 lbs., one of 90 lbs., and nine of 100 lbs.[5]

The Committee also expressly call attention to the "exceptionally large charges"[6] which this gun fired, and there is therefore the less excuse for this inaccuracy in Captain von Doppelmair's statement.

Further, this was wholly an experimental gun—a 13-inch bore in 23 tons of metal, and with an *untempered* steel tube.

Finally, the gun did not "burst" at all. What happened was that the *steel* tube split, and when at least nine more rounds had been fired, the outer tube split also, but not explosively. In fact, the failure of the steel interior was merely succeeded by the non-explosive disintegration of the surrounding wrought-iron mass.[7]

"Page 188.—They here speak of the bursting of the 9-inch gun, No. 287, rifled on the Woolwich system, after 368 rounds, of which 322 were fired with the battering charge of 19·5 kilos. (43·0 lbs.) of rifle large-grained powder, and the remainder with smaller charges.

Instead of 322 rounds with 43 lbs., as stated, the gun had fired 136 rounds with 45 lbs., and 260 lb. shot; and 186 rounds with 44 lbs.; all above the service battery charges.

Captain von Doppelmair omits also to mention that the Superintendent of the Royal Gun Factory knew that

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[1] Doppelmair, p. 75.

[2] Ibid.

[3] Extracts, Ordnance Select Committee, Vol. IV. p. 192.

[4] Ibid. p. 133.

[5] Ibid. p. 35.

[6] Ibid. p. 196.

[7] Ibid. pp. 136, 138.

This gun appears in the table, at page 70, as damaged after 104 rounds. The inside tube had been replaced by a new one of wrought-iron, rifled on the Woolwich system. In this altered state it burst after 368 rounds; but it cannot be discovered from this description whether the previous 104 rounds are included in this number. The inside tube and the coils gave way, but only two parts separated from the actual body of the gun—a part of the trunnion ring and a part of the outer coil."[1]

the coiled iron inner tube was a bad one, and that he reported that "had it not been desirable to see in what manner the gun would give way, he would have proposed to remove the tube after the fiftieth round and replace it."[3] He also thought "the result favourable to Mr. Fraser's mode of construction,"[4] and that it showed "the advantage of iron barrels, which yield gradually in place of suddenly, as is the case with steel."[5]

The failure was, in fact, due solely to an acknowledged defect in the workmanship of the tube.

The 104 rounds which the gun had previously fired as a shunt rifled gun, are *not* included in the 322 rounds which it fired subsequently with a wrought-iron barrel.

"Page 191.—Here mention is made of the bursting of the 9-inch gun, No. 286, of cheap construction. The particulars are not given. As regards bursting, the Committee arrived at the opinion that the cheap construction is probably little inferior to the Armstrong system, and that it has the advantage of the latter, that in case of bursting the number of pieces is considerably less. In order to decide the question of the construction of the guns, and material for the inner tubes, the Committee recommended that four 9-inch guns made on the two systems, and fitted with wrought-iron and steel centre tubes, should be submitted to a trial of endurance."[2]

The particulars which Captain von Doppelmair complains are not given, are in fact given in great detail;[6] and from these particulars it appears that the gun had fired 400 rounds, of which 350 rounds were with charges of 44 and 45 lbs., which gave a total consumption of "no less than 17,124 lbs. of powder, or very nearly 8 tons," and an aggregate weight of projectiles of 43½ tons.[7]

The Committee further observe "that they are not aware of any guns having consumed a quantity of powder and shot comparable with the above in such large charges."[8]

Attention is further specially called by the Committee to the circumstance—which Captain von Doppelmair also omits to notice—that the failure was entirely due to the giving way of the *steel* tube, and that the gun "held together at least fourteen rounds after the tube was split, during part of which the water was seen to pass through the gun when it was sponged"[9]—a circumstance which appeared to the Committee to afford "an indication of very great strength in the material

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[1] Doppelmair, pp. 75, 76.

[2] Extracts, Ordnance Select Committee, Vol. IV. p. 76.

[3] Ibid. p. 190.

[4] Ibid.

[5] Ibid.

[6] Ibid. pp. 75, 76.

[7] Ibid. p. 76.

[8] Ibid.

[9] Ibid.

and in the construction."[1] The Superintendent of the Royal Gun Factory observes also :—"The bursting of this gun is in no way to be attributed to the method of its construction, but simply to the failure of the steel tube."[2]

"Page 192.—In consequence of the repeated bursting of guns of large calibre with ordinary charges, the Committee recommended that, as a precautionary measure, the service number of rounds from the 9-inch guns should be limited to 400, and that of this number not more than 150 should be fired with the battering charge; and that a circular should be issued containing this order. This important acknowledgment by the English Ordnance Select Committee of the unreliable durability of English guns of large calibre, runs as follows, in the language of the original:—'They think, however, that as a matter of precaution, the service of the 9-inch guns should be restricted for the present to 400 rounds, of which no more than 150 should be with the battering charge, and that a circular should be issued to this effect.' "[3]

We have no hesitation in saying that this passage is calculated to produce a wholly incorrect impression of the transaction in question. The facts are as follows:—The Superintendent of the Royal Gun Factory was anxious to establish by testing three guns of each calibre—7-inch, 8-inch, and 9-inch—to destruction, what these guns were capable of standing.[4] The Committee did not think it necessary to incur "the enormous outlay" which this experiment would entail,[5] and they thought that their experience of these guns enabled them to assign *temporarily* a limit to the number of rounds to be fired from the guns, and to draw a line well within the limits of safety, beyond which the practice should not be pushed. The Committee distinctly and pointedly state (but this passage Captain von Doppelmair omits) that "they are satisfied that the guns, as at present constructed, are fully equal to the requirements of the service, and are not exceeded in strength and durability by those of any other known construction or material;"[6] but in the absence of definite data as to the final limits of resistance of these guns —data which could only be obtained by "an enormous outlay," data, moreover, which would gradually accumulate in the natural course of the experiments with these weapons—it was determined, as an extreme precaution,[7] to limit *for the time being*[8] the service of the 9-inch guns to 400 rounds, of which not more than 150 should be with battering charges. It was the intention of the Committee, as their experience of our heavy guns became developed, to advance the limit then imposed on the number of rounds—the line being always kept well within the limits of ascertained safety. This intention has been fully realised. Since 1866 our experience of our guns has vastly increased; and at a meeting of the Heads of the

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[1] Extracts, Ordnance Select Committee, Vol. IV. p. 76.

[2] Ibid. p. 78.

[3] Doppelmair, p. 76.

[4] Extracts, Ordnance Select Committee, Vol. IV. p. 191.

[5] Ibid. p. 192.

[6] Ibid.

[7] "As a measure of precaution."—Extracts, Ordnance Select Committee, Vol. IV. p. 192.

[8] "For the present,"—Ibid. p. 192.

Department, held at Woolwich in the beginning of June 1870, the following rules for the firing of the heavy Woolwich guns were adopted :—

> All service rifled muzzle-loading guns up to 9-inch inclusive, may be fired without restriction as to the number or nature of rounds.
>
> 10-inch guns to be carefully examined in the Royal Gun Factory or by skilled persons after 500 rounds, of which 250 may have been with battering charges. 12-inch guns (of which our experience is at present necessarily small), to be examined in the Royal Gun Factory or by skilled persons after 250 rounds, of which 100 may have been with battering charges.[1]

How far Captain von Doppelmair's account of the circumstances attending the adoption of a limit for the service of the 9-inch guns, and his statement that the adoption of such a limit was "in consequence of the repeated bursting of guns of large calibre with ordinary charges," can be reconciled with the actual facts, our readers will now be able to judge. What was, in fact, a mere precautionary and admittedly temporary measure—the adoption of which affords, indeed, an excellent example of the cautious and prudent manner in which our authorities have felt their way through the *terra incognita* of heavy ordnance—becomes, in Captain von Doppelmair's hands, an incident of the gravest significance, an interposition by the Ordnance Select Committee, to which they had been driven by the "repeated bursting of guns of large calibre."

It is necessary to make two further observations upon this subject. Captain von Doppelmair is probably unable to appreciate the cautious development of a large subject—the philosophical and prudent progress, step by step, the making good each position before occupying it—which has characterised the English treatment of the heavy gun question, and which justifies the impatience with which English artillerists regard alike the laudations of systems of heavy artillery, such as Krupp's, which rest upon no such basis, and the easy theories on the subject, such as that which affirms that "from the trial of one specimen (of steel guns), a judgment can be formed as to all guns of the same description."[2] The second observation which it occurs to us to make, is this:—Why, if Captain von Doppelmair sees an indication of mistrust, and an admission of failure in the circumstance that the service of the English 9-inch guns was temporarily limited to 400 rounds, of which 150 might be with battering charges of 43 lbs. of the severe English powder—why has he nothing to observe on the limitation of the service of the 8½-inch Krupp by a Russian Committee to 250 rounds, the maximum charge being 27½ lbs. of comparatively mild Russian powder?[3]

From our point of view, this precaution on the part of the Russian Committee was a proper and judicious one to take, and one which has been amply justified by subsequent experience. But clearly it is not open to Captain von Doppelmair to make use of the precautionary recommendation of our Artillery Committee as an argument against the English guns, while he ignores the far more stringent and less favourable recommendation of the Russian Artillery Committee with regard to the Krupp guns.

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[1] "List of Changes in Artillery Stores, &c." § 1919.

[2] Doppelmair, p. 69.

[3] "Proceedings, R.A. Institution," Vol. V. pp. 67, 68, §§ 12, 15.

"Page 196.—Here mention is made of the bursting of a 13-inch gun. The number of rounds is not stated, but it is mentioned that the gun was fired with very heavy charges, and that, among others, nine rounds were fired with 45·1 kilos. (99·43 lbs.) of powder."[1]

From this extract, it would appear that another 13-inch gun, besides that referred to in Captain von Doppelmair's second extract, had burst. This, however, is the same gun (No 300)—an experimental 13-inch bore in 23 tons of metal, and with an untempered steel tube. It is the gun about which Captain von Doppelmair had already made the curious blunder of stating that the charges used besides the service charges were all "smaller" than 70 lbs. and 60 lbs.; whereas, in fact, they were all, as we have seen, and as Captain von Doppelmair's own extract now informs us, exceptionally heavy charges—all heavier than 70 lbs., and nine of them of 100 lbs. each.

Captain von Doppelmair, in a note, and in an appendix, gives some particulars of the bursting, in September 1868, of an English 9-inch Woolwich gun.[2]

This failure was due, again, to an original defect in that portion of the gun which is made of the material which Captain von Doppelmair especially favours, viz. steel. The proof of guns is established specially to bring to light any such defects, and to prevent untrustworthy guns from passing into the service.

The proof, therefore, in this instance exactly answered the object for which it was established; and it is not necessarily a reproach to a system when a gun fails at proof.[3] The reproach attaches when a gun fails after proof—after admission into the service. The failure in question proved two things: It afforded a further and striking indication of the capricious character of even the best steel; and it showed that even an English gun, with a split steel tube, would not stand *proof* charges. The result of this experience has been the introduction of a slight modification in the construction, by which the quantity of steel is reduced, the thickness of the steel tubes having been diminished; while the single outer iron coil has been divided into a double coil.[4]

With regard to Captain von Doppelmair's statement that of four 13-inch English guns "three burst,"[5] it will be sufficient to observe that not one of these guns burst. They became unserviceable. The whole of these guns were of an experimental construction, with wrought-iron tubes, or tubes of untempered steel.

4th. Not content with making a number of statements with regard to the English guns more or less specific, but all, as we have seen, more or less inexact, Captain von Doppelmair seeks to strengthen his case by a sort of wholesale condemnation of the English system of gun-building which hardly admits of categorical reply. He states that English guns "are not guns with scientific arrangement of metal; the arrangement may be there, but it

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[1] Doppelmair, p. 76.

[2] Ibid. p. 77 note, and pp. 81–84.

[3] Sir Thomas Blomefield burst no less than 496 cast-iron guns in proof in one year, 1780–81. (See General Lefroy's Catalogue of Museum of Artillery).

[4] "Changes in Artillery Matériel, &c." §§ 1905, 1906.

[5] Doppelmair, p. 74.

is only accidental."[1] "The tension of the wrought-iron in the coils, according to their different diameters, is left entirely undetermined, great accuracy in making the coils is not observed, and no trouble is taken to fulfil any of the requirements of the theory of the resistance of guns;"[2] with more to the same effect,[3] which it would be unprofitable to quote. We are above all things desirous to conduct this controversy with every possible respect for the officer to whom we are replying, and carefully to observe throughout the limits of courteous discussion. It is therefore not open to us to meet these broad assertions with an equally broad and positive denial. And yet nothing can be more certain than that the construction of the Woolwich guns is based upon an intelligible principle, which may or may not appear to Captain von Doppelmair to be a "scientific" one, but which in any case admits of precise definition. The principle is well explained in Captain Stoney's paper on the "Theory of Gun Architecture."[4] "Sir William Armstrong's main principles of gun architecture," says Captain Stoney, "consist essentially:—First: In arranging the fibres of the iron in the several parts so as best to resist the strain to which they are respectively exposed; thus, the walls or sides of the gun are composed of coils with the fibres running round the gun, so as to enable the gun to bear the transverse strain of the discharge without bursting, whilst the breech end is fortified against the longitudinal strain, or tendency to blow the breech out, by a solid forged breech-piece, with the fibre running along the gun. Secondly: In shrinking the successive parts together, so that not only is cohesion throughout the mass ensured, but the tension may be so regulated that the outer coils shall contribute their fair share to the strength of the gun, in accordance with the theory . . . . that a gun should, if possible, be constructed in such a manner that each part of its mass would do its due proportion of work at the instant of firing."[5] Here, at any rate, is a distinct principle at the foundation of the construction of the English guns. Such modifications as have been adopted have been in the direction of a fuller application of that principle, and of the reduction to a minimum of the employment of the material which in practice has proved the most treacherous and the most difficult of control—viz. steel. In short, in the latest designs of English guns, the quantity of steel has been so reduced that, in point of strength, the guns are independent of it under the most trying conditions of service.[6]

To this, as a further reply to Captain von Doppelmair's statement, that the arrangement of the metal of our guns is wholly "accidental," may be added the fact already mentioned—that of 6000 guns made on this construction, not one has burst on service.[7] The "accident" which can produce such satisfactory and uniform results must at least be admitted to be a happy one, and perfectly unobjectionable.

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[1] Doppelmair, p. 71.

[2] Ibid. pp. 71, 72.

[3] Ibid. pp. 68–70.

[4] "Proceedings, R.A. Institution," Vol. VI. p. 335.

[5] Ibid. pp. 336, 337. For fuller details on this subject, the reader is referred to the paper from which these passages are extracted.

[6] See *ante*, p. 112. Also, "Proceedings, R.A. Institution," Vol. VI. p. 411, where the adoption of a steel tube only 2 ins. thick is recorded. Also, "Changes in Artillery Matériel," §§ 1905, 1906. The main reason for the retention of steel, is the superior hardness and surface which it presents for the bore.

[7] See what has been said, *ante*, pp. 106, 107, respecting the endurance of the Woolwich guns.

VII.

General Comparison of Woolwich and Krupp Systems of Heavy Artillery.

Thus far we have been content to parry Captain von Doppelmair's several attacks on our English system of heavy ordnance. We have confined ourselves as much as possible to examining the statements upon which those attacks rest, and to showing that the Tegel trials really furnished no comparison between the Krupp and Woolwich guns, for the reason that the former weapon was much bigger and longer and heavier; that it fired far heavier charges and projectiles, with a large resulting theoretical ballistic superiority; and for the further reason, that in the endurance tests it was not only fired with a far milder powder than its rival, but enjoyed special advantages which the English gun was not permitted to share. We have shown also, we believe, that, despite these disadvantages, the English gun, when fired with proper projectiles, actually surpassed the Prussian gun in penetrative effects; that it exhibited an endurance which was practically—notwithstanding the failure of its treacherous steel tube—more valuable and excellent than that obtained by the skilful nursing of the Krupp gun; that in accuracy of shooting it was not inferior to the Krupp; while in rapidity, simplicity, and economy, it was vastly superior to it. And these conclusions justify, we think, the surprise which we have already expressed at the attempts on the part of foreign critics to derive from the Tegel trials a verdict unfavourable to the English system of heavy ordnance and favourable to the Krupp.

But before quitting the subject, it is desirable to make some general remarks respecting the issue which Captain von Doppelmair and his fellow-critics have raised. That issue is not limited to the disparagement of the English ordnance. On the ruins of our system, it is proposed to erect another system—that of Krupp. The proximate object, no doubt, is the destruction of confidence at home and abroad in English guns. The ultimate object is the adoption at home and abroad of steel breech-loaders, manufactured at Essen. The road to this conclusion lies through the English ordnance. There is no byeway through bronze or cast-iron. The one real, substantial obstacle is the English wrought-iron gun. Until that obstacle is removed, the desired conclusion cannot be reached. We have written to little purpose if we have not shown that there is here no right of way—that English heavy ordnance rests on too broad and solid a basis of experimental approval to be thus easily disturbed.

But our defence of the position would be to some extent incomplete, if we were to stop here.

Let us briefly consider, then, in general terms: 1st. What is this system of artillery which it is now proposed to destroy; and 2nd, What is the system which it is proposed to establish in its place.

The English system of heavy artillery is a system which has been gradually and carefully developed by successive experiments, and which is compounded of all that seemed to us best. Elswick and Woolwich, Major Palliser and the French, have all contributed to it; even Sir Joseph Whitworth complained in his evidence before the Ordnance Council that "of late the heavier guns have been made to approximate more nearly to my proportions;" and this development has been effected at a cost of money and labour with which no foreign experiments can compare. From the small field guns which were introduced in 1858, we have advanced step by step to our 12-ton, 18-ton, and 25-ton guns; we are now busy with the manufacture of a gun of 35-tons. Can any foreign critic point to any failure—to any breach of continuity—in this gradual development and advance? Is it not a fact that, on the contrary, the English wrought-iron guns have uniformly exhibited the qualities which have been claimed for them? It is worth while again to repeat, that out of about 6000 of such guns, not one has burst on service. What other system of artillery, we may confidently ask, can produce such credentials?

It is altogether beside the purpose to argue—as Captain von Doppelmair and others have done—that the 9-inch Woolwich gun is, in respect of penetrative effect, inferior to the 9¼-inch Krupp gun. We have seen that, as a matter of fact, it is not inferior. But if it were, would that prove anything against the Woolwich system? Captain von Doppelmair does not need to be reminded that the penetrative power of a gun resolves itself ultimately into a measure of its endurance. It is happily not our practice in England to subject our guns to exceptional charges, with a view to producing sensational effects. Mr. Krupp's 9¼-inch gun was designed to fire 43 lb. charges; it was purely an afterthought, due to stress of circumstances, which prompted the adoption of a 53 lb. charge, and this before any trial had been made of the endurance of the gun with such charges. Why, we would ask again, was no increase of the English charge suggested or permitted? And why, again, was a Krupp gun of 14½ tons pitted against a gun of 12½ tons? And why has the former, since the Tegel experiments, been increased in weight to 16½ tons? What took place was, in fact, a trial of a very big, heavy, costly gun, against a smaller, lighter, and far less expensive weapon. In this trial—as far as penetration was concerned—the smaller, lighter, and less costly weapon held its own; and Captain von Doppelmair thinks the occasion suitable for instituting an elaborate comparison unfavourable to the English gun!

But, more than this. There is a strange fatuity in these attempts to determine the value of two systems of ordnance mainly by measuring the penetrative power of any two guns of those systems. In England we have ever sought to produce a gun which, *taken all round*, would be for its size the most suitable for purposes of war. If mere penetration is to be the test of success, this can easily be secured. It is merely a question of increasing the power of a gun, without reference to its weight or cost, its handiness or safety. But the Woolwich gun which was tried at Tegel was submitted on other grounds than these. It was never supposed that the value of the two systems would be judged exclusively—or nearly so—by the results obtained against iron plates; for if this had been the declared intention, assuredly another description of English gun would have been submitted. There is, from an artillerist's point of view, something monstrous in this attempt to decide the issue mainly by penetrative results, and in the circumstance that such a trial should be deliberately conducted with guns of admittedly different penetrative power.

A still more serious objection to Captain von Doppelmair's criticism, must be taken on the ground that he has mixed up a variety of things which have no necessary connection with the subject. He treats the question as if—nay, he expressly declares that—breech-loading is impossible with English guns,[1] because of the inferiority of our material; he assumes, moreover, that we are tied down to one particular description of powder; and he throughout conveys the impression that our calibre, length, and weight of guns are so inseparably mixed up together as to become, in fact, fixed beyond power of alteration. This is not, we make bold to say, fair or reasonable criticism; just as it is neither fair nor reasonable to claim for steel projectiles fired from Krupp guns a special advantage, as if such projectiles could not be fired from wrought-iron guns.

If breech-loading be better than muzzle-loading, there is nothing to prevent the English artillery and navy from adopting it;[2] if prismatic powder be superior to R.L.G., the former powder could be used here as well as in Prussia; if a long gun be preferable to a short one, there is no reason why the English guns should not be made longer—and heavier, if that be an advantage—or 9¼ ins. in calibre instead of 9 ins.; there is no inherent incapacity in English ordnance to fire the same sized projectiles and the same weight of charge as the Prussian guns, notwithstanding Captain von Doppelmair's statements to the contrary.[3] These are details which are open to all the world, of which neither Prussia nor Krupp possesses the patent, and which, if it seemed to us desirable to change them, could be changed to-morrow. Between these details there is no absolute or permanent connection; and arguments directed, like Captain von Doppelmair's, against these things *en masse*, without any such distinction as an artillerist ought to know how to make, must when handled fall to pieces. An English artilleryman, indeed, will smile at the statement that our system is so compact as to permit of no changes in detail without injury to the whole, when he thinks of the almost too numerous changes to which these details are continually being subjected. As an answer to Captain von Doppelmair's argument on this point, it will be sufficient to mention that at the present moment we are introducing a powder which has been proved to possess superior advantages to the prismatic powder, without its inconveniences; that the weights of our guns, and the relation of weight to calibre, undergo occasional modification;[4] that the amount of charge for each gun is not fixed by any unalterable law, but is susceptible of variation as circumstances may dictate—as is proved by the revision of the whole of the charges for our heavier rifled guns, consequent upon the introduction of pebble powder; that the material of the projectile is obviously quite independent of the nature of guns, and has been

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[1] Doppelmair, p. 24. An effective and complete refutation of this statement is afforded by the circumstance that some experiments at Vienna are now (November, 1870) about to be carried on with an English gun, which is in every respect an exact imitation of Krupp's 9¼-inch breech-loader, except that it is made of coiled wrought-iron instead of Krupp's steel.

[2] See note next above.

[3] Doppelmair, pp. 24, 25.

[4] Witness the recent adoption of the 11-inch instead of the 12-inch calibre for the 25-ton gun.

already once changed from steel to chilled iron, of which latter several descriptions exist in the service; that, finally, even the more comprehensive question of breech-loading for heavy guns has been more than once officially and keenly discussed, and only abandoned in consequence mainly of the heavy expense which such experiments—conducted, as they must be, with guns of the heaviest class, and on an extended scale—would entail, coupled with the consideration that there is no apparent necessity for the change.[1]

The question of breech *versus* muzzle-loading for heavy guns is one of exceeding complication. We hesitate to pronounce decidedly on one side or another. We are free to admit that under certain circumstances breech-loading is an advantage. It may be conceded that the breech-loading gun enables a weapon of greater length to be employed than is convenient with a muzzle-loading gun; but, on the other hand, it must be remembered that the breech-loading arrangement by which this advantage is gained greatly increases the weight of the gun. It is certainly a fact that the Krupp breech-loaders are relatively much heavier than the English muzzle-loaders;[2] and a lighter gun, it must be remembered, is not only more manageable, but admits of being carried in greater numbers by any given ship. The advantage which is claimed for breech-loading guns on the ground that they afford superior protection, disappears when the guns are used on board turret ships, in which case the guns while being loaded are turned away from the enemy. It is also more convenient in turret ships to bring the ammunition to the muzzle than to the breech of the gun. We have already shown that, in precision and in rapidity of loading, the muzzle-loading heavy gun is in practice not merely equal to the breech-loader, but that the muzzle-loader really leaves nothing to be desired. The assumed theoretical advantages in respect of accuracy are not corroborated by actual comparative practice, of which England, as we have before observed, has had more than any other nation, and before which the partial and limited results obtained at Tegel fade into complete insignificance. Of the superior simplicity of the muzzle-loader, there are no two opinions; and breech-loaders of which the shot have a lead coating require, as we have seen, an excess of ballistic power to produce penetrative results equal to those of the muzzle-loader. Respecting the efficiency of the particular system of breech-loading which Captain von Doppelmair advocates, opinions are sharply divided. In Belgium, for example, where the Krupp steel is employed for all the field guns, the breech mechanism is that of Wahrendorf.

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[1] The Ordnance Select Committee were, indeed, in favour of making some experiments in this direction. But the minimum expense was set down at £10,000 for testing even two or three of the best systems. Admiral Key, the Naval Director of Ordnance, expressed himself against the experiments (15. 9. '68), on the grounds:—1st. That no system of breech-loading has proved itself so efficient as to be worthy of adoption. 2nd. That the cost of the experiment would be enormous. In this view the Admiralty concurred, as did also the Director of Ordnance, General St. George (27. 9. '68), with the further observation that the prospects of success were not sufficient to justify the expense; and General Lefroy (the late Director-General of Ordnance) subsequently agreed with General St. George on similar grounds. Lord Northbrook also expressed his opinion that "it is out of the question to consider the suitability of Krupp's system for large guns."

[2] See table at p. 126, where it is shewn that the power of the Woolwich guns per cwt. of gun is greater than that of the Krupp guns.

For these reasons, and in view of the consideration that some change in artillery *matériel*—as, for example, the more general adoption of the Moncrieff carriage or of the turret ship—might subtract from breech-loading every one of the advantages which are claimed for it, while leaving as a residuum all its disadvantages, England may well pause before embarking in the large expenditure which would be entailed by the experiments which must necessarily precede the adoption of any breech-loading system.

But, in any case, it should be distinctly understood that, supposing such experiments to be undertaken, they would in no way prejudice or interfere with our system of *gun-making*. Whether we have reason to hesitate or not about the adoption of breech-loaders—whether it be or be not necessary for us to alter our calibres, to adopt steel projectiles, to use Russian prismatic powder, and to increase our charges—no one has yet been able to show the slightest grounds for abandoning our wrought-iron guns. Upon what basis that part of our system stands, we have already shown. It is too solid to be shaken. It is certainly unassailable by the advocates of steel.[1]

What do those who write like Captain von Doppelmair propose to give us in place of our present system? Do they propose that we should enter anew into a careful investigation of the various systems of foreign artillery —examining, rejecting, selecting? Do they propose that we should engage in a fresh gunnery competition, inviting a comparative trial of all the various elements which go to make up the artilleries of Europe? Not at all. All they desire is, that on such partial and imperfect evidence as a few isolated experiments, like those of Tegel, may have afforded—experiments, moreover, which, when carefully examined, appear to furnish conclusions diametrically opposed to those which Captain von Doppelmair has endeavoured to draw from them—that, on such grounds as these, and absolutely without any reference to the results of our long continued trials at home, we shall hand ourselves over, tied and bound, to the Krupp system. We are to exercise no independent judgment. Our own experiments must count for nothing. The voices of our own artillerists must be silent. Nay, we may

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[1] In passing, we would observe that Captain von Doppelmair makes a great mistake in supposing that, if England were by any unfortunate chance driven to use steel guns, instead of coiled wrought-iron, she would have to apply to Essen. Steel guns, if we require them, can be made in England as well as abroad. Indeed, Mr. Reed, the late Chief Constructor of the Navy, goes so far as to express an opinion very unfavourable to the Krupp system of steel manufacture. In a report dated January 12, 1870, he observes:—"Some time ago I visited some of the steel works in Prussia, and was much impressed with the insufficiency of the means then and there existing for securing soundness and uniformity in large castings, in combination with that ductility which is so indispensable in many articles made of steel. I was particularly impressed with this at the great steel works of Mr. Krupp, at Essen; the more so, probably, on account of the enormous scale upon which the manufacture of steel guns, and other articles, was there carried on. Close observations of the operations of steel-making at that firm convinced me that, while the method of casting must necessarily be attended by the risk of unsoundness in the cast ingot, the subsequent process of forging the metal under heavy steam-hammers gave no guarantee of soundness. . . . . The method of manufacture was seriously defective, and experience has, in fact, shown that great internal unsoundness frequently exists in castings so produced. In one instance that came under my notice—and was, indeed, notorious at the time among engineers—a very large cavity existed in the interior of a marine crank-shaft, and caused its speedy failure."

To this it may be added, that England certainly uses, and probably produces, more steel than any other country; and it is in the last degree unlikely, if coiled wrought-iron were to fail us as a material for ordnance, that we should be driven to purchase our steel ingots at Essen.

not even reason on the foreign experiments to which appeal is made, but must blindly accept them, and whatever conclusions the partisans of Essen may be pleased to derive from them. Do we prefer muzzle-loaders? We are wrong. Do we prefer chilled iron projectiles to steel? We are wrong. Do we prefer 12½-ton guns for general purposes to guns of 14½ tons? We are wrong. Briefly, do we prefer Woolwich guns to Krupp's? We are wrong—from beginning to end, in large things as in small. The foreign critics know our wants better than we know them ourselves. A few hundred rounds fired at Tegel have exposed our errors. The hundreds of thousands of rounds fired in England are of no value.

As regards this system which is being pressed upon our unconditional acceptance, we have already considered some of its more salient points, and have shown that—as far as penetrative effect, rapidity, accuracy, and facility of manipulation are concerned—we are able to produce with our English system equal or greater results at about one-third the cost.[1] The question of absolute endurance we have also discussed at some length, and shown that, while the Tegel trials afford no evidence whatever of the relative endurance of the two systems, which were tried with dissimilar weapons under totally dissimilar conditions, there have gradually through many years been accumulating proofs of the endurance of the English guns which are incontestable, and beside which the instances which are adduced of the endurance of Krupp's guns[2] are rare indeed.

There is another side of the question, to which we have before referred, but about which something more must be said. Captain von Doppelmair asserts that "from the trial of one specimen (of steel guns) a judgment can be formed as to all guns of the same description."[3] To this axiom we desire to take unqualified and emphatic exception. No more unsafe rule could be adopted for the introduction of any system of artillery than this; for *steel* guns it is an especially false and dangerous principle, because an essential feature and radical fault of steel is its uncertainty. Here, indeed, we touch at last the heart of the question which Captain von Doppelmair has raised. That question, as regards gun structure, when divested of the complexity with which Captain von Doppelmair has succeeded in surrounding it, is simply one as to the fitness of certain materials to resist dynamic strains. It is a common fact that steel is remarkable for its lack of uniformity in its power of resistance to dynamic strains. Its most inveterate advocates are obliged to make their steel approximate to wrought-iron as nearly as the nature of the former will admit, before they dare employ

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[1] It is unnecessary seriously to discuss the pretensions put forward by Captain von Doppelmair and Mr. Krupp on behalf of the 8-inch Krupp gun—as being superior in penetrative power to the 9-inch English gun. If what we have said be correct, as to the 9¼-inch Krupp gun being at most only just equal in its penetrative effects to the English 9-inch gun, if not actually slightly inferior to it, it is surely asking of us too much to believe that the 8-inch Krupp gun is more powerful than the 9-inch Woolwich. This is proving too much, for it amounts in effect to a statement that the 8-inch Krupp gun is superior also to the 9¼-inch Krupp—a conclusion from which we are sure Mr. Krupp would dissent, although it is one in which his own arguments, if accepted literally, land him.

[2] Captain von Doppelmair only adduces seven such instances; of these, four must be rejected as being solid guns (see *ante*, pp. 103, 104).

[3] Doppelmair, p. 69.

it for ordnance. The most suitable material for resisting dynamic strains is that which offers the greatest resistance through the greatest space, and not that which shows the highest statical cohesion. This is denied in language, but admitted in fact, whenever steel is used for guns; for it is only the weakest, the least tenacious and elastic, and the softest descriptions of steel, which the advocates of the material venture to employ for gun-making.

Mr. Mallet, in his "Treatise on Artillery," makes the following remarks on this subject:—"A gun formed of cast-steel, or of harsh, strong wrought-iron, provided it have an enormous surplus of strength above the highest strain to which it is to be exposed, will be very safe; but if its proportions be reduced within a narrower limit of balancing the final resistance with the bursting strain, or if the latter be brought up, accidentally or otherwise, so as to approach such balance, the cast-steel or the hard wrought-iron will be the most unsafe gun possible, while in all cases the gun of ductile iron will be the safest. This might be popularly illustrated by saying that the former gun approximates to one of enormous strength, but made of glass, while the latter approximates to a gun of sufficient strength, if conceivable, of leather, or of india-rubber, or to the silk-wrapped guns of the Chinese. . . . . The attempts, therefore, recently made at a great expense to fabricate guns of German steel, seem to be a step in the wrong direction, and made in ignorance or in defiance of the first principles that should guide us."[1]

Nor is this at all a question of theory. We have ample facts to warrant the statement that steel is above all else a treacherous material, and liable when it fails, to burst without warning and with explosive violence—points of even greater importance than the ultimate resistance of the material. It is far better to have a gun which will endure only 500 rounds, and will then give ample warning of its approaching dissolution, than one which will endure 5000 rounds, and then explode suddenly, without notice. And when, as in the case of the steel guns, this latter quality is aggravated by the fact that the material lacks uniformity, and may endure 5000 rounds, or may not endure 500—its only uniformity consisting in the manner and suddenness of its disruption—then the unsuitability of the material for ordnance becomes great indeed, and the importance of refusing to admit Captain von Doppelmair's principle, that from the trial of one steel gun you may infer the behaviour of all, becomes sufficiently apparent.

As to actual examples of the bursting of steel guns, there lies before us a list of failures with weapons of that material, which we do not quote *in extenso* only because we are anxious to avoid the innumerable discussions and explanations and replications to which the publication of that list would inevitably give rise. It will be sufficient to state that that list includes guns large and small—from 4-prs. to 9-inch—and by various makers, including Fletcher, Morgan, Lynal Thomas, Mushat, Beaulieu, Brown, Vavasseur, and Krupp.[2] And these examples are culled from an experience of steel guns which is small, compared with the experience to which we have appealed as establishing the safety of our wrought-iron guns.

But other examples of the unreliability of steel are not wanting. Such examples are even furnished by the history of our own guns, and notably by

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[1] Mallet's "Treatise on Artillery," p. 74.

[2] See also "Engineer," October 29, 1870.

the behaviour of the Woolwich gun at Tegel, the steel portions having been the parts which have generally and most unexpectedly failed.[1]

Then, again, there is the instructive history of the vent-pieces of the Armstrong guns, which were originally made of steel, but which material had to be given up for this purpose in the larger guns, in 1862, in consequence of the numerous failures which occurred. Sir William Armstrong has said on this subject:—" In breech-loading guns, I pertinaciously adhered to steel for the screws and for the vent-pieces, until I was completely driven away from the material. I could not depend upon it, the material was so various in quality; and all subsequent experience has shown that, for those purposes, wrought-iron stands incomparably better than steel."[2]

We have, further, the recent failure of, and absence of uniformity exhibited by, the Whitworth steel shell which were fired at Shoeburyness on March 2, 1870. These shells had all been specially prepared for experiment with great care: one was good, one went to pieces on the target, and the third went to pieces in the gun.[3]

As an example of the impossibility of inferring from the statical resistance of steel, its power to sustain dynamic strains, we have the failures which attended the attempt which was made by Sir William Armstrong and others to employ steel for armour plates, and which illustrates the unfitness of steel, even when of the best and toughest quality,[4] to resist violent shocks or concussions.

The fact is, that between the strains exerted by the ordinary tests and those imposed on the material of a gun, there is no analogy. In the former case, it is a mere dead quiet pressure put on and relieved; in the gun, it is a sudden and violent blow, setting up a violent vibratory action; and experience goes to show that steel is much less adapted to resist a strain of this kind—however it may behave under a strain of the former kind—than wrought-iron. It is really not so much a question of dead strength or ductility, but of fitness for resisting violent concussions.

It is no answer to these objections to urge that the lack of uniformity in steel may be corrected and overcome by careful tempering; for, in fact, although the steel may be more or less improved by tempering, its normal variableness of nature is not annihilated, or even materially altered, by the

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[1] "All the failures, whatever failures there are, have been, not in the part which has been made of coil, but in the part which has been made of steel. All our experience shows that the steel is much more liable to fail than the wrought-iron part, and it appears to me that, if you alter the pattern, so as to discard the wrought-iron coil in favour of steel, you are really discarding that part which has never failed. . . . . As far as my experience goes, I should certainly avoid the use of steel to the very utmost in guns, because I consider it the only part that is not fully to be depended upon. I only introduced it originally as material for the bore, on account of its superior hardness, but I depend far more upon the strength of the coil than I do upon the strength of the steel, as far as the safety of the gun is concerned."—Sir William Armstrong's Evidence before War Office Council.

[2] Sir William Armstrong's Evidence before War Office Council.

[3] It may be well to state that these shells were fired without powder in them, and their failure cannot therefore be attributed to the action of the bursting charge.

[4] The steel tried by Sir William Armstrong for this purpose was toughened in oil. It was subjected to the ordinary statical tests, and "exhibited the most extraordinary strength and extraordinary toughness and ductility, far exceeding that of any specimen of wrought-iron I ever saw."—Sir William Armstrong's Evidence.

operation, while the operation itself may be said to introduce another element of uncertainty, since upon its careful performance, as even Captain von Doppelmair admits,[1] the ultimate result will depend.

Nor, again, is it to the purpose to instance the partial supersession of wrought-iron by steel in the domain of civil engineering, for tyres, locomotive and carriage axles, &c.,[2] the strains to which those articles are exposed being of a wholly different character to the strain which has to be borne by a gun. It would be more to the purpose to instance the case of steam-boilers, where the analogy is somewhat closer, an elastic fluid having to be resisted; and for steam-boilers wrought-iron is preferred to steel—the latter, after a lengthy and persistent trial, having been more or less abandoned.

This is the material, the reliability of which, we are told, may be confidently accepted on the trial of a single specimen. This is the material for which Captain von Doppelmair desires us to abandon our wrought-iron guns. Waving a garish light, and pointing to a few imperfect continental experiments, he invites us to leave the *terra firma* of our own experience, and to migrate to the *terra incognita* of steel. To this invitation we would make a twofold reply. We have good cause to be satisfied with our guns as they are. In no single instance have they failed us on service. We do not admit their inferiority—nay, we claim for them a superiority over any other guns in the world. The appeal which is made to the Tegel trials only strengthens our satisfaction with our own weapons; for, read aright, those experiments proved that with our English gun, firing not sensational but service charges, we could equal, if not surpass, the results obtained with a far heavier weapon of Krupp's manufacture, even when the latter was fired with charges considerably in excess of those for which it had been designed, and with which it had been proved. Nor do we know of any other experiments which point to any other conclusion. Secondly, of the Krupp guns, even if we desired them, there exists no sufficient experience to warrant their adoption. The statement that steel is statically stronger than iron may be accepted, but not as bearing on the relative strength of the two when the strain to be endured is not statical but dynamic. In the criticisms of our system, we can find nothing to satisfy us that the characteristic lack of uniformity in steel has been overcome by Mr. Krupp; on the contrary, in his complete abandonment of solid guns, once as confidently recommended as his present weapon, and in the adoption for all calibres, from 24-prs. upwards, of the multi-hooped system,[3] we find evidence of a failure with Krupp guns of the earlier construction not anticipated by the maker. While, as for the principle that "from the trial of one gun a judgment can be formed as to all guns of the same description," we distinctly and energetically repudiate it as unsafe of application to guns of any material, and doubly false and unsafe when that material is steel. And, except such trials of single specimens, the critics are unable to advance any proof that the present Krupp guns are more trustworthy than the solid Krupp guns, which, despite all the good things which were said of them in their day, have had to be given up. The present guns may or may not be

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[1] Doppelmair, p. 69.

[2] Ibid. p. 68.

[3] "The Prussian artillery are having hoops added to the solid steel guns in stock."—Doppelmair, p. 85.

all strong and enduring—let us say that we hope they are so; certainly, when we consider their cost they ought to be so—but of their strength and endurance there exists at present no sufficient proof.

Finally, this change of system which is pressed upon us—this abandonment of guns of satisfactory and established excellence, in favour of weapons whose character as yet rests upon no sufficient basis of experience—could be effected only at an increased outlay for the guns themselves of two to one,[1] to say nothing of the loss of a national plant of gun-making machinery and of a thriving department of national industry.

We may then fairly ask, in whose interests are these propositions made? —for assuredly they cannot be made in those of England, whether we consider them from the point of view of the artillerist, the economist, or the manufacturer.

VIII.

Conclusion.

Relative powers of Krupp and Woolwich Guns, with the Descriptions and Charges of Powders now officially adopted.

It is important to observe that, apart from other entanglements, the solution of all the difficulties which foreign critics have discovered in the Tegel trials really lies in the powder question. It is to the arbitrary assumption of Captain von Doppelmair and others that the use of R.L.G. powder is necessary to the English system,[2] while the Prussian system is free from any such restriction, that the confusion which affects all the foreign criticism is due. We have before taken exception to this fundamental error.[3] Fortunately, we can appeal to actual experiment to exhibit the truth. The following are the facts:—

Far from the R.L.G. powder having been selected specially for use with heavy rifled guns, it was provisionally introduced in 1860 (before a single heavy rifled gun had been made), for use with the smaller natures of breech-loading Armstrong guns. It was one of the first experimental powders tried by the Special Committee on Gunpowder, of which Colonel (now Major-General) Askwith was President; and Sir William Armstrong having observed that it fouled less than ordinary L.G. powder, recommended its adoption. The Gunpowder Committee consented to its temporary employment, pending the completion of the experiments upon which they were then engaged with a view to the introduction of a powder better adapted

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[1] A glance at the tables, at pp. 93, 94, will show that the Krupp guns are twice as costly as the English guns.

[2] "The selection of this energetic powder for the English 9-inch gun was necessary in order to obtain high initial velocities with the comparatively short length of the gun."—Doppelmair, p. 15. See also pp. 24, 62.

[3] See pp. 68, 69.

than R.L.G. for large charges, of which the defects were at that time, and have ever since been, distinctly recognised. What was required, was a powder at once less destructive, more uniform, and of at least equal efficiency. Thus, R.L.G. powder was not only not introduced specially for use with large guns, as stated by Captain von Doppelmair, but its employment was purely provisional, and for heavy charges it was provisionally superseded in 1866 by pellet powder, which in its turn has now been superseded by pebble powder. With regard to the alleged necessity which exists for the employment in the English guns of an "energetic" powder, it will be sufficient to quote some figures which are given in the Preliminary Report of the Committee on Explosives,[1] from which it appears that in the 8-inch gun not only pellet and pebble powders, but even the Russian prismatic powder—the use of which is made by Captain von Doppelmair and others to appear as inseparably connected with the use of Krupp guns—give higher velocities than R.L.G., with greatly reduced maximum pressures.

Nature of powder.	Charges.	Muzzle velocity.	Maximum pressure.
	lbs.	ft.	tons.
R.L.G.	30	1324	29·8
Russian prismatic	32	1366	20·5
Service pellet	30	1338	17·4
Pebble, No. 5	35	1374	15·4

With the 10-inch gun, again, a slow, mild pebble powder has been found to give a velocity of 1474 ft. against 1321 ft. with R.L.G.[2] Further, when the 9-inch Woolwich gun (precisely the same gun, be it observed, as was used at Tegel), was fired with a charge of 46 lbs. of Russian prismatic powder (precisely the same powder as was used by Krupp at Tegel, and which Captain von Doppelmair states cannot be employed effectively in a Woolwich gun), a velocity of 1365 ft. was obtained, as compared with 1336 ft. with 43 lbs. of R.L.G. Finally, experiments have shown that by employing a suitable pebble powder instead of R.L.G., the velocities of all the service Woolwich guns may be increased as follows, and pebble powder has in consequence been adopted:—

Gun.	R.L.G. Feet per second.	Pebble. Feet per second.
7-inch	1430	1543
8-inch	1363	1410
9-inch	1336	1410
10-inch	1298	1400

It follows from the above, that the natural development of the powder question in England has produced exactly the same beneficial results for

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[1] Preliminary Report of Committee on Explosives, p. 9.

[2] Mem. of Committee on Explosives, July 12th, 1870, p. 2.

English ordnance as were achieved for the Krupp ordnance in the emergency of Tegel; and the convenient assumption of the Prussian authorities and foreign critics that the English gun was unable to realise such benefit, is therefore completely disproved. And, as the Woolwich guns exhibited an equality in actual penetrative effect when confessedly from 18 to 30 per cent. inferior in theoretical ballistic power,[1] now that they are brought up to the Krupp guns in ballistic power, without any other change than that of using a suitable powder, it is clear—from the very theories, arguments, and tables admitted on both sides—that the English system, as it now stands, must be actually at least 18 to 30 per cent. superior to the Prussian system as it stands.

We append a table which shows the relative powers of the two systems, with the descriptions and charges of powder now officially approved.

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[1] See pp. 72, 73.

Comparative Ballistic Power of Woolwich and Krupp Heavy Rifled Guns.

Woolwich guns.											Krupp guns.*										
Nature of gun.	Length of gun.		Weight of gun.	Weight of charge.	Weight of projectile.	Initial velocity, feet per second.	Foot-tons.				Nature of gun.	Length of gun.		Weight of gun.	Weight of charge.	Weight of projectile.	Initial velocity, feet per second.	Foot-tons.			
							Total.	Per inch circumferential of projectile.	Per lb. of powder in charge.	Per cwt. of gun.								Total.	Per inch circumferential of projectile.	Per lb. of powder in charge.	Per cwt. of gun.
	ins.	calibres	cwt.	lbs. Pebble powder.	lbs.							ins.	calibres	cwt.	lbs. Prismatic powder.	lbs.					
7-inch ...	141·5	20·2	140	30	115	1543	1899	87·4	63·2	13·56	—	—	—	—	—	—	—	—	—	—	—
8-inch ...	136·5	17	180	35	180	1410	2483	99·8	70·9	13·79	21 $^{c}/_{m}$ say $8\frac{1}{4}$-inch	148·425	18	167	37·48	209·44	1345	2634	104·4	70·3	15·77
9-inch ...	147	16·3	250	50	250	1410	3448	123·0	68·9	13·79	24 $^{c}/_{m}$ say $9\frac{1}{4}$-inch	166·929	18	276	52·91	297·62	1335	3679	129·3	69·5	13·33
10-inch ...	170·75	17	360	70	400	1400	5440	174·6	77·7	15·11	—	—	—	—	—	—	—	—	—	—	—
11-inch ...	171·5	15·59	500	85	500	1400	6800	198·2	80·0	13·60	28 $^{c}/_{m}$ say 11-inch	198·031	18	496	88·18	496·04	1335	6133	181·0	69·5	12·36
11·6-inch..	191·75	16·5	700	120	700	1400	9519	263·0	79·3	13·60	30·5 $^{c}/_{m}$ say 12-inch	216·535	18	659	114·64	645·95	1335	7971	214·9	69·5	12·10

* The powers of the Krupp guns are taken from a table in Krupp's pamphlet, "Canons de Marine et des Côtes." In that table Krupp gives three guns of each calibre, varying only in length and proportionally in weights. We have not thought it necessary to encumber our comparative table with more than one gun of each calibre, and we have selected the guns of 18 calibres for the following reasons:—1st. It is with a gun of 18 calibres that the experiments at Tegel were conducted. 2nd. This length corresponds more nearly with (although slightly exceeding) the lengths of the English guns, and any increase of length would necessarily produce relatively the same increment of power in both systems. 3rd. The estimates of power of the longer Krupp guns, as given in his pamphlet, are evidently incorrect, because Krupp credits his longer guns with a higher increment of power as between guns of 20 and 22 calibres, than as between guns of 18 and 20 calibres long—a manifest absurdity, as the rate of increment instead of increasing towards the muzzle, of course decreases.

THE MOBILITY OF FIELD ARTILLERY;

PAST AND PRESENT.

BY LIEUT. H. W. L. HIME, R.A.

[No. II.]

"La qualité distinctive de l'artillerie de campagne (est) la mobilité."—*The Emperor Napoleon III.*

SHORTLY before the close of the Thirty Years' War, the Great Rebellion broke out, and field artillery made its appearance for the first time on English ground. The guns, although ponderous, were not powerful; the carriages, although massive, were not strong; the ammunition was in fit keeping with the guns and carriages; and an army pursued its tedious march, encumbered with a train of artillery

> "That, like a wounded snake, dragged its slow length along."

Between the Restoration and the expulsion of James II., the artillery appears to have been entirely withdrawn from the public gaze; for when William of Orange landed in England, "the apparatus which he brought with him, though such as had long been in constant use on the continent, excited in our ancestors an admiration resembling that which the Indians of America felt for the Castilian harquebusses."[1] Before the invasion, some attention had been undoubtedly paid to the artillery by Charles II.;[2] but whatever improvements the king introduced were confined to the fire of the guns—for as far as related to their mobility, they were in much the same state as the guns of the previous century. As late as the battle of Sedgemoor, 1685, the last battle fought on English soil, the horses and harness provided for the transport of the artillery were so bad, that the field pieces intended to act against the rebels were only dragged to the spot where the fight was raging by coach-horses and traces belonging to the Bishop of Winchester.[3]

The artillery which accompanied the invading army of the Prince of Orange was almost as cumbrous and slow as that which it was intended to oppose. When the Prince's force of ordnance arrived, it was found to consist of

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[1] Lord Macaulay's "Hist. of England," Vol. I. p. 317.

[2] Dryden's "Annus Mirabilis."

[3] Lord Macaulay's "Hist. of England," Vol. II. p. 189.

"21 huge pieces of brass cannon, which were with difficulty tugged along by sixteen cart-horses to each. Much curiosity was excited by a structure mounted on wheels. It proved to be a moveable smithy, furnished with all tools and materials necessary for repairing arms and carriages."[1] That the disorganised state of the *personnel* of the artillery attracted the new king's attention is sufficiently proved by the formation of companies in 1693, and the regimental organisation of 1698. I am unable to detect any evidence that the *matériel* of the arm underwent change, for better or worse, in fire or in mobility, during his reign. It is said, indeed, that he was the first to introduce travelling carriages into this country; but such cannot be the case, for Chamberlayne, in his "State of England," 1687, a year before the invasion, states that the train of artillery in the Tower consisted of "50 brass pieces on trauling carriages, besides several mortar pieces, some whereof are of an extraordinary bigness."

The state of the artillery was so bad during the latter half of the 17th century, that it is strange that it did not entirely disappear from the battle-field. As yet it was by no means universally allowed that fire-arms, great and small, were superior to the weapons of the knights and archers, and the ancient arms had not yet fallen entirely into disuse. Field guns were all but useless, from the difficulty of moving them; and not only was the fire of muskets slow and uncertain,[2] but they were unequal to withstand a charge of cavalry until the introduction of the bayonet in 1693. The pike was consequently still largely employed,[3] and bows were not unknown. Shortly before the period I speak of, Charles I. had granted two special commissions for enforcing the use of the long bow—the first in the fourth, the second in the ninth year of his reign; and Essex issued a mandate in 1643 for the formation of companies of Roundhead archers.[4] A full century afterwards, Benjamin Franklin wrote to General Lee, advocating the suppression of fire-arms and the re-introduction of archery,[5] and the Chevalier de Folard was employed, about the same time, in proving the superiority of the machines of the ancients over modern artillery.[6]

The degradation of the artillery, at the time I speak of, was chiefly owing to two causes—a reaction that set in on the death of Gustavus Adolphus, and the rise and progress of standing armies.

It was only in the nature of things that the reforms of Gustavus Adolphus should be forgotten on his death. Dulness abhors change; mediocrity detests reform; and men of average understanding seized with avidity the opportunity, which the unexpected death of the king placed within their

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[1] Lord Macaulay's "Hist. of England," Vol. III. p. 230. I am compelled to rest content with Lord Macaulay's account of the artillery of the day, as I have sought in vain for his original authorities, in the British Museum and elsewhere.

[2] "The muskets were such miserable machines, that in the middle of the 15th century it took a quarter of an hour to load and fire one."—Buckle's "Hist. of Civilisation," Vol. I. p. 190. Hallam's "Middle Ages," Vol. I. p. 342. In an action fought during the Thirty Years' War, which lasted from noon till evening, it is recorded that "each man fired, at the least, seven times." —Gen. M. Smith's "Modern Tactics," p. 36.

[3] Sir E. Cust's "Lives of the Warriors of the Thirty Years' War," Vol. I. p. 218.

[4] "Encyclodedia Britannica." Art. Archery.

[5] Franklin's Works, edited by Jared Sparks, p. 169.

[6] In his edition of Polybius.

grasp, of suppressing changes in field artillery which they could not comprehend. The king's military talents and acquirements were far in advance of his cotemporaries, and his reforms were proportionally above and beyond their ken.[1] His attempt to introduce admirable, but radical, reforms into the artillery not only failed, but produced a reaction which left the received opinions stronger than ever, and rendered hopeless for the moment any effort to improve the mobility of the arm; for artillerymen were not educated up to the king's standard, and no reform can produce real and permanent good in any society unless it be the work of public opinion, and unless the members of the society itself take the initiative.[2]

While forty days in the year was the longest period for which a feudal chief could claim the military services of his retainers,[3] long wars and permanent forces were alike impossible. In the revolution of time, however, feudal obligations became gradually relaxed and nugatory, and, like other rules, the rule of military service fell into disuse. The formation of standing armies, which the decline and fall of feudalism thus rendered possible, the rise and progress of fire-arms rendered necessary.[4] The bow, or sword, which under the old system every man possessed, were simple and inexpensive weapons, and their use was mastered without loss of either time or money. The arms of the new system were cannon, the musket, and the pistol, which were costly and difficult to manage. There arose, too, as time rolled on, mortars, howitzers, and the like; and these things made it necessary to set apart and train up bodies of men for the sole purpose of war, and to separate them as much as possible from those other employments in which hitherto all soldiers were engaged. There were other influences, no doubt, which tended to produce the same result, but the use of gunpowder was the most effectual; because, by increasing the difficulty[5] and expense of war, it made a separate military profession indispensable. Thus it was that there arose standing armies. The first of these was formed in the middle of the 14th century, immediately after the invention of cannon;[6] but they did not come into general use until the 17th century, nor was it until the 18th century that they began to influence to any extent the fortunes of the artillery. During the latter part of the 17th century (and, indeed, long afterwards), this service was looked on as something quite separate and distinct from the army proper, and the rise and progress of standing armies affected directly neither its efficacy of fire nor its mobility. But while the artillery slumbered on in an undisturbed repose, isolated, and unchanging, the efficiency of cavalry and infantry uninterruptedly advanced, in proportion to the superior steadiness and cohesion of the permanent forces. The artillery, therefore, by standing

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[1] Sir E. Cust's "Warriors of the Thirty Years' War," Vol. I. p. 219.

[2] Buckle's "Hist. of Civilisation," Vol. IV. p. 132.

[3] Hallam's "Middle Ages," Vol. I. p. 262.

[4] Buckle's "Hist. of Civilisation," Vol. I. p. 190.

[5] "The art of war, as it is certainly the noblest of all arts, so in the progress of improvement it necessarily becomes one of the most complicated among them."—Adam Smith's "Wealth of Nations," Bk. V. ch. 1, p. 314. "Through the mere necessity of self-preservation war becomes continually, and must become, more intellectual."—De Quincy's Works, Vol. IV. p. 218.

[6] Blackstone's "Commentaries," Vol. I. p. 413. "Œuvres de Turgot," Vol. VIII. p. 228. Quoted in Buckle's "Hist. of Civilisation," Vol. I. p. 190.

still,[1] comparatively retrograded, and at the time I speak of was little short of useless.

So ended the 17th century, during the latter half of which no improvement of importance, except the general use of limbers, was introduced into the field artillery. They were limbers destitute of any means of carrying either men or ammunition, but I regard their introduction as the third epoch in the history of the mobility of the arm.

Ere long, that spirit of doubt, of enquiry, of reaction, which forms the eminent characteristic of the 18th century, and which pervaded alike the literary, the scientific, the religious, and the political worlds,[2] began to be felt in the military world. A furious battle had been fought in England, during the closing years of the previous century, on the relative merits of ancient and modern learning;[3] the most liberal of all studies, the study of physical science, was advancing, although with tottering and unequal steps, and was dissipating the mists in which theology had enveloped physics; a bitter and deplorable crusade against Christianity had been begun in France; and dark clouds were gathering on the political horizon, which were to burst in the American War of Liberation, and the French Revolution. Men began to suspect that the possession of great power did not necessarily involve the possession of great wisdom, and they more than suspected that they had inherited some bad old customs and some false old beliefs from the good old times; for knowledge was diffusing itself through the masses of the people, and was undermining the brazen towers of protection and tradition. Nothing could escape scrutiny when men were in such a temper, and a thrill of liberalism shot through the most conservative of institutions—the army. Change was the god of the hour, and it ran riot in the arsenals as it did elsewhere. As might be supposed, disorder and confusion were the first effects of the new movement;[4] but there can be no reasonable doubt that had it been allowed to act without interference or interruption for a few years, order would have succeeded disorder, regularity would have followed confusion, and after the first rude burst of license was over, some system of artillery—as light and effective as the state of chemistry and metallurgy permitted—would have come into use. But the work of reform was opposed by two powerful influences—the system of battalion guns, and the wars of position—both of which had now reached a high degree of development.

The battalion guns, which had been in use in Germany since the Thirty Years' War,[5] attracted the notice of the French Court, where military

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[1] "L'Infanterie avait fait de grands progrès . . . L'Artillerie était restée stationnaire."—"Conférence sur l'Artillerie de Campagne." Paris, 1869, p. 11.

[2] Buckle's "Hist. of Civilisation," Vol. III. p. 174, Leipsig Ed.

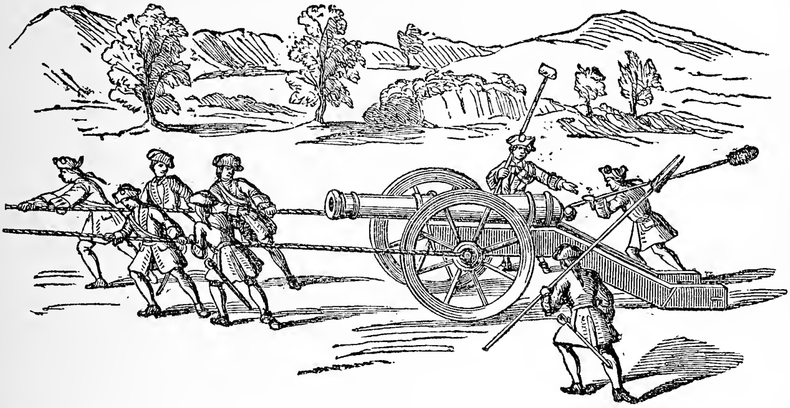
[3] See Dean Swift's "Battle of the Books," and Dr. Bentley's "Letters on the Epistles of Phaleris."

[4] Taubert, "On Field Artillery," p. 9. Favé's "Hist. et Tact. des Trois Armes," p. 113. "Conférence sur l'Art. de Campagne." Paris, 1869, p. 12.

[5] Gustavus Adolphus is responsible for the battalion gun system. Had the king lived long enough to see the pernicious effects of these guns in practice, he would no doubt have abolished them; but as a matter of fact he did establish them, and they remained in existence for nearly a century and a half after his death, always exerting an influence for evil so strong as to counteract almost entirely the effect of the improvements he introduced into the artillery service. As regards the leather guns, I cannot agree with the Emperor Napoleon III. ("Etudes, &c., &c.," Tom. IV. p. 83);—"Ces canons . . . n'ont aucune intérêt au point de vue de l'histoire de l'art." As

questions were settled by the intrigues of courtiers, in 1736;[1] and they were finally introduced into the service in 1756 by order of the Maréchal de Belle-Isle, in spite of the opposition of all the officers of note in the French artillery, except M. du Brocard.[2] The attempt to merge into one such different services as the artillery and infantry, proved abortive. In the first place, to prevent these guns from impeding the movements of the infantry to whom they belonged, their weight was reduced to an extent which made their fire, under the most favourable circumstances, all but useless.[3] Secondly, as a matter of fact, they did seriously encumber their infantry.[4] For infantry compelled to drag guns along with them could not be expected to march, even on smooth and level plains, with the same order and rapidity as infantry who marched free from such a hindrance; and in a cultivated country, intersected with ditches, hedges, and walls, the guns had to be abandoned altogether.[5] In this latter case, they not only failed to fulfil the very object

Fig. 1.



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far as the fire of these guns is concerned, His Majesty's position is unassailable; but taking into consideration not only their efficacy of fire but their mobility, I maintain that under the guidance of so great a military genius as Gustavus Adolphus, they proved themselves to be the most effective guns known up to his time. Fig. 1, taken from Folard's Polybius, shows a battalion gun.

[1] "Ce fut alors que la cour prit en consideration les pièces dites à la Suédoise."—"Lettres d'un Officier du Corps Royal de l'Artillerie au Lieut.-Col. du Régiment D. . . " Paris, 1774. p. 3.

[2] Ibid. p. 10.

[3] "Tout l'effet (des pièces à la Suédoise) se réduit seulement à faire du bruit."—"Mémoire et Observations sur l'Art. à cheval," par T. Durtubie, Chef de Brig. d'Art. Paris, 1795, p. 12.

[4] "Lettres d'un Officier du Corps Royal," &c. Paris, 1774, p. 5. "Notice sur l'emploi de l'Art.," par Capt. Mazé, in the "Etat Actuel de l'Art. de Campagne Anglaise," par Lieut. G. Jacobi, p. 7. "Ces pièces mal servies et presque toujours placées dans des positions défavorables, furent en général plus nuisibles qu'utiles aux Regimens dont elles embarrassaient les mouvemens."

[5] "La meilleure infanterie était désignée pour garder l'artillerie, et aider à son service; mais ce service toujours très pénible, et d'ailleurs momentané, n'était pas de nature à inspirer aux troupes beaucoup d'attachement pour le matériel qu'elles étaient chargées de défendre et de protéger. Aussi arrivait-il d'ordinaire que dans une bataille perdue toute l'artillerie restait au pouvoir du vainquer."—Ibid.

"In der Schlacht bei Erefeldt waren die, auf dem rechten Flügel vorgerückten Infanterie-Regimenter bei dem Korps des Erbprinzen von Braunschweig ohne Regiments-Geschütz, als sie von der überlegenen Kavallerie angegriffen wurden; es war zwischen den Gräben, die sie vorher passirten, zurückgeblieben."—"Ueber Reitende Artillerie; was sie ist, sein sollte, und sein könnte." Leipsig, 1818, p. 32.

of their existence, but left a gap in the line,[1] which, as they were generally placed in the centre of the battalion,[2] might produce fatal consequences. Thirdly, as it was necessary for them to take part in all the manœuvres of their battalion, the necessary time was not afforded to the gunners for placing, loading, or laying their guns carefully.[3] No guns could have been effective under this system, which violated both the fundamental principles of field artillery tactics—namely, that the movements of a battery in action should be minimum in number, and should be made at a maximum speed. Fourthly, their constant presence with their infantry led the latter to look upon the guns as necessary to the safety of the battalion,[4] and thus diminished that self-confidence which infantry must possess to be successful. Fifthly, as these guns were practically useless, not only was the money spent on their construction wasted, but the regular columns or trains of artillery were deprived of a corresponding number of guns, which might have been turned to good account by their own officers.[5] In fine, this bad system weakened the artillery without strengthening the infantry,[6] and raised a general prejudice against the use in the field of what was regarded as a complicated and useless mechanism.[7] This feeling tended to retard the progress of mobility; for its development essentially depended on experience, and an arm which was meanly thought of was not likely to be greatly used.

In a widely different, but in a no less prejudicial way, did the wars of position affect the progress of field artillery.

In the wars of Henri IV. of France there sprung up a system of tactics the spirit of which consisted in selecting and fortifying strong positions and in awaiting there the attack, which could only be made under great disadvantage.[8] From various causes, which it would be foreign to my subject to enumerate, this mode of fighting gained ground as time passed on, culminated in the epoch of Fontenoy,[9] and, finally, only gave way before the

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[1] "In der Schlacht bei Minden waren die Regiments-geschütze, als die Englische und Hannöverische Infanterie vorrückte, wegen der hohlen, ob wohl nicht sehr beschwerlichen Wege, zurückgeblieben und bei dem ersten Angriff der feindlichen Kavallerie befanden sie sich noch hinter der Fronte, wodurch es sich dann ereignete, dass ganze Trupps durch die Intervallen setzten."—"Ueber Reitende Artillerie, &c.," p. 32.

[2] "Memoirs of Capt. Creichton," by Dean Swift. Nimmo's Ed., p. 529. "Hist. of the Military Transactions of the British Nation in Indostan." London, 1799, Vol. I. p. 368.

[3] "Essai sur l'usage de l'Artillerie." Amsterdam, 1771, p. 7.

[4] "Ce malheureux sentiment n'est deja que trop répandu."—"Réflexions sur la pratique du Pointement du Canon." Amsterdam, 1771, p. 58. A few general and vague directions for the handling of battalion guns may be found in Muller's "Elements of the Science of War." London, 1811, Vol. II. p. 169.

[5] "Cinquante pièces de 4 ajoutées à l'artillerie d'un parc . . . feront plus de mal aux ennemis et contribueront plus à la réussite des actions de guerre que les 160 attachées constamment aux Bataillons."—"Réflexions sur la pratique, &c.," p. 57.

[6] Notwithstanding the disasters in which the adoption of this system involved the Royal Artillery during our Flemish campaigns of 1793–4, some benighted artilleryman, only a few years afterwards, describes battalion guns as "a late and admirable invention!"—"Hist. of the Royal Art.," in the "British Military Library." London, 1799, Vol. I.

[7] The Chevalier Folard, in his edition of Polybius, protests against this notion:—"L'Artillerie n'est pas un pur méchanisme, comme on le prétend, et il importe aux Généraux d'avoir au moins une idée de cette partie de la guerre."

[8] Favé, "Hist. et Tact. des Trois Armes," p. 64. Jomini, "Précis de l'art de la guerre," p. 135. American Trans.

[9] The battle of Fontenoy is the finest illustration I know of the old tactics. Marshal Saxe's dispositions were a masterpiece of tactical skill, according to the old method.

new tactics which the French Revolution brought forth. Nor did it yield then without a struggle. Men were wedded to the old system round which Frederick's genius had thrown a glory; they believed it to be unchanging and immutable; they persuaded themselves it was the be-all and end-all of military art. There is one system of tactics, said soldiers, and Frederick is its Prophet. They learned in time how grievous was their error, but they learned it in the school of adversity. It was only in his dying moments King Arthur saw clearly how—

> "The old order changeth, yielding place to new,
> Lest one good custom should corrupt the world;"—

it was only after a long train of disaster and defeat men learned that war, like everything human, is subject to the "imperishable change that renovates the world."

It is not difficult to trace the influence exerted upon field artillery by this system of tactics. The guns of a defensive army generally occupied entrenched positions, and were seldom called on to move during the whole course of an action. Mobility, therefore, was of no moment, and efficacy of fire was the attribute on which all attention was rivetted. In fact the artillery acted not as field, but as garrison artillery.[1] Things were not very different in the offensive army. Certain that nothing but some extraordinary contingency would tempt the adversary from his fastness, the attackers moved at their leisure. They marched and countermarched, broke into column and wheeled into line, with a gravity and solemnity that in our times would provoke a smile. There was this difference, indeed, between things before and after the Seven Years' War—that while the slowness of manœuvre before the war was to a certain extent a matter of necessity, after the war it was a matter of principle. Before Frederick's time, the want of drill and discipline compelled armies to move slowly and cautiously; after it, cavalry and infantry were carefully drilled, and only moved slow because it was thought incorrect to move fast. For men had mistaken the letter of Frederick's system for its spirit, his drill for his tactics, his means for his end. They set up a false god, and the whole military world fell down and worshipped it. Frederick moved his army after a fashion of his own, and gained countless victories; therefore, it was said, the king's method is correct, every other method is incorrect, and no future method that may be devised can be correct. The oblique order was believed in with such unquestioning faith, that at Jena General Ruchel thought he could save the army by giving an order to advance the right shoulder![2] Frederick showed his disapproval of the inversion of a brigade at the battle of Prague,[3] and inversions were in consequence looked on with such superstitious horror, that at the battle of Laswarree a brigade of British infantry was wheeled with its back to the enemy by an orthodox Brigadier, and then calmly countermarched under a tremendous fire of grape, in order to avoid the proscribed and dreaded formation![4] The rapidity of Napoleon's movements

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[1] "Le canon sert extrêmement à la défense des lignes d'un camp fortifié."—"Mémoires de Montecuculli." Amsterdam, 1756, p. 246.

[2] Jomini, "Précis, &c." p. 57.

[3] The *contre-temps* at Prague is amusingly described by Capt. Nolan in his book on Cavalry, p. 198.

[4] This unfortunate brigade, "in obedience to the rules and regulations, wheeled into line and stood with its back to the enemy, requiring to be countermarched under a storm of grape shot,

was looked on as indecent, and Napoleon himself was considered a barbarian, unworthy of the name of soldier. "In my youth," exclaimed a correct old German, "we used to march and countermarch all summer without gaining or losing a square league, and then we went into winter quarters. But now comes an ignorant, hot-headed young man, who flies from Boulogne to Ulm, and from Ulm to the middle of Moravia, and fights battles in December. The whole system of his tactics is monstrously incorrect."[1] The evolutions of an army were necessarily dilatory and protracted under this extravagant and pedantic system, and its spirit was eminently prejudicial to the progress of field artillery, for it produced a tendency to increase efficacy of fire to the detriment of mobility; and, if my reasoning be correct, the movement in favour of large calibres which took place in Prussia about 1759,[2] far from being exceptional and abnormal, as it is generally regarded, was a natural consequence of the prevailing system of tactics.

But potent as were the two influences which I just described in counteracting the effect of the spirit of reform, they were unable to extinguish it altogether. They might crush it, but they could not kill it; and the successive efforts to create an artillery that could move as well as fire, which I shall now briefly describe, are a sufficient proof of its vitality during the first half of the 18th century.

The first unmistakeable symptoms of reaction were the establishment of organised bodies of gunners in France, Germany, and England,[3] towards the close of the 17th century, and the general tendency to diminish the weight of guns, observable during the early years of the 18th.[4] This latter movement was in the right direction, but it was imperfect, and necessarily involved failure; for it was founded on the false assumption that mobility was attainable by merely lightening the guns, without any corresponding improvement in the carriages and the mode of draft. So long was the mistaken notion received in England that the guns were of all importance and the carriages were of none, that the Carriage Department was not founded until 1806,[5] although the Royal Arsenal was established in Woolwich Warren in 1716.

While the century was yet young, the Chevalier Folard proposed a gun of his own invention, which, if it was not the very first, was one of the first attempts to construct an artillery that could move. "Le Chevalier de Folard," says Père Daniel,[6] "officier de beaucoup d'esprit et de capacité . . . . a entrepris de trouver le secret qu'on cherche depuis longtemps, de diminuer la longeur des canons, et par consequent leur poids immense, aussibien que celui de leurs affûts, sans préjudice de leur portée et de leur effet." The Chevalier's gun was a 24-pr. (length, 2 ft. 4 ins.; weight, 15·1 cwt.; charge, 6 lbs.), and compared with the ordinary 24-pr. of that time (length, 11 ft.; weight, 45·5 cwt.; charge, 12 lbs.), it was no doubt "infiniment

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and leaving, by this delay, all the brunt of the action upon the 76th Regiment, and about two battalions of Sepoys."—Col. Hamilton Smith's "Sketch of the Science and Art of War," in the "Aide-Memoire to the Military Sciences," Vol. I. p. 27.

[1] "Lord Macaulay's Essays; Lord Byron," Vol. I. p. 330.

[2] Taubert, "On Field Artillery," p. 9.

[3] Favé, "Hist. et Tact. des Trois Armes," pp. 105, 114. "Die Beziehungen Friedrich des Grossen zu seiner Artillerie." Von Troschke, p. 6.

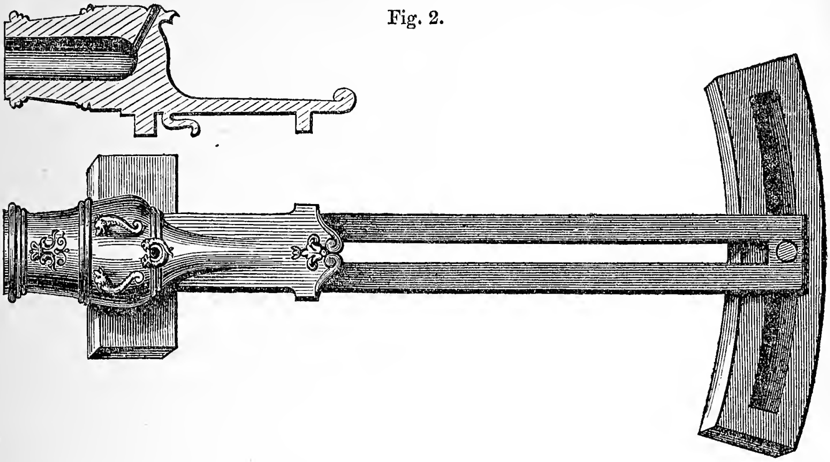
[4] Taubert, "On Field Artillery," p. 7.

[5] MS. Notes on the History of the Royal Carriage Department, by an Officer of the Royal Artillery.

[6] "Hist. de la Milice Francaise." Paris, 1724, Tom. I. pp. 327, 330.

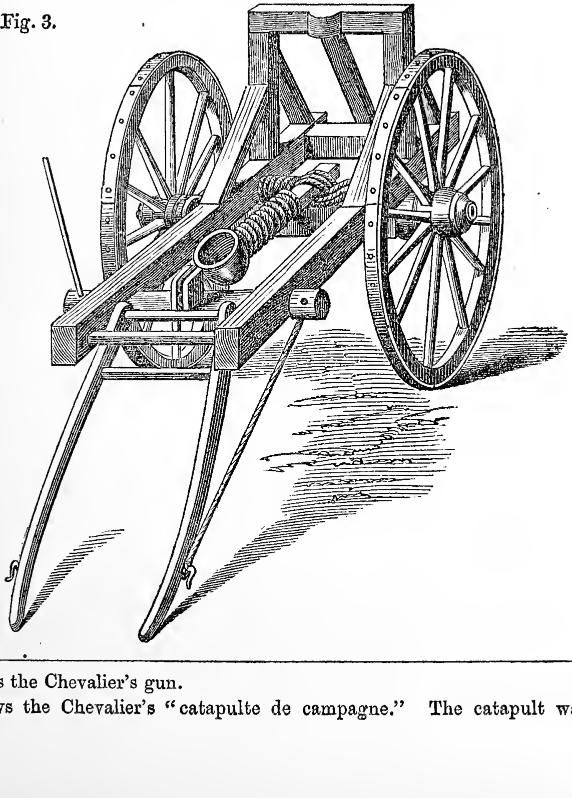
plus légèr que ceux de ce calibre."[1] The gun failed, however, and the

Fig. 2.



Chevalier appears to have been so chagrined at the unhappy result, as to come to the unwarrantable conclusion that it was impossible to improve either the fire or mobility of modern artillery. Certain it is that in his dreary "Commentaries on Polybius," he virtually proposed to abolish artillery altogether, and to supply its place by the ballista and catapulta of the ancients.[2] This proposal, made in open day to the whole military world, is

Fig. 3.



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[1] Fig. 2 shows the Chevalier's gun.

[2] Fig. 3 shows the Chevalier's "catapulte de campagne." The catapult was his favourite

the most striking proof I am acquainted with of the low position occupied by the artillery of the time. Had the Chevalier's theory been worked out secretly, had he been unsupported by a single friend, had his book been received from the first with contempt, had he himself at once become the object of public derision—then, indeed, we might have looked on the Chevalier as a Quixote in the flesh, and regarded his theory as the offspring of a disordered imagination. But far different was the real state of the case. Published in 1727, the book was soon in everyone's hands,[1] and gained for its author an immense reputation.[2] Although a costly work, within a few years it went through a second edition,[3] was translated into German, both at Berlin and Vienna,[4] and was so highly thought of in England that the Chevalier was made a member of the Royal Society.[5] He was warmly attacked, it is true,[6] but he was as warmly defended;[7] and he was only finally defeated after a whole library had been written on his system of tactics. In what a degraded state must the artillery service have been when attention was paid, even for one moment, to the pedantic heresies of the Chevalier Folard!

While the Chevalier Folard was constructing a light field artillery in France, the Germans were busying themselves at the same task. In the "Maximes et Instructions sur l'Art Militaire," published at Paris in 1726, the Marquis de Quincy speaks of newly-invented guns, "courtes et carabinées," which were then in use east of the Rhine.[8] They were of two calibres, 8-prs. and 4-prs., and were mounted on carriages, without limbers, constructed in such a way that the guns could be fired without detaching the carriages from the horses. Their efficacy of fire was inferior to that of ordinary guns of the same calibre, and their use entailed other inconveniences; but the Marquis inclines to the opinion that the balance of advantages was in their favour, because their lightness more than compensated for the weakness of their fire:—"On peut manœuvrer ces pièces devant un ennemi sans avantrain, en y attelant quelques chevaux qui les traineroient avec facilité en quelque terrain que ce fût. . . . Cette nouvelle manière donneroit le moyen à un Commandant d'Artillerie de suivre la Cavalerie, quand même elle iroit au trot. . . . Ce moyen seroit encore d'une utilité merveilleuse

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machine. "Il avait fait construire une catapulte dont les expériences le transportérent d'admiration."—Biog. Universelle.

In the attack on Dalimkote, in Bhotan, 1864, some loss was inflicted on the British force by the catapults of the Bhoteahs who defended the place. The occasion was an exceptionally favourable one for the catapults, for the fort stands on the top of a hill, and the British force lay in a valley immediately beneath it.

[1] The author of the "Essai sur l'usage de l'Art.," speaking of Folard and his supporters, says (p. 3), "Leur ouvrages sont entre les mains de tout le monde."

[2] "Une grande réputation."—Biog. Universelle. Art. Folard.

[3] 1759.

[4] "Polybs Geschichte a. d. Gr. ubersst, mit Folard's Anmerk a. d. Franz." Berlin, 1755. "Polybü Geschichte . . . mit Bemerkungen des Ritters von Folard." Wien, 1760.

[5] "Cet ouvrage le fit admettre dans la Société Royale de Londres."—Biog. Universelle.

[6] "Mémoires Militaires," par Col. Guischardt. Paris, 1758. "L'Esprit du Chev. Folard," Berlin, 1761; written by command of Frederick the Great.

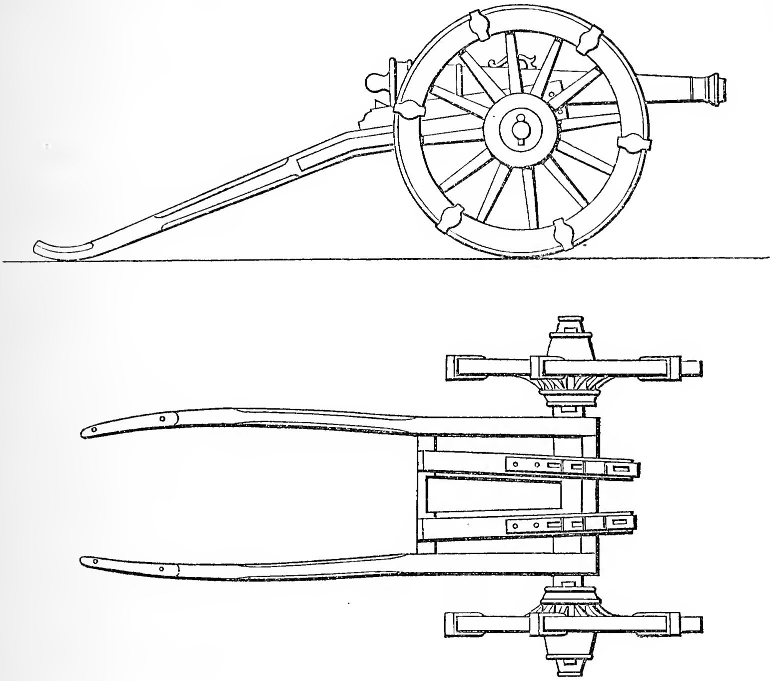
[7] "Récherches d'antiquités militaires, avec la défense du Chev. Folard, &c," par Loolooz. Paris, 1770.

[8] pp. 323, 325.

dans de certains occasions, parceque rien n'impose tant aux troupes que l'artillerie, particulièrement lorsqu'elles ne s'y attendent pas."

The galloper guns, which came into use some years afterwards, were probably a development of this system. It is said, I know not with what truth, that Frederick the Great used 3-pr. gallopers, "which answered very well,"[1] and it is certain that in 1747 in Germany the Duke of Cumberland had six gallopers, 1½-prs., "such as are now (1799) fired in St. James's Park on rejoicing days."[2] The carriages were "made with shafts, so as to be drawn without a limber,"[3] the shafts acting as a trail when the gun was in action.

Fig. 4.



The cheeks of the carriage terminated in a splinter-bar, on which the coin or elevating screw rested. This system furnishes a remarkable illustration of the difference between mere lightness and mobility. Light to excess, it yet possessed no real mobility; for if the guns were pushed forward into action at a faster pace than that at which the ammunition, carried in country carts, and the gunners, marching on foot, could move, namely, a walk, the

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[1] James's "Military Dictionary." London, 1802. Art. Carriage.

[2] "British Military Library." London, 1799, Vol. I. Hist. of the Royal Regiment of Artillery.

[3] James's "Mil. Dict." Fig. 4 shows a galloper carriage. It is taken from the "Artillerie Pratique, employée sous les règnes de Louis XIV. et de Louis XV.," par le Baron Espiard de Colonge. Plate 14.

batteries were exposed to the enemy's fire without any means of returning it.

In 1732 the French king, infected with the prevalent spirit of reform, and desirous of putting a stop to the confusion which reigned in his arsenals,[1] ordered M. de Vallière to reorganise the artillery. The king could have hardly selected a man fitter to establish order and uniformity in his factories; he could not have chosen a man more incapable of carrying out the gigantic task of reorganising an artillery; for de Vallière was emphatically a "safe man," who could never achieve a brilliant success or make a signal failure, because he never dared to attempt what was great. His narrow, bigoted mind revelled in paltry and insignificant details, but shrunk from reforms of any magnitude as doubtful, if not dangerous. In any case, failure stared him in the face; for he had undertaken the impossible task of fusing the siege and field artillery services into one system. His work possessed the merit of solidity and simplicity, and many of his alterations were undoubted improvements; but his innovations were exclusively confined to matters of detail, and he introduced no new principle. He whited a time-worn sepulchre, he propped up a tottering house; but the storms would deface the one, and time would undermine the other. Efficacy of fire received no new impetus in his system, and mobility was completely neglected.[2] The changes he effected in the carriages were not important. The means of transport for the ammunition were deficient; the horses still worked in single file; the drivers were unorganised; and the harness was not thought of. De Vallière lacked genius to sieze the splendid opportunity Fortune had thrust upon him. It is for genius to create, it is for mediocrity to arrange; and while he arranged everything, he created nothing. In accomplishing the task of reorganising the artillery he failed; he succeeded too well in staving off reform in the French artillery for a quarter of a century.

Marshal Saxe's attempt to improve the artillery was neither a very trenchant nor a very happy one. No one had a higher opinion of that service, as it might be,[3] than he; but he seems to have despaired of any successful effort to confer greater mobility upon it, as it was. It is most unlikely that the artillery will ever move faster, thought the Marshal; it is impossible that it can ever move slower.[4] Having come to this conclusion, he virtually proposed to convert the existing guns into guns of position, and to create a light field artillery to supply its place, armed with a piece invented by himself, called an "amusette"—somewhat more than a blunderbuss, somewhat less than a cannon. The amusette carried a $\frac{1}{2}$ lb. lead ball,

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[1] Favé, "Hist. et Tact. des Trois Armes," p. 113. "Conférence sur l'Artillerie de campagne." Paris, 1869, p. 12. "La confusion était grande dans les calibres, les formes, les dimensions des pièces."

[2] "Complétement negligée."—"Conférence sur l'Art. de camp." p. 12. It may be necessary to say that in the above remarks I speak only of M. de Vallière as an organiser of artillery; for by all accounts he was a good soldier in the field.

[3] "L'Artillerie de campagne feroit la principale force des armées aujourd'hui, si l'on y donnait plus d'attention."—Marshal Saxe, quoted in the "Esprit des Loix de la Tactique," par de Bonneville, Tom. I. p. 40.

[4] "Combien de fois les equipages restent-ils en arrière, aussi-bien que le train d'artillerie, ce qui vous met dans la necessité de rester-là tout court!"—"Rêveries, &c.," Tom. I. p. 147.

and was mounted on a light carriage drawn by hand.[1] These pieces were to be distributed in large numbers in front of the line of battle.[2] As to the guns with which the ordinary batteries should be armed, he is by no means explicit, but he seems to incline towards 16-prs. He distinctly insists, however, upon all guns of the ordinary artillery being drawn by oxen,[3] and for the following reasons:—Firstly, oxen cut up roads less than horses; secondly, oxen cost less; thirdly, they can live upon almost anything; fourthly, they require little harness and no grooming; and lastly, "si un bœuf s'estropie, on le tue, on le mange, et en prend un autre au depôt."[4]

Fig. 5.

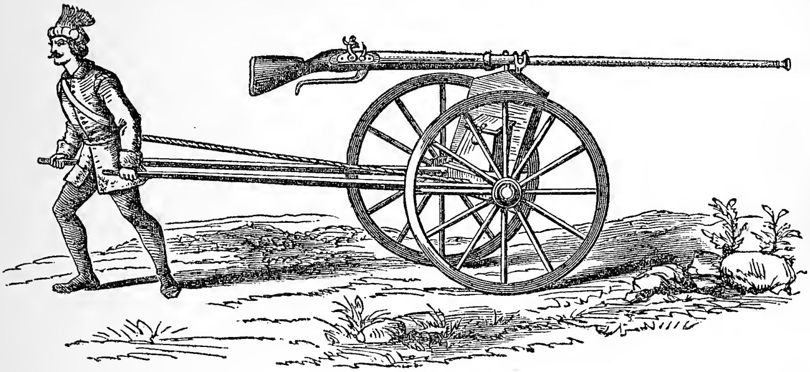
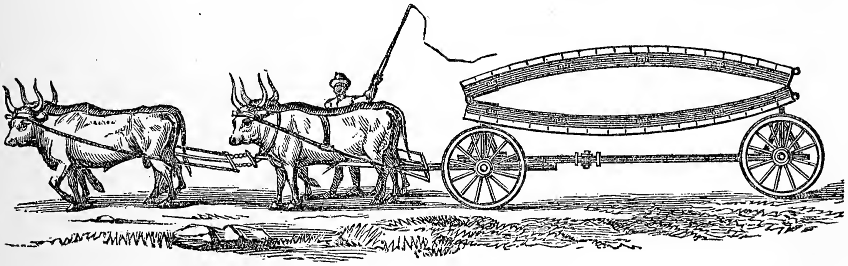


Fig. 6.



Deplorable must have been the state of the artillery, if, indeed, these changes would have been improvements!

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[1] Fig. 5 represents an amusette.

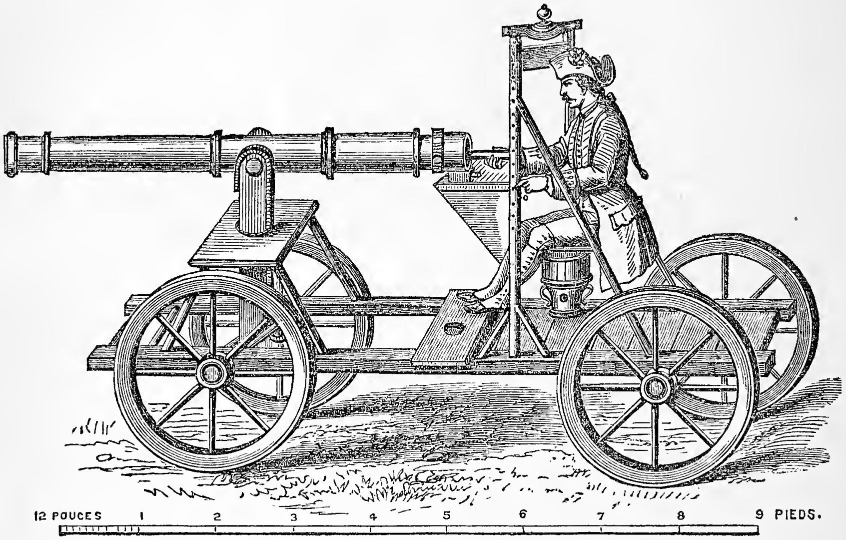
[2] See Plates 22, 23, 24, of the "Rêveries," Paris ed. of 1757.

[3] "Le canon et les chariots doivent être attelées de bœufs."—"Rêveries, &c." Paris, 1757, Tom. I. p. 53.

[4] Ibid. p. 148. Fig. 6, taken from the "Rêveries," shows a flying bridge drawn in the manner proposed for the artillery by Marshal Saxe. It would be absurd in 1870 to re-open the question of horses *versus* oxen, but I may mention that on one occasion, during the Central India campaign of 1858, Sir Hugh Rose's artillery took 12½ hours to march 10 miles, in consequence of the invincible sloth and obstinacy of the bullocks.—Lowe's "Sketches of the Central India Campaign," p. 65.

A few years later, a breech-loading system of field artillery was proposed by M. de Bonneville, a French officer of Engineers.[1] The gun, which weighed 1·6 cwt., carried a 1 lb. lead ball, and, according to M. de Bonneville, it could be loaded and fired while on the move:—"Les canonniers pourront toujours servir leur pièces, quand même les chevaux iraient au galop."

Fig. 7.



While these movements were taking place in western Europe, Captain von Holtzman was endeavouring to construct for Frederick William of Prussia a gun which would combine in itself the rival attributes of mobility and efficacy of fire. Like all his cotemporaries, Holtzman overlooked the fact that the nature of the gun carriage and limber, and the organisation of the means of draft, drivers, horses, and harness, are most important considerations in constructing any system of artillery, and he devoted all his energies to the impossible task of lightening to a great extent the gun without diminishing its efficacy of fire in a corresponding degree. It was evident that the charge must be lessened in the same proportion as the length and weight of the gun; but Holtzman imagined he could compensate for the reduction of the

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[1] "Esprit des Loix de la Tact.," à la Haye, 1762, Tom. II. pp. 75–78. In the early part of the 18th century breech-loading guns were by no means so uncommon as is generally supposed. Father Daniel, when describing Sieur de la Chaumette's breech-loader ("Hist. de la Mil. Fran.," Tom. II. p. 331), says the idea was not a new one. See also the Emperor Napoleon's "Etudes, &c." Tom. IV. p. 4, and the "Dict. Militaire," par M. A. D. L. C., Dresden 1751:—"Il y a eu et il y a encore des canons que l'on charge par la culasse; cette idée de charger un canon n'est pas nouvelle." Breech-loaders had fallen into disuse before the end of the century, for reasons pointed out by M. Durtubie in his "Mémoire et Obs. sur l'Artillerie à cheval." Paris, 1795, p. 18.

Fig. 7 represents M. de Bonneville's gun and carriage.

charge by the construction of a chamber in the gun, cylindrical or conical, which would increase the effect of the charge. Thus arose the chambered guns which were introduced into the Prussian service in large numbers between the years 1740 and 1758. After this latter period they fell into disrepute, partly from their small effect and partly from the difficulty of loading them; and before the close of the Seven Years' War they had dropped entirely into disuse.[1]

I am unable to give any details of the changes which took place in the Russian field artillery about this time; but the invention of the much-vaunted Schuwalows,[2] and the organisation of these guns which enabled them to act with cavalry,[3] prove conclusively, not only that the causes I have enumerated were operating so strongly in Russia as to draw great attention to the artillery service, but that the value of mobility was beginning to be appreciated in that country.

It was in Austria, however, that the movement in favour of a mobile field artillery produced the most decisive results; and at the breaking out of the Seven Years' War she could boast of possessing, what she probably possesses still, the finest artillery in the world. In reply to a series of questions sent to him to Vienna by the French Government in 1762, Gribeauval gave a minute description of the Austrian artillery,[4] which, as Frederick the Great truly said, reflected honor upon its organiser, Prince Lichtenstein. "Wir haben während dieses ganzen Krieges," writes Frederick, "die österreichische Armee . . . . von dieser furchtbaren Artillerie unterstützt gesehen. Die Flanken sind mit Kanonen gespickt wie besondere Citadellen. Jeder kleine Vorsprung des Terrains wird benutzt, um Geschütze aufzustellen."[5]

In the foregoing pages I have attempted to describe the various forces that acted on the field artillery during the first half of the 18th century. On the one hand, its progress was retarded by the battalion guns, the wars of position, and the prejudice raised against the arm by its own immobility. Its progress was accelerated, on the other hand, by the spirit of enquiry which characterises the 18th century, and by the moral force generated by its increasing efficacy of fire. To form a correct notion of the resultant effect of these conflicting influences on the mobility of the arm, it is necessary

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[1] "Die Beziehungen Friedrich des Grossen zu seiner Artillerie." Von Troschke, pp. 7, 28. "Etudes sur le passé et l'avenir de l'Artillerie," par l'Emp. Napoleon III., Tom. IV. p. 93.

[2] Schuwalows—so called after their inventor—were small chambered guns, with a charge of 5 or 6 lbs., exclusively intended for firing grape or canister. Their bore was elliptical, the minor axis being vertical—an arrangement which (it was supposed) considerably increased the lateral spread of the canister. At the beginning of the Seven Years' War the Russians threw a veil of deep mystery round these guns and their belongings—like the French and their Mitrailleur in 1870—and Frederick the Great, to relieve the public mind, placed one of them which he captured at Zorndorf in a public thoroughfare in Berlin, with the inscription—"Hier ist das grosse Mysterium der Russen zu sehen!"—Von Troschke's "Die Beziehungen, &c.," p. 10. Scharnhorst's "Manuel des Officiers sur les pratiques de l'art militaire."

[3] "Zu den vorübergehenden Erscheinungen dieser Art (Horse Artillery) muss man auch die wunderlichen Geschütze (Schuwalows) zählen, welche sich im 7 jährigen Kriege bei der russischen Kavallerie befanden."—"Die Königlich Preussische Reitende Artillerie, vom Yahre 1759 bis 1816." Von General-lieutenant von Strotha, p. 1. Von Troschke, p. 38.

[4] "Etudes sur le passé &c. &c. de l'Art.," par l'Emp. Napoleon III. Tom. IV. p. 98.

[5] Von Troschke, p. 34.

to consider what estimation it was held in at the time I speak of, and how it behaved on the field of battle.

One of the most noticeable features of the military books written between the Thirty and Seven Years' Wars, is the almost unbroken silence in regard to the artillery observed by the majority, and the unsatisfactory account of it given by the rest. Montecuculli seldom mentions the arm, except in the two short chapters he has specially devoted to it; and he evidently sets little store by what he calls "la principale machine de l'armée."[1] Feuquières contents himself with referring to St. Remy on the few occasions he has to speak of the artillery.[2] St. Remy's excellent work deals rather with the technical than the tactical side of the subject; and while it leaves nothing to be desired regarding the weight and dimensions of the *matériel*, it throws but little light on the state of the *personnel*, or the use of the arm in action.[3] The Marquis de Puységur casually mentions the position of a train on the march and in camp; but he says no more of the artillery throughout his book, and he does not include it among the troops that compose an army.[4] From the short chapter devoted to the artillery in the "Rêveries" of Marshal Saxe, absolutely nothing is to be learned; and the Chevalier Folard was so engrossed with the wars and military machines of the Israelites, the Ammonites, the Greeks, and the Romans, that he had no time to devote to modern artillery.[5] The scanty information afforded us by Père Daniel, of the Society of Jesus, is intelligible, because he had little faith in modern artillery, and he openly says, "Il est certain que le canon, soit dans un siége, soit dans une bataille, tue ordinairement très peu du monde . . . Ce n'est pas une chose si certaine qu'il le parôit d'abord, que les Francoises combattant avec les armes des Romains dûssent être défaits par les Anglois, ou les Allemans, qui se serviraient d'armes à feu."[6] "Le Jésuite est excusable de l'avoir pensé," exclaims the author of the admirable "Essai sur l'usage de l'Artillerie,"[7] bursting with wrath at the flippant contempt with which the father treats the artillery, "il n'avait peut-être jamais vu tirer de fusil qu' à la chasse, et de canons qu' aux rejoüissances publiques." Other military writers treated the subject in the same manner as those I have mentioned, and the spirit which pervades the military literature of the age shows that field artillery occupied a mean and subordinate position in the line of battle.

The low estimation in which field artillery was held was owing, not to the weakness of its fire, but to its want of mobility; for there can be no manner of doubt that if, by a happy combination of good fortune and great exertion, the field artillery was dragged into the decisive position at the decisive moment, its fire was by no means ineffective. "Il est arrivé

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[1] "Mémoires de Montecuculli." Amsterdam, 1756, p. 53.

[2] "Mémoires du Marquis de Feuquières." Londres, 1736.

[3] "Mémoires d'Artillerie, tant par mer que par terre." Paris, 1697.

[4] "L'Art de la Guerre." Paris, 1749, Tom. I. p. 115. "Les troupes en France se distinguent, scavoir l'infanterie, en Francoise et l'étrangere; la cavalerie, en gendarmerie, cavalerie légère, et dragons."

[5] In the 1st vol. of the "Abregé des Com. de M. de Folard," p. 319, may be found a military plan of the "bataille sur deux fronts" delivered by the Israelites to the allied armies of the Syrians and Ammonites, accompanied (as usual) by an elaborate commentary.

[6] "Hist. de la Mil. Francaise," Tom. II. pp. 432, 436.

[7] Preface, p. xviii.

quelque fois dans une bataille," says Father Daniel, from whom such an admission could have been only wrung by undeniable facts, " qu'une artillerie, bien placée et bien servie, a beaucoup contribué à la faire gagner; mais pour l'ordinaire ce n'est pas par-là qu'on la gagne."[1] A glance at the military history of the time will dispel any doubt that may still hang round this point.

At Fontenoy, 1745, our unhappy infantry, massed in a deep column, were hampered in their movements and delayed under a shattering fire of cannon and musketry by their field pieces, which they had to drag by hand.[2] "We have not lost any colours, standards, or kettle-drums," says the "Gazette" of the day, "but have taken one standard; and the cannon lost was left behind for want of horses, the contractors with the artillery having run off with them so early that they reached Brussels that day."[3]

At Preston Pans, in the same year, the guns were not served by regular gunners, but by seamen, "hastily collected from the ships;" and when Lochiel led the Camerons and Stuarts straight on the guns, "the countrymen whose horses had been seized to bring them into position ran away."[4]

Seven guns were lost at Falkirk in the following year. "At the beginning of the engagement," says the "Gazette Extraordinary" of the 23rd January, 1746, "the horses of the artillery ran away, and some of the dragoons in the left wing immediately gave way, as did some of the infantry in the same wing." "Of our cannon," says General Wolfe, who was present,[5] "not one would have been lost if the drivers had not left their carriages and run off with the horses."

In India, where the country is generally favourable for the movements of artillery, field guns were as ill able to keep pace with infantry as in Europe. In a battle fought between the French and English near Tritchinopoly in 1753, "the English, for more expedition, marched without any field pieces;" and when the infantry advanced against the French in an action fought shortly afterwards, "the artillery in the hurry could not keep up with the battalion."[6]

The conduct of some Prussian drivers at the battle of Zorndorf, 1758, was so disgraceful, that Frederick the Great at once issued orders that when the guns were in action the teams and limbers should be taken charge of by cavalry officers specially detailed for this duty.[7]

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[1] "Hist. de la Mil. Francaise," Vol. II. p. 432.

[2] Carlyle's "Hist. of Friedrich the Great," Vol. IV. p. 118.

[3] Whitehall, 11th May, 1745, in the "Annual Register."

[4] Cust's "Annals of the Wars of the 18th Century."

[5] Wright's "Life of General Wolfe." It is satisfactory to know that Capt. Koningham, who had charge of the artillery drivers, and who led them in their flight, did not belong to the Royal Artillery. No such name is to be found in "Kane's List." It is not true, as stated in Ray's "Compleat History of the Rebellion," 1749, p. 265, that Capt. Koningham committed suicide and "made his escape by going out of the world;" for the "Annual Register," Vol. XVI. p. 168, proves that he was shortly afterwards dismissed from the service with ignominy by sentence of Court Martial, his sword being broken over his head in presence of the whole army.

[6] "Hist. of the Military Transactions of the British Nation in Indostan," Vol. I. pp. 312, 368.

Von Troschke, p. 33. "Abweichend von der bisherigen Regel, der Geschütze im Gefecht durch Menschen zu bewegen, hatte man seit einiger Zeit versucht, die Gespanne mit ins Feuer zu nehmen. Bei der Beschaffenheit der Knechte, welche auf alle mögliche Weise zusammengerafft und aus Kriegsgefangenen gepresst waren, ist es nicht unerklärich, wenn dieser Tross beim plötzlichen Vorbrechen der russischen Kavallerie nicht stand hielt. Unglücklicher Weise wurde

It was as clear to soldiers then as it is now that mobility was impossible until the weight of the guns and carriages was considerably reduced, and until the drivers were to some extent organised; and the disasters of the artillery called forth loud, although unheeded remonstrances. "'Tis surprising," says a writer in the "Annual Register," referring to the battle of Falkirk,[1] "as this is not the first loss of artillery by bad horses, or by the country people going off with the horses, that one out of several remedies that might be thought of is not provided against suffering again by such defects. . . . But it seems the *old way* is supposed to be *the best;* without explaining whether the good old way be that of staying for the cannon till the enemy gets off, or that other of leaving it behind when the enemy comes on. . . . Horses of strength ought to be as much bought up and appropriated to draw a train of artillery as for carrying our troopers and dragoons,[2] and the drivers ought to be enlisted under the military oath. . . . Several other methods, slighted as irregular (though on that account the more useful) might be mentioned; but it may not be proper, lest we should be first taught the use of them at a multiplied expense from the wisdom of our enemies, who have catched at inventions disregarded here, and whose principles of economy do not condemn the extravagant practice of having two anchors to a ship." But these just complaints fell upon dull ears. Ignorance and obstinacy ruled where liberality and wisdom should ever reign, and the artillery was hardly more disorganised than the infantry and cavalry. "As to the English army," says Mr. Carlyle, writing of this melancholy period of our military history, "we may say it is, in a wrong sense, the wonder of the world, and continues so throughout this History, and further! Never before, among the rational sons of Adam, were armies sent out on such terms—namely, without a General, or with no General understanding the least of his business. The English have a notion that generalship is not wanted; that War is not an Art, as playing chess is, as finding the Longitude and doing the Differential Calculus are (and a much deeper Art than any of these); that War is taught by Nature, as eating is; that courageous soldiers, led on by a courageous Wooden Pole with a Cocked Hat on it, will do very well. In the world I have not found opacity of platitude go deeper among any people."[3]

Such was the state of things on the eve of the creation of horse artillery.

ALDERSHOT,
July, 1870.

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die Infanterie dadurch in Verwirrung gebracht und das Resultat des sonst so herrlichen Sieges verkümmert.

"Der König (Frederick the Great) gab in Folge dessen der Artillerie Kavallerie-Kommandos, um die Gespanne in Ordnung zu halten."

[1] Vol. XVI. p. 28.

[2] Before the breaking out of the Great Rebellion, the price of horses in England varied from 30s. to 50s. In 1643 it had risen to £4. (See Warburton's "Hist. of Prince Rupert and the Cavaliers," Vol. I. p. 291). From the Pretender's Proclamation to the Commissary of Supply for the Shire of Linlithgow, 30th Dec. 1745, it appears that the price of horses for military purposes was then £10. In Charles I.'s time, money was three times as valuable as at the present day.

[3] "Hist. of Friedrich the Great," Vol. III. p. 121.

A PROPOSAL FOR A

VERY HEAVY BREECH-LOADING GUN

OF NOVEL CONSTRUCTION.

A PAPER READ AT THE R.A. INSTITUTION, WOOLWICH, APRIL 12, 1870,

BY

CAPTAIN J. P. MORGAN, R.A.

Colonel W. J. Smythe, R.A., in the Chair.

In making a proposal for a new gun, it is necessary to prove three things :—

1. That a new gun is needed.
2. That it is not advisable to make it on any of the present systems.
3. That it ought to be made on the system I now propose.

I. *Necessity for a very Heavy Gun.*

In order to shew the necessity for a very heavy gun, I cannot do better than quote from the very interesting book on "Our Iron-clad Fleet," by Mr. Reed, the Chief Constructor of the Navy. Talking of the "Hercules," he says, at page 30 :—

> " The total thickness of iron (neglecting the girders and frames) is 11¼ ins., and of this 9 ins. are in one thickness; the teak backing has a total of about 40 ins. The trial at Shoeburyness of a target constructed to represent this part of the ship's side, proved that it was virtually impenetrable to the 600-pr. gun; and perhaps no better idea of the increase of the resisting power of the sides of our iron-clads can be obtained than that derived from a comparison of the 68-pr. gun, which the 'Warrior's' side was capable of resisting, with the 600-pr. tried against the 'Hercules' target. But the limits of the thickness of armour carried must not be considered to have yet been attained. Coast defence vessels and rams are being built to carry 11 and 12-inch armour; the new turret ships 'Thunderer' and 'Devastation,' lately designed, will carry quite as great thicknesses, and ships have been designed for sea-going purposes, and may yet be constructed, which are to carry even 15 ins. of armour. There can be little doubt that, as improvements are made in the manufacture and working of heavy guns, corresponding additions will be made to the resisting powers of iron-clads built. It is hardly possible to foresee in what way the competition between guns and ships will terminate; but,

having the experience we possess of the successful accomplishment of what only a few years ago were regarded as impossibilities in the construction of iron-clads, it would be folly to set a limit to the results that will be attained in the future. The Admiralty have long been in possession of a design for a turret-ship with sides plated with 15-inch armour, and turrets with 18-inch armour. I have also prepared outline designs, not on extravagant dimensions, to carry 20-inch armour, both on broadsides and on turrets."

Mr. Reed also quotes from Captain Scott, R.N., in a foot note, page 58:—

"At the Royal United Service Institution, in 1863, Captain Scott made the following interesting remarks:—'The size of the gun is of vast importance—more than is generally assigned to it—and for this reason: 20 guns, each a 1-pr., are fired at a target 1½ ins. thick, and produce no effect; one gun, a 20-pr., is fired and smashes it; the velocities in both cases being equal, in both cases the same amount of metal is used; and on this principle an official record of experiments at Portsmouth states that one 68-pr. produced more destruction than five 32-prs. Arguing thus, it appears that one 150-pr. is more effective than ten 68-prs., one 330-pr. is equal to seven 150-prs., and a broadside of three 330-prs. is more destructive than 10½ 'Warriors.' In this last statement the 'Warrior's' broadside is taken at twenty 68-prs.'"

Arguing thus, I may say that a ship carrying two 1200-prs. would be nearly equal to one-half of the British Navy.

II. *The present Systems of Gun Manufacture.*

A very heavy gun, therefore, being necessary, let us examine the sufficiency of the present systems for producing it.

1. PRELIMINARY REMARKS.

a. Longitudinal Strain.

The two great strains to which a gun is subjected are the longitudinal and the circumferential. Of these, the latter is undoubtedly the greater, but the former is that which has given most trouble to know how to meet it.

Mr. Rigg, C.E., in the end of 1867, read "A paper on the connexion between the Shape of Heavy Guns and their Durability," before the Society of Engineers, in which he shows that the mass of the breech is of great importance in meeting the difficulty.

He says, at page 3:—

"If the breech, or that portion of the gun behind the base of the bore, be heavy, it opposes a considerable resistance to the shot, absorbs the force of the blow, and so reduces the longitudinal strain upon the barrel. If the breech be light in weight, the first impact is delivered upon a mass of metal, perhaps not greater than the shot itself. The breech in this case does not absorb the blow, but transmits it at once to the barrel. Time is not given for so heavy a mass to begin its recoil; the longitudinal strain is greater than the tenacity of the metal will bear, and fracture is inevitable. It may happen that the breech is blown off, or that the barrel bursts; but in either case it is the double cross strain that causes great weakness, and any means by which either of them can be reduced will not fail to be beneficial.

"The relief which a heavy mass affords in receiving and absorbing the force of a blow, admits of many familiar illustrations. The different feelings with which a heavy or a light stone may be struck when held in the hand are well known, but perhaps the most singular instance of this law may be found in a case which excited much wonder in the last generation—namely, that of a man who was accustomed to exhibit himself sustaining a very heavy stone on his chest while lying on the floor. Several large sledge-hammers were freely used upon the stone, but although so much force was applied, there was no injurious effect upon him who submitted to such an ordeal. The relief afforded by simple weight in these examples gives just the same immunity to a gun. Such a conclusion would lead to the inference that the greatest durability will be associated with the heaviest breech, and the following examples will prove this deduction to be well founded."

Mr. Rigg gives illustrations of various guns in support of this idea, and mentions specially that at the siege of Charleston—

"One gun, a 30-pr., showed most extraordinary and unique powers of endurance. Through some accident in its construction, the wrought-iron reinforce was shrunk firmly on the breech, and not on the body of the gun; consequently its weight and inertia became available to resist the first impact of the discharge; the longitudinal strain was thereby diminished, and the gun relieved from much of its usual load. . . . .

"After firing 4606 rounds, this gun burst into seven pieces." . . . .

Mr. Rigg also quotes from Major Palliser as follows, page 11:—

"The same idea lurks in the following remarks by Major Palliser, although the last sentences contain the gist of the whole argument:—'There are two ways in which a gun can burst—viz., by the bursting of the barrel, or by the end being blown off. In an ordinary cast-iron gun, the whole longitudinal pressure acts on the end of the bore. If the bore be 8 ins. diameter, this pressure will, in round numbers, be distributed upon 50 square inches. If, however, the gun be bored up to 13 ins. and lined with a barrel 2½ ins. thick, the longitudinal pressure will act upon 50 square inches, as before, but will be transferred to a surface of about 130 square inches, and thus the longitudinal strength of the gun becomes more than doubled. In fact, every way of regarding the subject shows that the circumferential strength should be applied internally, and the longitudinal strength should be borne by the outside; and this is precisely the reverse of the principle upon which the wrought-iron guns of the service are made.'"

Mr. Rigg adds:—

"The idea of separating the forces into circumferential and into longitudinal is very correct in theory, and practical, as well as the assignment of a special share of duty to each part of the gun. . . . .

"In conclusion, it is evident that there can be no reason why English guns shall not always reliably exhibit the same endurance that was shown by the solitary Parrott gun that bore 4606 rounds. It is simply a question of correct principles of construction, and if it be desired still further to enhance the powers of the guns which Major Palliser has begun so well, the question of longitudinal strain is that to which attention must be given."

These remarks by Mr. Rigg are very valuable, and it is to this very question of longitudinal strain that my proposition is mainly directed. Allow me, however, before stating what my proposition is, to shew you that the longitudinal strain, in addition to the injury it causes in itself, also injuriously affects all the endeavours in the present systems of gun manufacture to meet the

β. *Circumferential Strain.*

In Fig. 1, the solid lines represent the inner and outer surfaces of a hollow cylinder before extension—the dotted lines after extension. Supposing the most favourable case of the metal being perfectly dense, the area between the two solid lines will equal the area between the two dotted lines; and the area between the inner solid line and its dotted line will equal the area between the outer solid line and its dotted line. But as the outer area is further removed from the centre than the inner, its length is greater, and consequently its breadth less in proportion. The absolute amount of extension of the outer surface will thus be to that of the inner inversely as their radii. Owing, however, to the greater length of outer area, it is capable of extending more instead of less in proportion to the radius. The total proportionate extension, therefore, of outer to inner surface is inversely as the squares of their radii; and as the tension increases directly with the extension, the tension or useful effect decreases as you recede from the centre, and is inversely as the square of the distance from the centre.

If the metal be not dense, the decrease is even more rapid than this.

Fig. 2 represents the tensions at different distances from the centre on the principle above stated. The horizontal distances are the distances from the centre, the vertical distances are the tensions. Notice how rapidly the tension diminishes as the thickness increases, when the radius is small.

The following equation shows the actual amount of useful effect which can be obtained by one thickness of metal, as compared with what it would be if all the metal could be made to do its work:—

Let r be the radius at any point,
t be the tension at that point,
a be the internal radius,
b be the external radius,

$$T \text{ (total useful effect)} = \int_a^b \frac{m}{r^2}\,dr$$

$$= -\frac{m}{r} \text{ between limits } a \text{ and } b$$

$$= m\left(\frac{1}{a} - \frac{1}{b}\right) = \frac{m}{ab}(b - a).$$

If the tension were uniformly equal to that at a, it would give a total strength $\frac{m}{a^2}(b - a)$. Therefore $\frac{\text{actual tension}}{\text{total strength of metal}} \; \frac{\frac{m}{ab}}{\frac{m}{a^2}} = \frac{a}{b}$. So that the value of any hollow cylinder may be represented by the ratio of its internal to its external diameter multiplied by its thickness. The more nearly this ratio is unity, the greater will be the proportion of work obtained; also, as the calibre increases, so may the thickness be advantageously increased.

By taking the internal radius as the unit of thickness, we can readily see the very small addition of strength which is gained by increasing the thickness. A thickness of $\frac{1}{2}$ calibre gives a strength of $\frac{1}{2}$ of $\frac{1}{2}$ calibre; a thickness of 1 calibre gives a strength of $\frac{1}{3}$ of 1 calibre or $\frac{2}{3}$ of $\frac{1}{2}$ calibre; a thickness of $1\frac{1}{2}$ calibres gives $\frac{3}{4}$ of $\frac{1}{2}$ calibre. So that we have $\frac{1}{2}$ for the first $\frac{1}{2}$ calibre, $\frac{2}{3} - \frac{1}{2}$ or $\frac{1}{6}$ for the second $\frac{1}{2}$ calibre, $\frac{1}{12}$ for the third, and so on; the total is therefore $\frac{1}{2} + \frac{1}{2.3} + \frac{1}{3.4} + \frac{1}{4.5}$ + *ad infin.* for an infinite thickness. Now, as the sum of this series can never reach unity, it follows that, even with an infinite thickness, we can never obtain as much useful effect as we shall from $\frac{1}{2}$ calibre of thickness if all the metal could be made to do its work. This law is fatal to a very heavy gun ever being made of one homogeneous piece of metal.

2. Armstrong Guns.

It was for the reason above stated, that Sir William Armstrong gave initial tension to the successive coils adopted in his system, so that, if properly arranged, they should have all their interior surfaces at their greatest tension at the moment of maximum strain. The great amount of strength gained by this method will be seen in Fig. 3, which represents a 9-inch gun, on the Armstrong plan, with all the coils extended so that the inner surfaces are all at the elastic limits of the iron. The area below the continuous curve is all the strength that could be obtained if the whole gun were of one piece. The areas between the continuous and discontinuous curves are the additional strengths obtained by initial tension. It will be noticed that more waste power is rescued as the distance from the centre increases. But this also involves greater initial tension; and for this purpose, at one calibre thickness, the initial tension must be eight-ninths of the strain the coil is to bear. If so much initial tension as this is put on, there is a danger, on the one hand, of overshooting the mark and overstraining the coil so much that it may break; and this was actually the case in a 600-pr. which burst one of its coils, while the barrel and all the other coils remained sound. On the other hand, if too little tension be put on, it may so happen that the iron beneath is more compressible than usual, and the greater part of the tension may be absorbed without compressing the bore. These two dangers both increase as the thickness of the metal increases; and, for this reason, Major Palliser's remarks are very appropriate—viz., that the circumferential strength should be obtained as near the bore as possible. This useful maxim, however, cannot be carried out in the Armstrong gun, on account of the breech-piece, which surrounds the most vital point at the powder chamber (see Fig. 11). The breech-piece has its fibre arranged longitudinally, for the sake of longitudinal strength, and gives in consequence, circumferentially, only half the strength coiled iron would give, inasmuch as iron across the fibre is only half as strong as it is along the fibre. The breech-piece, also, is very thick, and undergoes a still further loss of strength on that account. Altogether, we can only count on one-half of the tension of bar iron for the inside of the breech-piece, and something like one-sixth or one-eighth for the outside, and on a total strength of not much more than one-fourth of the useful effect of the iron. In Fig. 3, the shaded portion of the diagram shows how much strength is lost.

When we come to the outside coils, the conditions are apparently much more favourable, for there seems to be very little strength lost. But these coils are far removed from the bore, and, as we have seen, there is not the same certainty of their doing their work as there would be if they were near. Also, since the bursting of the 600-pr., the initial tension has been very much reduced, and the same amount is not now given, as shown in the diagram. Owing to the large diameter of these coils, they are expensive to make, so that this is not an economical way of getting up the strength.

Another fault may be added. The longitudinal strain is, to a considerable extent, borne by the steel barrel, contrary to Major Palliser's principle and Mr. Rigg's objection to the cross strain on the bore. It is, however, to be remembered that, at Elswick, these guns were first made with a loose end, which avoided the cross strain on the bore, and threw all the longitudinal strain on the breech-piece. The advantage thus gained is, however, very questionable; for if the longitudinal strain be not partly borne by the steel tube, it is necessary to have a thicker breech-piece, which leads to even greater errors, as we have seen. None of these guns are now made with loose ends, but they are sometimes made at Elswick with thinner breech-pieces.

3. Fraser Guns.

a. With one Triple External Coil.

Fig. 12 shows the first pattern that was made without a longitudinal breech-piece. So far, this is a very important step; for if the gun be all coiled iron, it will much better resist the most dangerous circumferential strain. In the construction of this gun there has evidently been a due regard paid to longitudinal strain, as well as to economy; for there is a good thick steel tube, as well as a very thick coil, brought to bear on it. If the thick coil be properly welded, the longitudinal strain may be fairly considered as met.

But mark the other objections which this involves. Owing to the great thickness of the external coil, $\frac{2}{5}$ of its useful effect only can be obtained for circumferential strength, seeing that the internal and external diameters are as 2 to 5. Also, on the one hand, if the welds are not properly made, there will be a deficiency of longitudinal strength; and, on the other, if to make sure of longitudinal strength the iron be strongly heated, there is a danger of the iron becoming deteriorated by overheating. These are the two dangers which have to be avoided in manufacture; and though, with one exception, they may have been successfully avoided, a great risk is run should there be any carelessness, especially when it is considered that there is only one coil to depend on.

On the subject of overheating iron, Dr. Percy says, in his "Metallurgy, Iron and Steel," pp. 8–10 :—

"The crystallisation of iron has excited much attention, especially amongst engineers; and although much has been talked and written about it, yet no small confusion respecting it still prevails. However, a careful examination of the subject will tend to remove this obscurity. Bar iron acquires a largely crystalline structure by long exposure to a temperature which, though high, is yet very far below the melting points of the metal. On the application of a certain amount of heat, the particles have sufficient freedom of motion to arrange themselves in crystals. We have previously had a striking illustration of this fact in the annealing of sheet zinc, at a temperature bordering on, yet sensibly below its melting point. Hence we can readily understand why iron which has been frequently and strongly heated, or iron which has been forged into large masses, and which must necessarily have been subjected during a considerable time to a high temperature, should tend to become largely crystalline in structure. The operation of hammering iron while strongly heated and during cooling, to a certain degree will obviously interfere with the action of the forces which determine crystalline arrangement, and may consequently be expected to diminish the size of the crystals. But in the case of large masses, it will be difficult to affect the metal far below the surface, unless a very heavy hammer is employed, and very powerful blows are applied; and even then it is hardly possible to conceive that uniformity in the size of the crystals should be produced through the mass. For, when the exterior may be cooled down to redness, the interior must still be at a much higher temperature—it may be white hot; so that on subsequent cooling, after the cessation of the blows, the particles in one part of the mass will be in a condition to assume a more largely crystalline structure than those in another part. It is this which constitutes the difficulty in large forgings; and it cannot be overcome by continuing the hammering until the metal in the interior is sufficiently reduced in temperature to prevent the formation of large crystals in that part; for if the metal on the exterior were hammered at too low a temperature, as would certainly be the case in the condition supposed, it would become brittle and tender. It must be borne in mind that these remarks relate to iron, and not to steel, or iron containing any sensible proportion of carbon. With reference to the size of the crystals, it should here be stated that the presence of phosphorus favours the formation of large crystals; and this element occurs in most commercial varieties of British iron. The rapid cooling of large forgings by immersion in water, might be expected to render the interior less largely crystalline.

"When iron is hammered cold—especially in various directions—the crystals of which it consists will obviously become more or less disaggregated, and therefore the strength of the metal will be diminished. The larger the crystals, the more easily will the iron break; for, as fracture will occur in the direction of least resistance, which is that of the cleavage planes, and of the planes of junction of contiguous crystals, it will be facilitated in proportion to the size of these planes. I have buttons of fused iron, in which the crystals are so large, that the cleavage planes extend completely across the fracture. On the other hand, when the crystals are comparatively small, they are, so to speak, more interwoven with each other; there are no large cleavage planes, and consequently there is less tendency to fracture. Whether the foregoing considerations be correct or not, it is well established in practice that largeness of crystal in a bar of iron indicates facility of fracture."

Mr. Kirkaldy's 56th concluding observation on experiments on wrought-iron and steel is:—

> "Iron is injured by being brought to a white, or welding heat, if not at the same time hammered or rolled."

My own experience corroborates these views. While employed in the duty of inspecting the conversion of guns at Elswick, on Major Palliser's system, a portion of one of the tubes got accidentally overheated, and the fault was not discovered until the tube was tested by water pressure of 3 tons to the inch before being put into the gun. It then broke into two pieces, and on examination the fracture was found to be largely crystalline, as described above by Dr. Percy.

There is another objection, which must always hold good against these very thick coils. It is claimed in the Armstrong system that, if the interior of a coil be cooled more quickly than the exterior—and that is always done by water from the centre during the building up of the gun—the interior will be in a state of compression, while the exterior is in a state of extension, so that a more regular succession of tension obtains than by steps from coil to coil. The increased temperature from which the coil is cooled after forging, will make this law act more powerfully in the case of the Fraser coil. It will cool from both outside and inside; so that both outside and inside are in a state of compression, while the interior is in a state of extension. The tendency is thus to separate into two cylinders, the outer of which will not support the inner.

This tendency is very much increased if, after once cooling as above, it be again heated and cooled; for the second heating commences at the surface, and causes it to swell out before the interior is softened. The internal extended portion remains as it was, and, on the whole mass again cooling from the surfaces, the bad effects double themselves. I have seen a case of this. A large Morrison hammer was being made. A Saturday night intervened, and it was allowed to cool in a half-finished state. On Monday it was again heated and completed, but on being turned, it was found to contain a hole in the interior so large that it had to be condemned. This second heating happens in the thick Fraser coil; for the trunnion-piece, with its fore and after coil, having been made separately, are all allowed to cool. They are then joined together, all heated a second time, and welded into one piece.

If we consider all these various objections, it is not surprising that one of these guns should have burst at proof.

β. Pattern with two External Coils.

Fraser's latest pattern, Fig. 13, is perhaps as good a pattern as is ever likely to be arrived at for 9-inch guns, unless the system which I am about to propose, and which introduces an entirely new principle, be adopted. It has no prominent faults. All the difficulties are so evenly balanced, that it is hardly possible to improve on it. None of them are, however, removed, and any serious fault in manufacture might bring one or other into prominent play. Instead of the thick coil, we have two thinner coils. Thus, very much strength is gained by the second shrinkage, as shown by a comparison of Fig. 5 with Fig. 4. There is much less risk from overheating, and from second heating; for the inner coil is thinner, and not joined on to the coil in front. The outer coil is still heated a second time; but not being thick, and, besides, being outside, the danger is not so great. There is a slight disproportion in the increasing thickness of the coils, as shown in the diagram. The first might be slightly thinner with advantage, if circumferential strength only be considered, but this might detract from the longitudinal strength.

Captain Stoney, R.A., Assistant-Superintendent Royal Gun Factories, appears to be aware of the risk run, for he says in Vol. VI. page 411, of the "Proceedings of the Royal Artillery Institution:"—

> "With respect to the precise pattern for future construction, it would perhaps have been the safest course to have continued firing No. 332 gun (of the pattern under consideration), and then if it did not blow its breech off (its tube being so thin), or burst explosively without giving ample warning, to adopt it as the pattern for all the heavier natures. The authorities, however, have decided on constructing 7-inch and 8-inch guns as before, on the No. 368 type (the pattern with triple coil), but to make 9-inch guns and upwards on the 332 type."

Thus the principle is recognised that the heavier the gun, the greater the necessity for coming to true scientific principles of construction; for as the size of the gun increases, our power is tested to confine and restrain the enormous pressure which is called into play. With the heaviest gun no fault can be tolerated. Though I admit that the Fraser gun is well suited for 9-inch guns, and guns even much bigger may be made on this principle, especially if the pressure of the gunpowder be reduced, yet I do not believe that it is capable of supplying the heaviest gun that can be made. It may stand up to a 1000-pr., but I am doubtful of its being able to exceed this, for the following reasons.

From Captain Stoney's remarks it may be inferred that, on account of the longitudinal strain, it will not be safe to reduce the proportion of thickness of the first coil. It will be necessary rather to increase it; for the pressure of the gunpowder on each square inch of the base of the shot must of necessity increase, on account of the column of metal in front of each square inch of base increasing in length. With the 1000-pr., therefore, the actual thickness of this coil will be at least equal to that of the triple coil, which failed in the 9-inch gun. The proportion of power gained will thus be reduced. The danger, too, of Dr. Percy's law of crystallisation coming into play will increase. External compression will manifest itself, and the tendency to split into two cylinders.

4. Palliser Guns.

These guns will never be able to compete as heavy guns, but they afford a wonderfully practical illustration of the value of the laws I have noticed. Instead of having the outside contracted on the inside, the inside is expanded on the outside, and this can be done by using wrought-iron for the bore (see Fig. 14). If we take a 32-pr., whose internal and external radii are roughly 3 ins. and 10 ins. respectively, we have a strength of $\frac{3}{10}$ of 7, or 2 ins. of cast-iron. But if the internal radius be bored up to 5 ins., and a wrought-iron tube 2 ins. thick be put in place of the cast-iron bored out, we have, for the strength of the remaining cast-iron, $\frac{5}{10}$ of 5, or $2\frac{1}{2}$ ins. So that the cast-iron is actually stronger than it was before. The strength of the wrought-iron tube has to be added, so that these guns are probably at least twice as strong as they were before conversion for circumferential strain. See Fig. 6, where the unshaded portion represents the strength before conversion. The slightly shaded part represents the gain by conversion.*

III. *New Proposed Pattern.*

I have now to examine the pattern proposed by myself, and to show that it is the system which ought to be adopted for very heavy guns.

The principle consists in receiving the longitudinal strain on a solid block of metal not rigidly connected with the rest of the gun. There is thus no longitudinal strain on the gun, and consequently no cross strain on the bore. Mr. Rigg's views are thus perfectly met. Major Palliser's maxim is also fully carried out; for, the longitudinal strain being entirely removed, it is quite easy to turn our whole attention to getting circumferential strength as near the bore as possible. The iron can be used in the best possible condition, and under the best form of arrangement. I have already noticed that near the bore the coils ought to be thin, but that they may increase in thickness towards the outside. A reference to Figs. 7 and 15 will show how this is carried out. About one-fourth only of the useful effect of the iron is lost. In addition to this, the iron need not be over-heated. All the coils may be made short, and the inner ones could be well hammered, which is a matter of great importance. They could even be rolled out like tyres of railway wheels. The outer coils, which are thicker, could, without danger, be on the side of under-welding rather than over-welding. Their shortness would be favourable to perfect manufacture, and at least the two ends of each coil would always be sound. No second heating is necessary; so that there would be no tendency to form cavities in the iron, or to split into two cylinders.

Sir William Armstrong last year, in his address as President of the Manufacture Institution of Mechanical Engineers, at the Newcastl meeting, says:—

> "Krupp and Whitworth—both great names in gunnery—though differing widely in their views in other points, agree in this, that steel is the right material for the entire gun. I, on the other hand, have always advocated wrought-iron in the form

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* The diagram is to be considered as representing strength, and not elasticity. Cast-iron is quite as elastic as wrought-iron, or more so; but it is probable that wrought-iron, owing to its malleability, allows the tube to be extended beyond its elastic limits without rupture or great loss of strength.

of welded coil for the chief mass of the gun, limiting the use of steel to the internal tube, which has abrasion to resist, as well as tensile strain. The expression of my opinions upon this point may, probably, not be considered impartial; but I will, nevertheless, state the grounds upon which my preference of wrought-iron, thus applied, is based.

"It has been found both in Elswick and Woolwich guns, that whenever failure takes place, it almost invariably originates with that part which is made of steel. It is the steel tube which is nearly always the first to crack. So also when the vent-pieces, or closing blocks of the breech-loading guns were made of steel, their fracture was alarmingly frequent; but since wrought-iron has been substituted, such occurrences are rare. The conclusion, therefore, at which I long since arrived, and which I still maintain, is that, although steel has much greater tensile strength than wrought-iron, it is less adapted to resist concussive strain. This conclusion is in strict harmony with the fact that armour-plates made of steel have proved, on every occasion of their trial, greatly inferior to plates of wrought-iron. The experiments which I made some years ago, on the toughening of steel in large masses by immersion, when heated, in oil, led me to expect that this fragility would be obviated by that process; and I felt sanguine that I should be able by such treatment to produce steel armour-plates of extraordinary resisting power. An armour-plate of steel was accordingly manufactured for experiment, and was tempered in a large bath of oil. Its quality was tried by test pieces cut off after tempering, and proved by tension and bending. The result showed a very high tensile strength, combined with so much toughness that I was unable to match its bending power by any sample of iron I could compare with it. The plate was then sent to Portsmouth for trial, in the fullest confidence of its success, but two shots from a 68-pr. sufficed to break it in various directions, and it was justly pronounced a failure. With these experiences before me, it is impossible that I can hold any other opinion than that the vibratory action attending excessive concussion is more dangerous to steel than iron; and were it not necessary to provide a harder and more homogeneous substance than wrought-iron for the surface of the bore, I should entirely discard steel from the manufacture of ordnance."

I do not wish to trench on the much-vexed Armstrong and Whitworth controversy, but in investigating this subject I have arrived at a very curious result. Fig. 8 represents my gun made wholly of steel. The lower margins of the faintly shaded portions give the strains on the gun in its natural state. Above the horizontal line is the tension, below the compression. The tension must balance the compression, and therefore, on the supposition that within the elastic limits the tensile and crushing strengths are equal, the area above the line is equal to that below. OA and OA' are the elastic limits of iron; OB and OB' of steel. The compression area is necessarily limited, so as not to exceed the elastic limits of the metal at the bore. The amount of tension must therefore also be limited, and the result is that, when the whole are extended, the outer coils are by no means strained to their utmost.* If the crushing strain were greater than the tensile

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* Even in the Armstrong gun, with steel tube and wrought-iron coils outside, it is not possible to put any great amount of shrinkage in the iron coils; for it is invariably found that at proof the steel tube not only becomes diminished in diameter, but also springs forward at the muzzle, thus shewing that it has taken up a new position, in which its compression balances the initial tension of the wrought-iron coils. The fact that both these guns and the Fraser guns stand heavy firing after the steel tube has failed, is thus readily accounted for.

strain, the conditions would be more favourable; but in the case of wrought-iron, where the crushing strain is less, the conditions would be less favourable. It would not, therefore, be advisable to discard steel entirely from wrought-iron guns. There must be some strong metal to bear the crushing strain which initial tension brings on the bore. It is not necessary, however, that the steel be at the bore itself. It may be used much more advantageously in the second course.

Fig. 9 represents my gun with the second course of steel in the region of the powder-chamber. The result shows much greater strength. In calculating the strength, it is necessary to multiply the steel area by 4, as the elasticity is only half, while the tenacity is twice that of wrought-iron.

Fig. 10 shows both 2nd and 3rd courses of steel. The result is equally satisfactory.

The absolute mathematical strengths of these three constructions may be given in the order in which they have been considered, as 9, 8, 10. This, however, does not take into account any errors of manufacture, which will tell more severely against steel than iron, as an error of $\frac{1}{10000}$th in dimensions represents a loss of 1 ton per square inch in iron, and 4 tons in steel.

In the all-steel construction, there would be no gain by increasing the thickness of metal beyond 1½ calibres. It might be made in two pieces, the inner ½ calibre, and the outer 1 calibre thick, giving ½ of the useful effect of the metal. The explosion would thus be resisted by steel, equal in value to 1½ times the dimensions of the bore; and thus by working the steel up to 20 tons, or its elastic limits, the pressure in the bore might be 30 tons, if gradually applied. A large reduction, however, has to be made on account of the suddenness of the strain, as shown in the following calculation:—

Let P = pressure in the bore suddenly applied, *i.e.*, uniform during the time of expansion.
r = radius of bore.
s = space described from the centre by the mass of metal m, in the time t.
T = tension caused by the extension of the metal, and which, varying with s, may be put $= \mu\, s$.

We have—

$$P = \frac{T}{r} + m\,\frac{d^2s}{dt^2}$$

$$= \frac{\mu s}{r} + m\,\frac{d^2s}{dt^2}$$

$$2\,\frac{ds}{dt}\,\frac{d^2s}{dt^2} = 2\,\frac{P}{m}\,\frac{ds}{dt} - 2\,\frac{\mu s}{rm}\,\frac{ds}{dt}$$

$$\left(\frac{ds}{dt}\right)^2 = 2\,\frac{P}{m}\,s - \frac{\mu}{rm}\,s^2$$

$$= 2\,P\,\frac{T}{\mu m} - \frac{T^2}{\mu r m}$$

Now, when T is a maximum,

$$\frac{ds}{dt} = O,$$

$$\therefore 2\ P = \frac{T}{r};$$

i.e., in accordance with the rule laid down by engineers, we can only meet half the pressure when it is suddenly applied.

The Gunpowder Committee gives, with the new gunpowder, the maximum pressure in guns of 8 ins. calibre as 15 tons per square inch, and not suddenly applied. With a 10-inch gun, the pressure is about 24 tons. Supposing it, therefore, to be 15 tons suddenly applied, or 30 tons slowly applied, to cover any margin of error in calculation or manufacture, or to allow an extension to heavier guns, the result is that a steel gun would be worked up to its elastic limits of 20 tons per square inch. Now, it is laid down in engineering, that in no case will metal stand 900 vibrations, if worked up to its elastic limits, or one-half its breaking strain; but, if worked up to one-third of its breaking strain, 10,000, or even 100,000 vibrations will produce no visible bad effects. A wrought-iron tube reduces the diameter of the bore nearly one-third, without affecting the useful employment of the steel behind it, and the possible effect might be that it would give the necessary safe margin within the elastic limits, and thus produce a beneficial effect out of all proportion to the reduction of strain which it would cause. Taken in connection with the new gunpowder, it might therefore increase the endurance even of very heavy guns from 1000 or 2000 rounds to 10,000, or even 100,000, if the bore were renewed so as not to wear out.

These good results are owing to the great elasticity of wrought-iron, which, if used for the bore, not only allows a greater thickness of steel to be employed advantageously behind it, and, as a consequence, greater initial tension, but also brings into play twice the extra tension beyond the initial tension. There seems to be nothing to prevent this plan being carried out with heavy guns, if my system of construction were adopted; for a hard surface would not be necessary with lead coating, and the absence of longitudinal strain would make the welds safe. My gun might thus be made a Palliser gun of enormous strength, and the amount of steel which it is possible to employ usefully would almost make it a Whitworth gun, while the coils, wrought-iron, and initial tension, make it essentially an Armstrong gun. It is a Fraser gun, too, with a thick outer coil, where a thick coil ought, and ought only, to be. The only novelty I claim is the new principle whereby it is possible to reconcile all these great authorities.*

Breech-Loading.

In addition to the advantage of great strength, breech-loading comes in as a most important element in the gain which will be obtained by this method of construction.

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* No doubt these advantages might be combined in any breech-loader which had a wrought-iron barrel and steel breech-piece, but not so effectually as in this gun. I may, however, claim the combination independently of my system of breech-loading.

Lead coating is the only method that has been used in our service with breech-loading guns, but it is not a necessary consequence; for we find that on the continent, where breech-loading prevails, though the Russians, Prussians, and Austrians use lead coating, the French do not. In deciding between these two systems, it is a point of great importance to know what is the maximum initial pressure of gunpowder in the bore. One of the chief dangers, in using lead-coated projectiles with very heavy guns, will be the stripping of the lead. It can hardly be doubted that the moment of first starting is that at which this is most likely to take place, when the shot begins to take the grooves, and when the pressure is the greatest. Not only does the pressure per square inch increase with the size of the gun, but another law acts adversely; for the mass rotated increases as the cube of the calibre, while the lead-coated surface which produces rotation increases only as the square of the calibre. We know, however, that lead coating is safe with a 7-inch gun and our present gunpowder. If the initial pressure can be reduced to one-half, a 15-inch gun could be made as safe in this respect as a 7-inch gun at present is. A committee is now sitting on the question of gunpowder, and has already issued a preliminary report showing that, by a modification of the size and shape of the grain, the initial pressure can be reduced to about one-half. This is for smooth-bore guns and windage. It would be very useful to know whether the same results hold good with lead-coated projectiles where there is rifling and no windage. The gun I propose would be a useful means of determining this; for, as designed for service, it will fire out its breech at the rate of 15 miles an hour. By reducing the size of the breech to one-fourth, it could be made to retire along a railway at the rate of 60 miles an hour; and, while it retired, a record could be obtained from it on a revolving cylinder, which would give a curve, continuous throughout, from which the spaces described in given times could be measured, and so the velocities and pressures deduced.*

Before adopting rifling by lead coating with a very heavy breech-loading gun, it would be necessary to know what is the initial pressure under the exact circumstances to be used. The initial pressure should be as much reduced as is consistent with the maintenance of initial velocity. In itself, however, lead coating has the effect of increasing the initial pressure; for it gives no relief by windage, and the compression and friction of the lead coating give considerable retardation, so as still further to increase the pressure. There is also to be added the resistance which is produced by the necessity of having an uniform twist. All these causes act, not only in a degree which can be mathematically calculated, but also, in an uncertain degree, by affecting the explosion of the gunpowder, so that nothing but experiment can be depended on.

Lead coating has one very great advantage. It is the best method of preventing windage; and, as windage has the effect of scoring the

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* This was suggested to me three years ago by the Rev. F. Bashforth, Professor of Mathematics to the Advanced Class of Artillery Officers at Woolwich.

bore of the gun to such an extent as to render the gun unserviceable from this cause alone, this is a matter of some moment. It would especially be an advantage with a very strong and heavy gun, such as the one I propose, for, as a rule, the bigger the gun the greater the scoring; and if the strength of the gun were such that it would wear out in this manner before bursting, this would be the point most requiring to be attended to. No doubt, with breech-loading, greater facility would be given for stopping the windage than in muzzle-loading guns, by using a tight-fitting wad between the powder and shot; but it would not do this so effectually as lead coating.

At present, windage has one advantage, owing to the difficulty of providing a suitable fuze for breech-loading guns. It is not probable, however, that this will long be a serious objection, now that attention has been directed to the difficulty. Captain Nolan and myself have proposed a method of using muzzle-loading fuzes with breech-loading guns, by making a channel through the projectile, so that the flash of the discharge may pass through and ignite the fuze.*

Construction.

I have dwelt at some length on these principles, because it is on them that I depend for the success of my gun. The mechanical details are merely the means of carrying them out, and may possibly have to be modified. They seem very simple and natural when embodied in this model, with which I was furnished by the kindness of Sir William Armstrong and Company, while employed at their works at Elswick. It took me fourteen years, however, to arrive at this result. What puzzled me most was to provide for the elevation. I first thought of having a joint between the plug which closes the breech and the weight which absorbs the blow; but that would soon have been smashed to atoms. The next idea was to butt the plug against a dead weight; but, from the varying elevation, the force would not have acted through the centre of gravity, which is a necessity with such an enormous pressure. The present idea is to make the plug and weight in one piece, and let it slide along bars which are rigidly attached to the sides of the gun.

When loaded, the gun is balanced on the trunnions with only a slight preponderance, sufficient to cause the breech always to rest on its carriage. Elevation or depression is given by running the breech carriage backwards or forwards.

When the gun is fired, the shot and breech move in opposite directions, with velocities inversely as their weights. The shot will thus have left the bore long before the breech is opened. The method of preventing any escape of gas at the breech is shown in Fig. 15, where a steel disc fits on to the front of the plug, and has a paper wad in front of it. This will become tightly jammed so long as the pressure of gas acts on it, and will afterwards be withdrawn by the momentum of

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* This experiment has since been carried out successfully at Shoeburyness.

the breech.* The breech-carriage also recoils, and this, together with some play between the breech and the bottom of the guide bars, prevents any alteration of elevation during the instant of firing.

The weight of the breech is kept as small as possible, and this no doubt will have the effect of reducing the amount of pressure of gas on the shot; but it will only be to a very slight extent. I have taken the breech as fifty-six times the weight of the shot; so that the pressure would be about 1 per cent. less than in ordinary guns, which are about 112 times the weight of the shot. The initial velocity of recoil will thus be twice that of an ordinary gun, and this would require four times the amount of resistance to pull it up in the same space. Twice the resistance, however, would pull it up in double the space; and I propose doing it in this manner, so as to give sufficient room for loading. There are two sets of compressor bars which act on the breech, one on each side immediately inside the guide bars. There would, besides, be compression between the breech carriage and slide, so as to pull up the carriage when it had recoiled to a suitable distance. The construction of the carriage would also bring the action of gravity to bear at the most suitable moment to produce the same effect. Breech ropes are added for greater security. It may be supposed that this double strain would be apt to injure the pivots with a very heavy gun; but it will be seen that this is not likely to happen, when it is considered that what injures the pivots is not the compressors, but the friction which is brought to play between the carriage and slide during the impact of discharge. In an ordinary gun, the whole weight of the gun rests on the carriage, but in the case of this gun it does not; so that the carriage can more readily slip away.

When the breech-piece is back, the gun is loaded at the breech. The compressors are then released, but not before the breech has been secured to its carriage, in the position it may then occupy, by chains, or some other contrivance. This prevents the breech from descending, and is useful, because the higher the breech, the more readily will it run forward. For if the guide bars are above the horizontal, they tend to help the breech forward; but if below, they tend to retard it in running forward. Should the breech accidentally get low on its carriage, it would have to be run up the bars by means of the running-out-and-in gear. Wheels would be brought into play between the breech and guide bars, and between the breech carriage and slide; but they are not shown in the model, as their action is well known in the working of heavy guns.

This breech action is very simple, and suited to very heavy guns, where great weights must necessarily be moved. The explosion opens the breech, and alters the position of the gun from that shewn in Fig. 16 to that shown in Fig. 17. Gravity brings it back again to its original position.

A much smaller breech carriage can be used, which provides for only

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* Or the wad might remain in the bore after the pressure had ceased, to prevent any escape of smoke, and could be withdrawn at leisure.

sufficient motion of the breech to allow of elevation and depression; but the large one has the advantage of causing the muzzle to dip after firing. This dipping would be useful in allowing the muzzle to hide itself behind a shield or counterscarp, where it would remain sheltered during loading and running up, and need only be exposed at the instant of firing. Another shield or turret could be placed about the position of the trunnions, so as to protect the most vulnerable parts in rear.

The model is designed for a 15-inch gun, and with some alterations, for greater convenience, and to suit the new powder, it represents a very powerful gun firing 200 lbs. of powder, and a projectile of 1200 lbs. The body of the gun could be made wholly of coiled iron, with the usual steel tube; or, if the suggestions I have made could be carried out, it might have a wrought-iron coiled barrel, and a second course, or a second and third course of steel, in the region of the powder-chamber. It would weigh about 40 tons. The breech would be almost wholly of cast-iron, with a wrought-iron hoop to support the trunnions and the plug of steel, and would weigh about 30 tons. The total weight of the gun would, therefore, be 70 tons, and this is about one-sixth heavier than the proportion of gun to shot, if we consider the present service guns of smaller calibre; but it would probably not be more than the proportion which would be necessary if the present patterns were extended to such a heavy gun. At all events, any excess of weight would be more than counter-balanced by its being divided into two, and by having so large a proportion of the material of cast-iron. I am doubtful, however, if a gun of this size could be made to stand on any of the present patterns, and it is for this reason I have chosen this particular size, though it is impossible to say to what extent the modification of the pressure of gunpowder may extend the limits to which any pattern of gun may be carried. But if, on any of the present systems, a 15-inch gun can be made, I am confident that, on this system of mine, a 20-inch gun might be obtained, firing a 1-ton shot, with a breech-piece and barrel of 50 tons each. If Mr. Reed makes ships carrying 15 and 20-inch armour, both guns will be needed, for it will require 15 and 20-inch guns to pierce them.

At the conclusion of the paper—

The CHAIRMAN invited discussion, saying that Captain Morgan would be very happy to hear suggestions or answer questions on the subject of his gun.

Captain NOBLE said that Captain Morgan had not explained how the gun was to be loaded.

Captain MORGAN said the projectile and ammunition would be lifted by a crane and inserted at the breech. There would be a space of 4 ft. when the breech was open.

In answer to other questions, the lecturer showed by his model how he proposed to draw the breech-piece backwards and forwards.

Captain NOBLE asked if the breech would act as a rammer?

Captain MORGAN said it might be so adapted.

Captain BROWNE said he understood Captain Morgan to say that there would be no windage at the breech; in fact, that there would be no room for escape of gas until the shot had left the muzzle. How, then, he would ask, would he contrive to effect this? How tight would he make the piston to fit?

Captain MORGAN said the plug would have from one-tenth to one-quarter inch play. A steel disc would be screwed on to the face of it, having less play, and in front of that he would put a paper wad. By this means he had every confidence that any escape of gas would be prevented. The recoil of the breech would be about 3 ins. during the discharge, but the plug was in point of fact a foot and a half long, so that there was at least 9 ins. to spare before there could be any danger. In reality it would be a safety-valve, escaping only when a shot got jammed in the bore, and thereby preventing the destruction of the tube. Even in case of such an escape of gas, the breech would be so constructed that the gas would be thrown forward.

Captain BROWNE said that, under those circumstances, it would seem that there was danger from the gas escaping at the breech; and he asked if it was not saving the gun at the expense of the gunners?

Captain MORGAN said the gunners would be protected behind the breech, which would direct the flash against the turret.

Colonel SHAW asked what was proposed to be the battering charge of powder?

Captain MORGAN.—About 200 lbs.

Colonel SHAW.—And would a breech of that size resist the explosion of such a charge?

Captain MORGAN.—Yes; it is the strongest form for resistance I can think of.

Colonel SHAW.—How would the gun be sighted?

Captain MORGAN explained, by reference to the model, that it might be done by means of a small hole in the face of the turret. He added, however, that he should prefer having the gun and carriage to rise and fall, on something like the Moncrieff principle, having already prepared a model for that purpose.

Captain HARRISON asked if the extra 10 tons in the weight of the gun was an absolute necessity? Ten tons of dead weight, in comparison to the weight of a service gun, seemed a very heavy addition.

Captain MORGAN replied that, with good compression, it might be possible to keep within what would be the service limit—60 tons, but he would not recommend it. He calculated that about one-sixth of the gun's weight would have to be added as a sacrifice for this arrangement of the breech. Thirty tons, however, are cast-iron.

Captain HARRISON.—You do not think your arrangement is possible without sacrificing that weight?

Captain MORGAN.—I do not say that. What I mean is, that I would not risk my gun by trying experiments to reduce the weight; but I think it might possibly be reduced.

Captain HARRISON said he did not recommend such a reduction if the weight was essential, but it seemed a considerable sacrifice to lose so much attacking power as 10 tons.

Lieut. Jones said he had understood Captain Morgan to explain that the gun, being in two divisions, would be easier to move than a gun of less weight; so that the extra 10 tons would be of no disadvantage in that respect.

Captain Harrison said his objection was, the ship would lose power by the sacrifice of this 10 tons. Another ship might be met, armed with a gun of the service weight, and another 9-inch gun in addition.

Lieut. Stewart said it was very doubtful whether they could make a gun so large as a 1200-pr. yet.

Captain Harrison said there need be no difficulty on that ground. He thought they would find Colonel Campbell quite prepared to make a gun of that weight if necessary.

Colonel Miller.—What is the weight of the heaviest gun made?

Captain Harrison.—Twenty-five tons.

Captain Noble.—We can make them up to 37 tons at present.

Colonel Miller asked if he was to understand that there was a demand for a 15-inch gun, or that they ought to anticipate such a demand, and provide for its construction before they required it?

Captain Morgan said he believed that they must advance to that weight, and they must consequently provide for the emergency.

Colonel Miller said it seemed to him that there were two questions involved. First, was it necessary to have these very heavy guns? for if so, they must consider how to make them. But if there was no reason to expect that they would be required, it was doubtful whether it was worth while to proceed in a proposal which would involve so much expense and such loss of power.

Captain Browne said: Captain Morgan had already stated that such a gun was required for piercing armour-plates; for that, if they had 15 and 20-inch plates, they must have 15 and 20-inch guns to pierce them. As to the objection raised by Captain Harrison respecting the weight of the gun, he thought the additional 10 tons was but a small consideration in comparison with the weight necessarily entailed by the plating, fittings, carriage, ammunition, &c., belonging to each gun on board ship.

Captain Harrison said his objection had been misunderstood. He believed that if they employed a service gun, the spare room could be more profitably employed by putting another gun in the same turret. Thus, supposing they had a 7-inch gun of the service pattern in the turret, they might find room for a 9-inch gun besides. This he thought would be preferable to "putting all the eggs in one basket."

Captain Strange said, if he comprehended Captain Morgan's design, it was to save material in the gun rather than add to it, because there was no necessity for a breech-piece.

Captain Morgan said he could not take credit for any saving of material. He calculated that in a gun of the size proposed, 10 tons would be added to the service weight.

Captain Browne said it should be shown that a 9-inch gun could be put into the same turret with a 15-inch, before basing arguments on such an arrangement.

Captain Morgan said the principle of his design was this:—He assumed that they could not make a gun larger than a 1000-pr. by the present plan; they must stop short there for want of the means of constructing a larger gun sufficiently strong. It would then be a consideration whether it would not be advisable to sacrifice a large proportion of weight to attain their object, seeing that there was every probability of larger guns being required, owing to the great increase of force obtained relatively by every increase of size.

Colonel Smythe, in the name of the meeting, thanked Captain Morgan for his interesting paper, saying that whatever results his design might lead to, it had been evidently well considered; and that, at all events, the proper place for the discussion of that and all other suggestions on the subject of gunnery was the Royal Artillery Institution. (Applause).

The proceedings then terminated.

Pl I.

Fig 2.

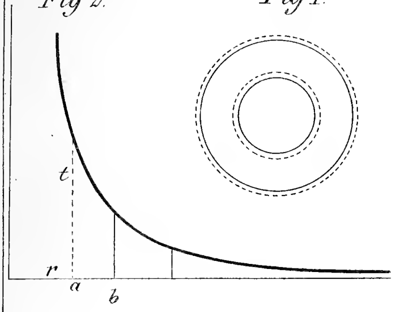


Fig 1.

Fig 5.

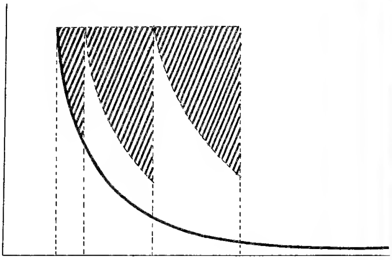


Fig 3.

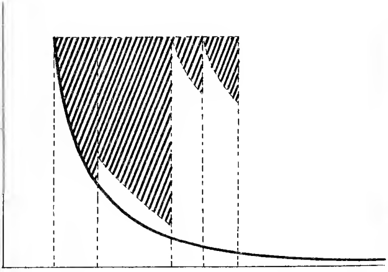


Fig 6.

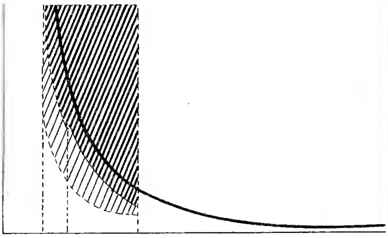


Fig 4.

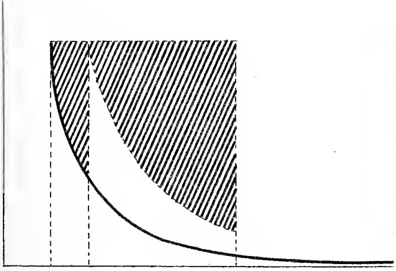
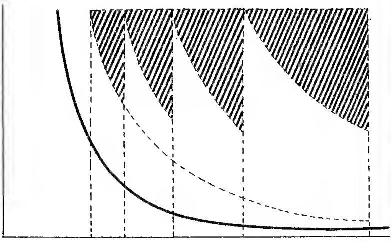


Fig 7.



Pl. II.

Fig. 10.

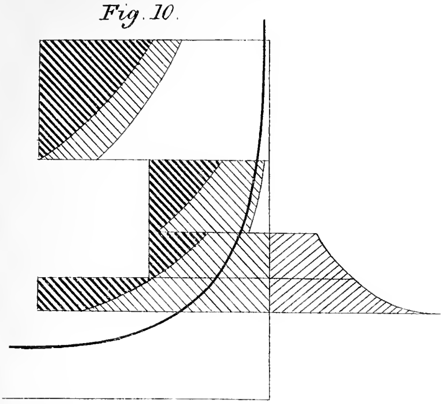
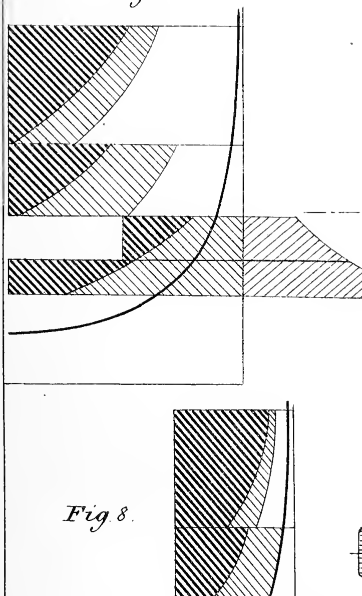


Fig. 9.



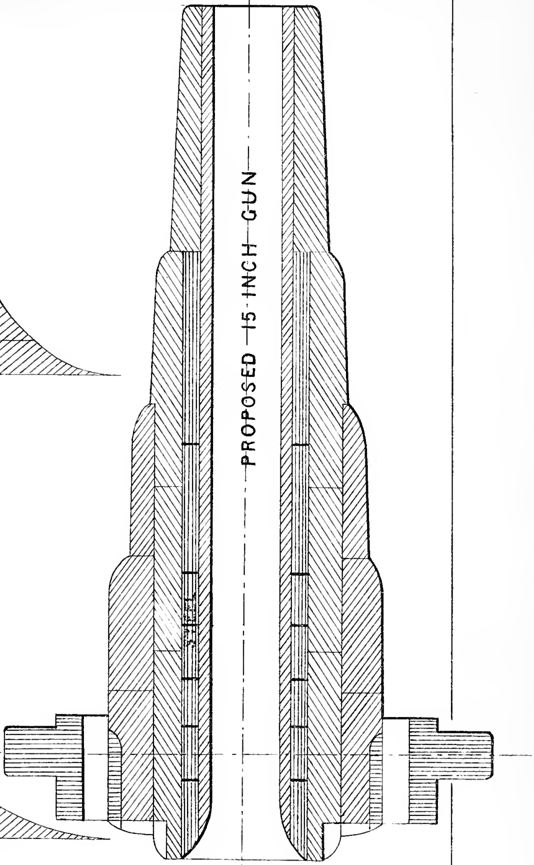


Fig. 8.

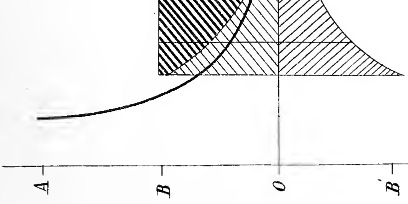


Fig. 15.

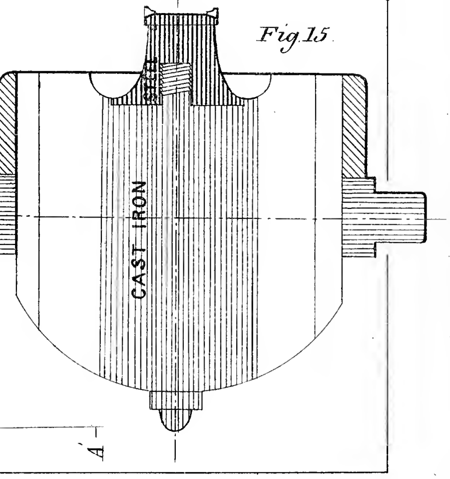


Fig. 11.

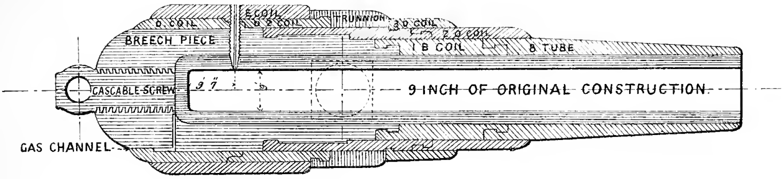


Fig. 12.

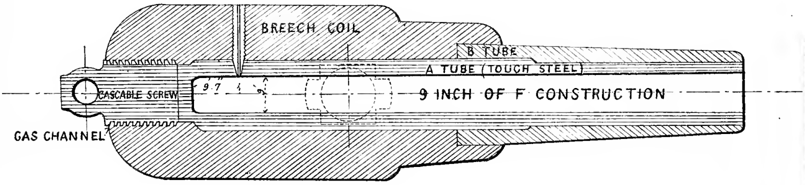


Fig. 13.

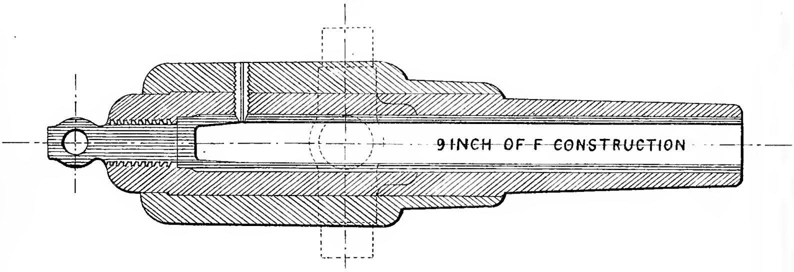


Fig. 14.

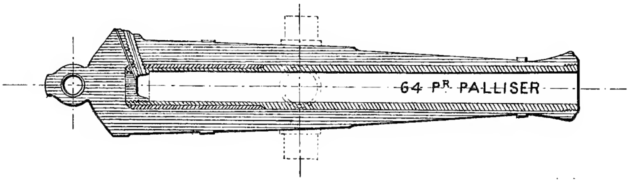


Fig 16.

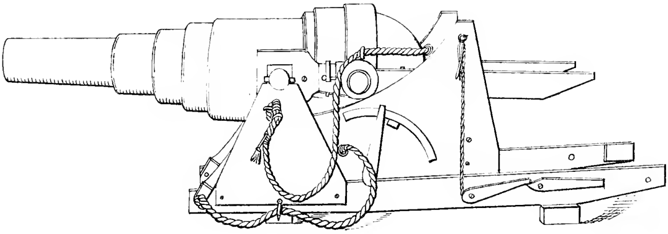
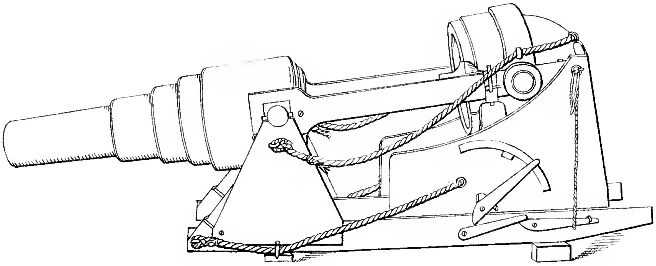


Fig 17.



Scale $\frac{1}{120}$

CAMEL GUNS.

BY

COLONEL H. H. MAXWELL, R.A.,

SUPERINTENDENT COSSIPORE GUN FOUNDRY.

In those parts of Asia where the camel, or, more correctly, the dromedary, is the chief beast of burden, and where no made roads exist, the "ship of the desert" has, ever since the invention of gunpowder, formed the ordinary means of transport of artillery. The camel swivel-gun, however, appears to have been of Affghan invention; for we find that "Mohammed Affghani, having crossed the deserts of Seistan and Kerman with 15,000 men, for the most part mounted on camels, and having with him, in lieu of ordinary artillery, a number of camel swivel-guns, on the 8th March 1722, encountered the Persian army numbering 60,000 men with 24 guns, at Goul-Nabat within ten miles of Ispahan. On the Persians' approach, the left wing of the Affghans giving way, the former pursued with ardour; but soon their enemy's ranks open, and disclose a line of 100 camels kneeling down, each with a gun on its back. The fire knocking over the leading ranks of the column, the Affghan horse charged, and put them completely to the rout."*

Tahmasb-Kouli-Khan, better known under the title of Nadir Shah, the invader of India and the author of the Delhi massacre, introduced the camel gun into the Persian service. It was under this famous warrior that the camel gun received the name of "zumbooruk," from "zumboor," a wasp. After making good use of this species of artillery in various campaigns in Asia, the invader of India appeared before Delhi with 250 zumbooruks, his 12 pieces of artillery having been left at Umballah.

Since his day, almost without interruption, camel artillery has formed a portion of the Persian army.

Some thirty years back a regular organisation was given to the corps of Zumboorukchees, under the order of Hadji Mirza Aghassi, the then Prime Minister.

The gun of twisted iron was 27·6″ long, and carried a wrought-iron ball of 14 ozs. in weight, and consequently of about 1·8″ in diameter.

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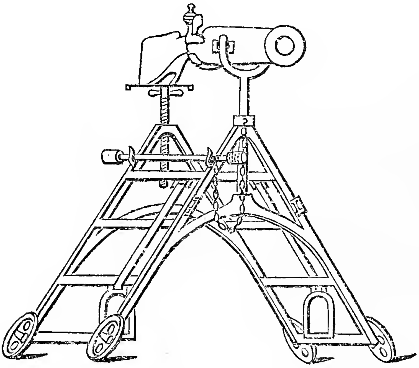
* "Les Zemboureks." By Colonel F. Colombari. Paris, 1853.

The piece had a flint lock. Two saddle bags contained 50 cartridges of round balls and grape shot, besides 20 blank cartridges for salutes.

The following are the weights of the camel's load :—

	lbs.
Weight of piece, swivel, and sponge	80·85
Saddle, numdah, girths, bridle, schabraque, and ornaments	97·02
Ammunition and saddle bags	122·89
Rations of the gunner, consisting of 3 lbs. of bread; and of the camel, 6 lbs. of flour, mixed with barley, made up into balls; and 12 lbs. of hay or straw	22·64
Weight of the gunner (11½ stones)	161·70
Total	485·1 lbs., or 4·3 cwt.*



Improved pattern Pack Saddle for the Gun.

The subjoined table gives some idea of the rate of marching of a camel :—

Nature of load.	Weight of load.	Number of paces at a walk, per minute.	Length of pace.	Distance travelled in an hour.
	cwt.		ft.	miles.
Camel laden with provisions or baggage, that is with full load	6·93	80	2·63	2·39
Camel, with camel gun	4·33	90	3·61	3·69
Camel, with rider and plain saddle	1·73	100	4·27	4·84

As to length of march, most camels are capable of making forced marches of 35 miles a day. Lightly loaded, they can cover 70 miles.

Napoleon, during his occupation of Egypt, employed camel corps, to enable him to cope with his fleet antagonists, the Arabs.

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* The accompanying lithograph will give some idea of the appearance of the camel artillery of Persia.

Zembourekchis réguliers.

Sir Charles Napier, in the year 1842–3, mounted a company of the 13th Light Infantry on camels, each soldier being seated behind a native camel driver. The infantry man was armed with his musket, and was provided with 60 rounds of ball-cartridge. Sir Charles' object was to give this company a highly increased power of locomotion. The troops under his command were few, as compared with the area of the ground he had conquered and had to hold. By this means, he greatly increased the value of a small portion of them. This idea was doubtless borrowed from the camel-gun corps of native states, and from the usual method of fighting of the Beloutchees.

At Sobraon, many of these camel guns were captured in the Sikh entrenchment, after having been vigorously used against us.

In the mutiny of 1857, in India, and for some time subsequently, two camel corps, on Sir Charles Napier's model, were organised—one company being taken from the Rifle Brigade and another from the 92nd Foot.

Could such corps, in addition to their power of locomotion, be endowed with increased power of musketry fire, their value, from a strategical and tactical point of view, would be vastly increased. Combined with cavalry, they would be more especially suitable to such operations as reconnaissances, as they would provide the reconnoitring force with precisely the element in which reconnoitring parties are usually deficient—viz., missile power and capacity of resistance in case of surprise; further, for suddenly seizing important strategic points, such as the junction of a number of ordinary roads or railroads, fords, bridges; or for making requisitions, covering forage parties, seizing boats in a river, escorting convoys, and the like.

As we have, in the north-west of India, a splendid breed of camels, it seems desirable to adapt their locomotive and carrying power to military purposes, in combination with the latest invention in firearms.

The Gatling gun having met with the approval of a mixed committee of officers at Shoeburyness, it may be worthy of consideration whether a light gun on this system could not be made of a weight suitable for a camel gun.

The data may be taken from the figures above quoted. From these we may gather that a Persian camel can carry, in the form of gun and ammunition, about 180 lbs., leaving a margin of 20 lbs. for saddle bags, &c. One hundred rounds of Martini-Henry ammunition weighs 10⅓ lbs. But the load of the ordinary stamp of Indian camel is known to be 5 maunds, or about 400 lbs.—that is, 85 lbs. less than the Persian gun-camel. With picked camels the weight might be such as to admit of carrying 152 lbs. of gun and ammunition. This would give a gun of 112 lbs. and some 400 rounds of ammunition. A spare camel would carry some 1500 rounds more.

With a gun of 112 lbs. weight on his back, the camel would not feel the discharge. Being on the ground with his legs tucked under him, and the upper arm lashed to his shank, he forms a steady platform for firing.

ON

AXLE-TREE SEATS FOR FIELD BATTERIES.

BY

CAPTAIN H. L. BALFOUR, R.A.

The want of some means of mounting a certain number of the detachments of field batteries, and conveying them rapidly to the front when required, is generally acknowledged.

The subject has been much discussed, not only in the corps, but by the press and other writers, and has been again brought forward quite recently, in consequence of the prominent part taken in the present war by the Prussian field artillery, a large proportion of which are field batteries. They differ in many respects from those in our service, but principally in the manner in which they are manœuvred. They move more rapidly, unaccompanied by ammunition wagons, and they are enabled to convey a sufficient number of men to the front to work the guns by carrying three men on the limbers and two on the axle-tree seats.

The Special Committee assembled to report on Field Artillery Equipment for India, recommended that the height of the axle-tree boxes of the new 9-pr. M.L.R. gun should be reduced, and rails added to render them available for carrying two gunners. This, however, was not approved of by the Director-General of Ordnance, who stated in his reply to the Committee forwarding their report, "The proposal to provide means for mounting two men on the gun axle-tree boxes, is a matter of minor importance, and Mr. Cardwell does not consider it desirable to adopt the Committee's recommendation in this particular." The question, therefore, has been brought under consideration, but the final approval not yet obtained. It is understood, however, that the axle-tree boxes for the new field gun are to be constructed so as to admit of being easily fitted for seats.

The axle-tree seats in the accompanying sketch were made in 1868, at the time of the Fenian raids in Canada, when the field batteries were required, under the circumstances, to perform duties which in our service are not considered as properly belonging to them.

An instance of this occurred at the time of the first Fenian raid, when two guns of the 4th Brigade were disembarked off a train at St. Armand, in Lower Canada, and ordered to proceed as rapidly as possible with an escort of cavalry to Pigeon Hill, about three or four miles distant.

The officer in charge could only mount three men on the gun limbers, leaving the remaining numbers of the detachment to keep up on foot. The ammunition wagons, fully packed, and horsed with teams of only four instead of six horses, followed at a walk. The guns consequently were brought into action with only three numbers besides the No. 1, giving an instance of the incomplete footing on which our field batteries are kept, and the uselessness in attempting to make them, in their present state, move rapidly from place to place, which they are frequently called on to do.

The same description of raid occurred again in 1868, and authority was obtained to increase the mobility of the field batteries, by making use of the axle-tree boxes for carrying two men of the detachments. Temporary seats, therefore, were constructed by one of the batteries, a short description of which is here given.

The present pattern of axle-tree box for the 12-pr. Armstrong gun not being sufficiently wide for a seat, the additional width is obtained by a wooden movable ledge and extra side, fastened together and strengthened with corner plates; it is shaped to fit over the nuts of the bands fastening the axle-tree boxes, and two small stop plates let in on the inside to catch the box underneath. It is kept tight to the box by an iron retaining band passing round both, and screwed to the extra side by nut-headed bolts and plates. The ledge, therefore, does not in any way interfere with the lid or other part of the box. A guard iron is fastened on outside, of sufficient height to allow its being also used as a handle for mounting. An extra rail is added, nearly as high as the top of the wheel; this is covered in with painted canvas or leather, which supports the arm, and protects it from the wheel. A support for the back is given by a wide leather strap, fastened to the top of an upright iron rod let into sockets on the side of the gun carriage, and passing across to the lower guard iron, to which it is fastened. The stirrup is an iron band, secured on one side to the cheek of the gun carriage by a nut and bolt, and on the other, to the extra side of the box, by a bolt and key on the outside. This description of stirrup is much to be preferred to the breast chain of the gun, which is recommended to be used for the purpose. The advantages of it are, that it is fixed, and serves also as a step for mounting; it does not project below the bottom of the axle-tree bed, and cannot touch when going over rough ground. The disadvantages of making a stirrup of the breast chain are, that it sways inconveniently for mounting, hangs down below the axle-tree bed, and may touch uneven ground. Hand-straps are fastened on outside each cheek of the gun carriage, and crossed over the top of the gun, for the inner hands of each man.

With these appliances nothing short of the gun upsetting could throw a man off the seat. A battery has been drilled over rough ground with men on these seats, and they are preferred to those on the gun limbers.

This plan of putting seats on the present pattern of axle-tree box admits of the required fittings being removed in a few minutes, which is not advisable for many reasons. The box and seat should of course be made all complete. The circumstances under which this description was made necessitated it to be movable without interfering with the box.

It has been the practice of many officers in command of field batteries to utilise these axle-tree boxes, in some way or other, for mounting men on the line of march; and until new boxes and fittings are issued, the above method will be found to answer all purposes, and the workmanship required can be easily executed by battery artificers.

It may be noticed here what great importance is given to these seats in the Prussian service. Their field gun carriages, horse artillery not excepted, are carefully fitted so as to make the best possible seat for two axle-tree gunners. Means are provided to lessen the concussion by buffers, made of layers of india-rubber and iron. The boxes underneath are almost sacrificed, nothing being carried in them but a few small stores. The back rests against a frame of wire net-work, supported by iron stays fastened to the trail in rear, and there are fixed stirrups for the feet. They are consequently used for carrying men at all times, as much as the gun limbers.

Having brought this subject forward, it may be advantageous to consider one or two points connected with it.

The Special Committee in their report referred to the system of carrying men on the off-horses, in addition to two on the axle-tree seats.

On this point there is much difference of opinion; but it appears indispensable to adopt the plan to some extent, in conjunction with other available means, for conveying detachments of the required strength. By doing this they might be made to consist of seven gunners besides the No. 1, and distributed in the following manner:—

Nos. 2, 3, and 6 would be mounted on the gun limber. This third number, when seated, facing the usual way, throws much additional weight on the shaft-horse. If, however, he sits reversed, and facing the gun, the shafts are very little heavier than when two men only are on the limber. It seems practicable to arrange a seat for that method, by putting additional rails on the ammunition boxes, and a rest for the feet on the trail of the gun.

Nos. 4 and 5 would be carried on the axle-tree seats.

No. 7 would be mounted on the marker's horse, which is allowed to each subdivision on service. The horses of this number and the No. 1 might be held by a spare driver, riding the off-centre horse of the gun team, and dismounting when in action.

No. 8 might be mounted on the off-horse of the spare pair that would accompany each gun when available. The occasions on which it would be necessary to hook in eight horses are very exceptional; and it is generally considered best to keep the fourth pair as spare horses.

It is evident if a certain number of the gun detachments of a field battery can thus be conveyed with the gun alone, and moved rapidly when required, it will be necessary to accustom the men and horses to move accordingly.

It appears to be a tradition in our service, though unknown in any other, that field batteries should not be moved faster than at a walk, except at regimental drills; and that when the ammunition wagons are sent away from the battery, the detachments must keep up on foot, as well as they are able, should the guns be ordered to the front at an increased pace.

It is scarcely credible that a well-known instance, on service, of the serious results attending such a system should have happened sixteen years ago, and no effort yet made, either by our own or other officers in authority (with the exception of the Special Committee here referred to), to put the field batteries on a better footing.

One result, therefore, of carrying a sufficient number of men with the guns, unaccompanied by ammunition wagons, will be to acknowledge the necessity of their being moved rapidly when required, and manœuvred accordingly.

Much difference of opinion exists as to the degree of rapidity at which field artillery should manœuvre. Foreign writers of authority consider all descriptions of that arm should be organised so as to be able to move rapidly when required.

In the "Règlement sur les Manœuvres et les Évolutions des Batteries

GUN OF

Roy: Art

6 *Feet*

ADE

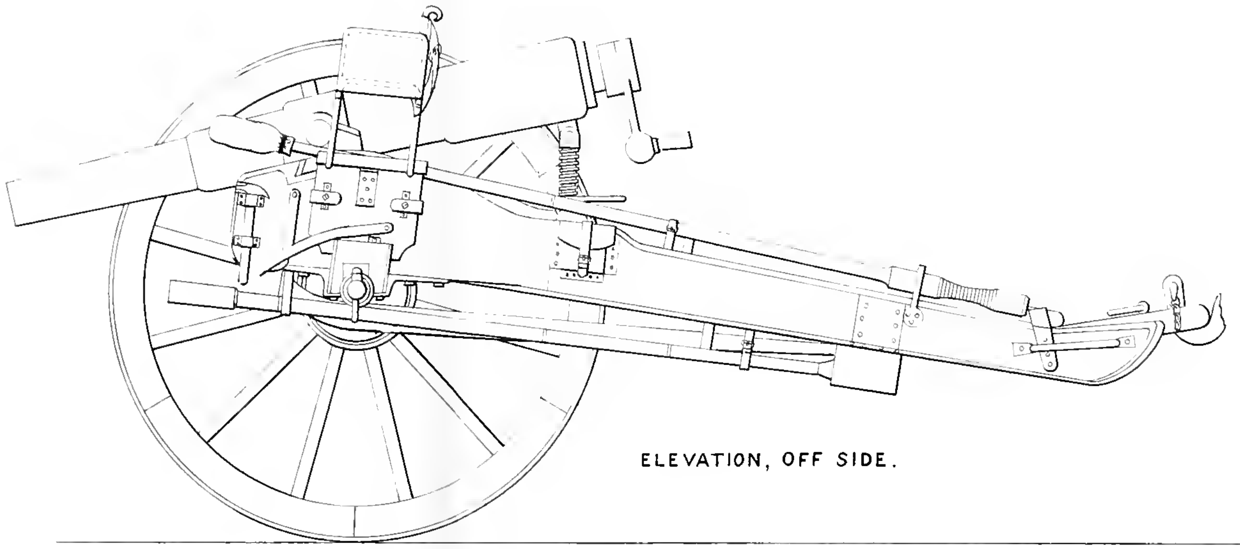
AXLE TREE SEATS

FOR SIR WILLIAM ARMSTRONG'S 12 POUNDER GUN OF 8 CWT.

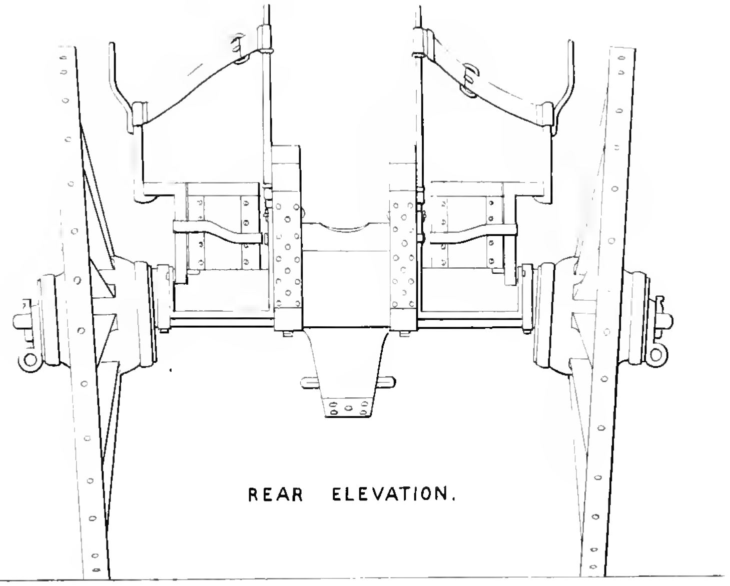
As designed by Captain H.L. Balfour. Roy. Artill.y

Scale.

Inches 12 9 6 3 0 1 2 3 4 5 6 *Feet*



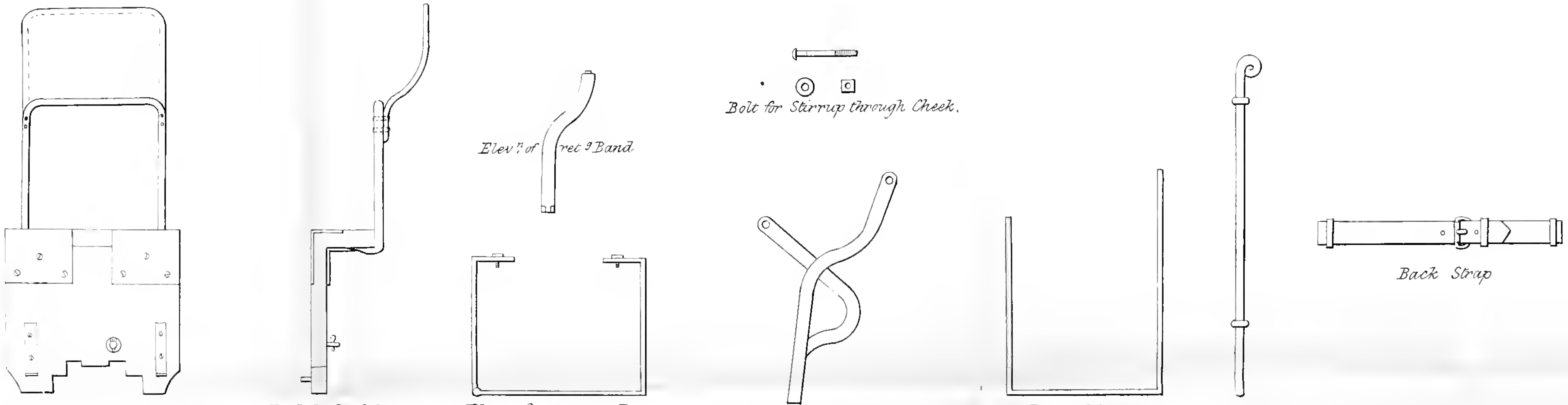
ELEVATION, OFF SIDE.



REAR ELEVATION.

ENLARGED DETAILS

OF THE IRON AND WOOD WORK REQUIRED & MADE
BY THE BATTERY ARTIFICERS.



Bolt for Stirrup through Cheek.

Elev.n of ret.g Band

Inside Elev.n of Seat

End Elev.n of Seat.

Plan of retaining Band.

Elev.n of Stirrup.

Plan of Stirrup

Back Strap

Enlarged Scale for details

Inches 12 9 6 3 0 1 2 3 *Feet*

K Howard del. Limerick. 3rd Sept.r 1870.

Attelées," Paris, 1864, it is laid down that galloping is to be regarded as an exceptional pace, and the "*trot*" and "*grand trot*" are to be the standard paces.

In our own service, it would appear, one branch takes the maximum, while the other is given the minimum pace as their standard.

The following table shews that, as far as the weight behind the teams is concerned, there is no reason why our field batteries should not move as rapidly as those of other armies:—

Nature of gun.	Weight, gun and carriage complete.			Number of men carried on gun and limber.	Weight of men and two kits.			Total weight behind teams.			Remarks.
	cwt.	qrs.	lbs.		cwt.	qrs.	lbs.	cwt.	qrs.	lbs.	
Prussian 6-pr.	35	2	15	5	9	3	0	45	1	0	
" 4-pr.	30	2	0	5	9	3	0	40	1	0	
French 4-pr.	25	3	0	3	6	1	0	42	0	0	Weight of each man taken at 14 stone. Weight of kit, &c. taken at 56 lbs. Only two kits are allowed.
Austrian 4-pr.	23	2	14	4	8	0	0	31	2	14	
English 12-pr. B.L.R. ...	37	0	0	2	4	2	0	41	2	0	
				3	6	1	0	43	1	0	
				4	8	0	0	45	0	0	
				5	9	3	0	46	3	0	
Indian 9-pr. M.L.R. ...	33	2	0	2	4	2	0	38	0	0	
				3	6	1	0	39	3	0	
				4	8	0	0	41	2	0	
				5	9	3	0	43	1	0	

But it is urged, if greater mobility is required to be given to field batteries, it would be far better to increase the horse artillery than have recourse to a make-shift and inefficient plan for carrying gun detachments. This is unanswerable; and it is much to be regretted that no considerable increase has yet been made to this arm of the service. It is, however, manifest that the proportion of field artillery to other arms of the service will in future be so large, that a considerable portion of it must, under the most favourable circumstances, remain field batteries. It seems absolutely necessary, therefore, that some plan should be adopted and recognised by which they could attain a certain degree of mobility.

It is again urged, if field batteries are put on this proposed footing, they may be required to act as horse artillery, and a rivalry would be engendered between the two branches detrimental to the service. The mobility of the two differs so widely, both in degree and character, that it is difficult to understand the grounds on which such a result is expected.

Moreover, it is considered by the best authorities the field batteries will in future be armed with a still heavier gun. This increased weight, together with the make-shift plan of carrying their detachments, would quite preclude the possibility of their attaining mobility by which they could at all simulate the present rapid manœuvring of horse artillery.

If, therefore, their special requirements are impartially considered and defined with more modernised views than hitherto, their mobility might be increased without risk of interfering with the distinctions that exist between the two branches of field artillery.

The well-established superiority of the horse artillery over that of other powers is indisputable; but many changes are needed to place the field batteries even on an equality with those of continental armies.

ON

THE RE-ARMAMENT OF GIBRALTAR.

BY

CAPTAIN J. B. RICHARDSON, R.A.

GIBRALTAR is about to be armed with 9-inch guns. The guns, indeed, have been for some years lying on skidding in various parts of the Rock; but until lately, when owing to the present outbreak of war, the attention of the public was prominently directed to the comparatively defenceless state of our fortresses and forts, caused by the modern improvements in both artillery and armour-plated vessels of war, it has been thought unnecessary to provide for mounting them, and just now our Engineers are busy preparing sites on which these guns will be placed.

Choice of sites.

The choice of good sites is a matter of the utmost importance—not only to the artillery, who will have to work and take care of the guns, but to the country, from an economical point of view. Immense expense is incurred in building adequate protection, and the large sums so spent will be more or less thrown away if the works are erected in faulty positions. Sooner or later, in spite of their strength on paper, they will be abandoned for better positions, and the labour and money expended on them be in vain regretted.

Plan fixed on for re-armament faulty.

Having paid considerable attention to the subject, I have arrived at the conclusion, right or wrong, that the general plan of re-armament, as far as heavy guns are concerned, is faulty, and that the situations in which they are about to be placed are bad. If I am wrong, it will no doubt be easy to expose the fallacy of what I advance; if the sites now chosen be really the best available, discussion in these papers will but confirm the judgment of those who fixed on these positions; while should my view of the matter be correct, there is yet time to curtail a useless outlay.

Plan now adopted.

At present it is chiefly intended to dot the 9-inch guns over the north-west portion of the Rock, in no particular order—few close to the level of the water's edge, but in sites varying between this and the height of the Queen's Road, which runs along the western face of the Rock at a considerable height, some 630 ft.; and it is this arrangement which I take exception to.

Guns should be mounted on a definite system.

I maintain that this armament of heavy guns should be disposed in two lines along the side of the Rock—one at a very high, and the other at a very low altitude, each line having a perfectly distinct duty to perform. By the word "line," I do not wish to convey one exact level along the face of the Rock, but I do mean to state that it is an error and waste of strength to place guns in the intervening space between the maximum height of a lowest and the minimum height of a highest line. The limits of this maximum and minimum could not be safely pointed out without careful calculations, observations, and drawings, and I should be sure to err if I attempted arbitrarily to fix such limits; indeed, without practical experiments added to such theoretical investigations, I should be disposed to regard with suspicion any definition of the minimum height of the highest line; but if I can satisfactorily shew that there is a space in which it is not possible to place a gun so as to obtain from it the greatest effective work of which a gun of its nature is capable, I think it will be admitted that there is scope for such calculations, and that my views are worthy of a thought.

I may fail in my reasoning; I only desire that what I advance should be taken as the common-sense view of a practical artilleryman, not as the logical argument of a theorist; but I claim a certain amount of attention to what I urge, however feebly, inasmuch as I have enjoyed opportunities of learning the practical work of a garrison artilleryman which have fallen to the lot of few of my brother officers. I was one of the first batch of gunnery instructors trained at Shoeburyness in 1859, and the instruction I received there has naturally directed my attention to all gunnery proceedings which have come under my observation since; while, from having been quartered at our chief artillery stations in three different garrison brigades, I have had unusual opportunities of observing the progress of garrison artillery without falling into one groove.

I assume the following, none of which I believe are open to objection:—

Axioms.

1. *A.* That para. 7, Part IV. "Artillery Manual," is correct in supposing that, "against ships in motion the rate of firing cannot be too rapid, provided the pointing be careful."

2. *B.* To obtain rapid firing, the utmost efficiency, both in ordnance, stores, and men is required.

3. *C.* That it is impossible to fire as rapidly from a gun whose line of fire is at a depression angle, as from a gun whose axis is horizontal or slightly elevated. (Because an additional operation is required to bring the gun horizontal to assist loading).

4. *D.* That none, or at any rate very few, of the systems in vogue render armoured ships impervious to even weak vertical, or nearly vertical, fire.

(Ships of war have at all times been exceedingly averse to taking up positions, or passing any place in which they were exposed to the fire of guns, even field guns, if stationed on heights overlooking them. Numerous instances could be mentioned).

5. *E.* That there are, or may in future be, iron-clads so constructed

as to be practically invulnerable to horizontal fire at moderately long ranges.

6. *F.* That with our present knowledge of naval architecture, it is impossible so to arm a ship that it shall be equally impervious to artillery fire in every part; the weight of iron armour being too great for flotation.

7. *G.* That if an armour-plate be struck in reverse (as in the case of a shot passing through the deck, or open port, on one side of a vessel, and striking the far side), a comparatively weak projectile will break away the armour-plates, and in so breaking them do far more damage than a similar shot either racking or penetrating them directly.

8. *H.* That one shot opening a large jagged hole in a plated ship's bottom, where she is unprotected, would probably disable her, or at any rate do more damage than several punched holes above the water-line.

9. *I.* That a shot which would just penetrate an iron plate if it struck it at right angles, would fail to do so should it strike at an acute angle.

10. *J.* That iron-clads cannot fire their guns at a very considerable angle of elevation; and that even if in future they are so constructed that their guns shall be capable of great elevation, their elevated firing will probably be far less accurate than their horizontal fire.

11. *K.* That no instrument is in use, or from the nature of the circumstances can ever be in use, which will as accurately and instantly follow the motions of a ship, and read off the corresponding elevation, &c. for the gun, from a low battery, as will an instrument placed in a very high battery, reading off the range with the assistance of the varying angle of depression. The greater the height the greater the angle of depression, and consequently the greater the correctness of the estimate of distance.

(The instrument known as the "Malta instrument" can be so sighted and marked that an officer in a battery can follow the motions of a ship, and constantly read off, without the slightest calculation, the angle of elevation required for the guns in the battery, without referring to the distance in yards or anything; but there is not one of these instruments in Gibraltar so sighted, and very few "Malta instruments" of any sort).

Comparison of guns in very high and very low batteries.

I proceed to compare the advantages of guns situated in very high and very low sites, together with their disadvantages relatively, each to each, and for the purposes of comparison, suppose two 9-inch guns α and ω; the gun α placed in position on the terreplein of the Signal Battery—a height of about 1220 ft., and about the centre of the Rock—the gun ω somewhere in the neighbourhood of the Saluting Battery, immediately below the gun α, but as close to the water-line as possible. On this comparison being instituted, I shall compare both guns, α and ω, with the merits and demerits of a similar gun θ, situated in some intermediate position—say below Ferdinand's Battery (620 ft.) on the Queen's Road, and above the level of the Alameda. That the positions of guns α and ω are as nearly extreme as can be, will be granted, while that of gun θ is a mean, taken if anything rather low; because, as I have stated, I have not determined any minimum altitude for the high line of guns, and I might err in placing it as low down even as the Queen's Road. My conviction is that the extremes taken are the best positions; but I may be unable to convince others of this, particularly as I feel that I am alone in my opinion, many most distinguished officers having suggested the armament of the Queen's Road.

Gun ω.

The gun ω (in the low line) would have the following:—

Advantages over gun α.

1. *a.* A very horizontal line of fire, causing its projectile to have a fair chance of hitting a ship in spite of its distance being but roughly determined.

2. *b.* It would be nearer the ship.

3. *c.* It would fire horizontally, or at only a slight elevation, obtaining the advantages mentioned in (*A*) and (*C.*)

4. *d.* It is placed in the best situation for penetrating the side of an armour-plated ship, the shot striking direct (*I.*)

5. *e.* It could be cheaper worked, less transport being required for projectiles, stores, &c.

6. *f.* In firing at night, its low horizontal fire gives it a great chance of striking a ship, firing at random in its supposed direction.

Disadvantages of gun ω compared with gun α.

1. *g.* It is exposed to more accurate fire from a ship of war (*J.*)

2. *h.* In consequence of this, it requires strong protection.

3. *i.* The constantly changing distance of a ship is harder to determine (*K.*)

4. *j.* With the march of science, this gun is more apt to lose its relative power, for the reasons given in (*E*); while gun α retains its superiority (*F, G, H.*)

5. *k.* Owing to its being mounted in some sort of cover (unless mounted on some system similar to that of Moncrieff, which is not in use in Gibraltar), the gun has less lateral range.

6. *l.* Its detachment of gunners is exposed to fire, and will not perhaps work as coolly and accurately as at ordinary practice. (Our men get so little practice at rapid firing, or in firing at moving objects, that I have always found them get much flurried and their pointing very inaccurate, when attempting to fire quickly. This fault would increase, I imagine, under fire).

Gun α.

The gun α (on the high line) would have the following:—

Advantages over gun ω.

1. *m.* Range accurately and quickly ascertained (see *K.*) (A "Malta instrument" should be near each gun, properly sighted and marked).

2. *n.* From its great height the decks of vessels are visible, enabling plates to be struck in reverse (see *D, F, G, H*),

a fire almost equivalent to vertical mortar fire, but much more accurate, being obtained. With a properly and specially made carriage, a gun in this position would also have a considerable chance of damaging a ship below the plating and water-line, on the side nearest to the gun.

3. *o.* The gun itself could not be touched by the enemy's fire (*J.*)

4. *p.* Consequently, little or no protection is required.

5. *q.* And therefore much smaller expense incurred.

6. *r.* Almost unlimited lateral range.

7. *s.* The gun detachments never under fire, and consequently working cooler and more accurately—to say nothing of the saving in men.

Disadvantages of gun *α* compared with gun *ω*.

1. *t.* It is difficult to hit a ship with plunging fire, unless the range is accurately known.

2. *u.* Its projectile strikes the vessel's plates at a small angle (*I.*)

3. *v.* It is further from the ship.

4. *w.* It cannot fire rapidly (see *A, C.*)

5. *x.* Greater expense in the transport of projectiles and stores.

6. *y.* It would be almost impracticable to hit a ship at night, if firing at random in its supposed direction, owing to its plunging fire.

7. *z.* Owing to its height up the Rock, unless barracks are built there for gunners, it would not be so well kept in order as gun ω, and (*B*) stands a chance of being infringed.

General object of low line of guns.

The work expected from the low line of guns, therefore, may be generally stated as being penetration, by directly striking the armour-plates; and to aid this, the guns are considerably nearer their target than the high guns, and are capable of very rapid firing. They are also specially useful in opposing a night attack of iron-clad ships, which the higher guns are not capable of doing effectually. Their principal disadvantage is the very strong protection they require, and the consequent enormous expense of placing them in position.

Object of placing guns in high sites.

The object of the guns in high sites would be to sink opposing ships by striking them in vulnerable parts, such as the deck; and to strike plates in reverse through the deck, which their great height, and consequent angle of depression, enables them to do with accuracy. They possess the great advantage of requiring no fort, no armour, no protection, in fact, and consequently cost but little to place in position. Their principal disadvantage being slow fire, and the expense and labour of supplying them with projectiles. The necessity of this supply, however, ceases with the war, while the elaborate protections of the low guns require constant repair in peace as well as in action.

Each gun has a distinct duty.

I have shown that each gun has a distinct duty to perform, each doing something which cannot be done by the other, and therefore guns at high altitudes and guns close to the water's edge are both necessary; and I now proceed to consider whether a gun in an intermediate situation can do work distinct from either of these—whether a special duty can be assigned to it; or, failing this, whether it is capable of excelling either high or low guns in any one of their peculiar functions. Because, if it does so, such a gun might be well worth mounting; but if a gun in this intermediate position has no advantage of any sort over either the high or low guns, and possesses disadvantages peculiar to itself, why not at once move it to either the high or low line? Want of space cannot be pleaded, for there is ample room for any number of guns in either of the lines I have chosen.

The intermediate gun θ.

I can discover no special advantage for the gun θ, nor have I ever heard one stated, over either guns a or ω, taken separately; and it cannot be worth while to mount the gun in its intermediate position unless it in a greater degree combines the advantages of guns $a + \omega$, than the disadvantages of guns $a + \omega$; otherwise, having no peculiar advantages and plenty of space, it would be better to place it in one of the two lines of guns I have detailed.

Comparison of gun θ with guns a and ω.

Its fire is not horizontal (*a*); nor is its height sufficient to enable the range of its moving target to be accurately and rapidly ascertained (*m*). It holds about a mean position, as to distance from its target—a mean, in fact, between advantage (*b*) of the gun ω and disadvantage (*v*) of the gun a. It can fire with little greater rapidity than the gun a, for its axis has to be brought nearly horizontal after each round, entailing the second operation (see *C.*) It partakes of disadvantage (*w*) and loses advantage (*c*, *A.*)

Its projectile strikes the ship's plates at an angle, to some extent losing advantage (*d*), and partaking of disadvantage (*I.*) (A careful study of past experiments, with a view to seeing at what angles the projectile would penetrate the armour opposed to it *at all* at given ranges, with a calculation of the angles at which projectiles from intermediate guns θ would strike a ship's armour-plates or deck at such ranges, might determine how much it loses of the advantage (*d*), and it might probably be found to possess all the disadvantages (*u*); but not having calculated this, I can form no opinion.)

It would be in an intermediate position with regard to (*e*) and (*x*), and this may be left out of account.

Its fire is too plunging to be available for night attacks, losing the advantage (*f*) but holding to disadvantage (*y*); to say nothing of the danger of firing by night over the heads of the artillerymen in the lower batteries.

It entirely loses the great advantage (*n*), of seeing on to the decks of vessels, unless indeed they are so close as to enable the gun ω to penetrate their plates—a course which it is highly improbable they would adopt, as it would give the higher guns an almost certain chance of sinking them, to say nothing of the difficulty a ship in action experiences in manœuvring in shallow water.

The gun would not be out of the way of the enemy's fire; indeed it would probably suffer more from it at night than the low guns, as an iron-clad firing at the Rock at random in the dark would probably point high, as was done by the gun-boats during their most annoying attacks in the great siege. Even if she fired low, many shots would ricochet from the water, striking the Rock among the intermediate guns, while it would have no chance of effectively returning their fire. It would require protection therefore, though perhaps of not quite so strong a nature as the low guns. It loses, under this head, the advantages (*o*, *p*, *q*, *r*, *s*) of the high guns, and partakes of disadvantages (*g*, *h*, *i*, *j*, *l*) of the low guns.

Guns dotted about the Rock subject to accidental shots.

It is evident, too, that by dotting the guns at all heights about the Rock, even if the enemy fire inaccurately, some guns may be hit; both faulty elevation and faulty line on the part of the enemy being of little consequence. For the low line of guns, the correct elevation, at any rate, must be ascertained by the enemy—not an easy matter in a night attack.

From the above it will be seen, then, that while the gun θ has no advantage peculiar to itself, it in a great measure loses the peculiar advantages of guns α and ω, while it partakes of the whole of their disadvantages.

As I have said, had the gun θ any peculiar function of its own to perform, there might be a question of placing such a gun in position; but if my exposition of its faults is correct, there can no longer be a doubt of the positive waste of power in not moving a gun such as θ to either of the positions, α or ω, in which the greater weight of metal is required at the moment of action.

Weak point of argument.

It will be seen that the weak point of my argument is an inability to state any special function for the gun θ, not shared and even better performed by the guns α and ω. If there is any design in the present mode of arming the fortress, some such special function can doubtless be stated by those who planned the placing of nearly all the 9-inch guns in what I have taken as an intermediate position; and should the reasons for so placing them outweigh the advantages I claim for high and low lines of guns, my argument at once fails. But I think it would be very difficult to show that any definite plan has been pursued—positions for the guns having been chosen apparently more with reference to easily-built-on spots of ground than any combination of action among the guns themselves, and this I hold to be false economy.

Supposed case of iron-clad attacking.

Between guns mounted on very high sites and those near the water-line, an iron-clad attacking would lead a poor time of it. From up the Rock, the almost bird's-eye view enables each motion of the ship to be watched, and all the advantages of accurate vertical fire to be obtained. While the low guns were rapidly firing, and racking or penetrating her armour-plates on the side of the ship nearest them, the guns at a high altitude would, though firing slower, be firing at a better determined, if greater range; one successful hit doing incredible damage, and making up for all disadvantages; tearing away large portions of her plating from the side furthest from the guns, which they strike in reverse, or penetrating below her water-line; and this the gunners are doing without flurry, almost, if not quite, secure from the enemy's fire. Indeed, I believe that to engage the batteries of Gibraltar successfully, if guns are only placed high enough, a new form of iron-clad would have to be devised, proof against both horizontal and vertical fire of the heaviest description; so that, leaving out the probability of any nation incurring the enormous expense of building such vessels without certain advantage, I think it will be allowed that the solving of such a problem would require a great increase of knowledge in naval architecture.

Intermediate guns not entirely useless.

I do not in anything I have urged wish it to be understood that I hold guns in intermediate sites entirely useless; far from it, they would aid in the destruction of opposing ships. But the enormous expense of mounting these guns cannot but render it desirable that they should be, at the outset, placed in positions where their great power can be made to tell with the greatest effect. Space is not such an object on this vast Rock, that in order to mount many guns, some must be placed in faulty situations. The number of guns which it is at present proposed to mount, could readily be placed in situations differing entirely from the intermediate one which I have endeavoured to show to be bad.

Remarks apply to guns intended for sea defence.

All the above remarks apply to heavy guns intended solely to resist shipping, and only partially to such guns as combine this duty with that of land defence. There may be, and indeed I believe are, positions in which, though "intermediate," it would be highly desirable to place guns of this nature.

Iron-clad squadron at Gibraltar.

An admirable opportunity lately presented itself for testing the views obtained of the decks of iron-clads from the heights of the Rock; and could any theoretical artilleryman have been induced to ascend to the Signal Station and look down on the decks of the large ships composing the combined Channel and Mediterranean squadrons, he would have agreed with me that a very few guns, situated on the place he stood, would have rendered the whole number of these powerful men-of-war very insecure habitations.

Ship must circle to avoid accurate fire.

It must be borne in mind that, to avoid too accurate fire from the low batteries, a ship must circle, and so occasionally lie end-on—a most favourable position for the high line of guns. The low line of guns would strike her with terrible accuracy if she remained motionless, broadside on, returning their fire, but would be puzzled by her circling; while immediately she did so, she opens an opportunity for the high guns to sink her.

I should have been unwilling to have brought my ideas on the armament of Gibraltar so prominently forward, had they not been confirmed by many officers, capable of forming an opinion, to whom I have spoken on the subject. The opinion of a distinguished naval officer of high rank, who was good enough to examine my rough notes on the subject, is so valuable, that I append a portion of his remarks. To a great extent, it will be seen, they bear me out in what I advance; the chief difference being the minimum altitude at which the high line of guns should be placed. I shall afterwards state why I think he has hardly fixed on a sufficient elevation:—

Opinion of a naval officer.

> "It is very difficult to ascertain the exact distance of a ship from a low battery, unless you know the height of her mast-heads, and my belief is that with practice (which is indispensable), the same accuracy and rapidity of fire can be obtained from a high battery as from a low. The alteration of elevation spoken of as necessary while loading, should not involve any appreciable loss of time.
>
> "Two disadvantages of the medium height θ are omitted:—1. The danger of firing shell over the heads of the gunners in the front line. 2. The low angle at which the shot would strike the deck of a ship would not suffice for penetration.
>
> "Some experiments carried out at my suggestion last year, showed that 9-inch shot striking our 1-inch or $1\frac{1}{2}$-inch iron decks would *glance* at an angle of 8°.
>
> "I would, as soon as possible, place 9-inch guns in suitable positions, at heights of from 500 to 800 ft.—not more than two in each position (if this is practicable), placing the magazines away from the guns in safety. Each of these guns would command the whole anchorage, and be in comparative security from the enemy's fire.
>
> "The low batteries are of less importance, and must be made very secure against *close* attack by iron-clads.
>
> "We should fire common shell with large bursting charges and time fuzes at the high guns, but would concentrate two or three ships on the low batteries at close quarters, and use Palliser shot and shell.
>
> "In the low batteries, nothing less than 10-inch guns should be placed; in the high batteries, 9-inch guns would be nearly equally efficacious."

Reason for placing guns as high as possible.

Ferdinand's Battery, in the Queen's Road, is about 620 ft. high; and this I have taken in the outset as the height below which guns become intermediate guns, corresponding to gun θ. I have also stated that I believe the extreme height α better than any lower site. Gibraltar is almost the only fortress in which guns *can* be placed at a great height, and it appears to me to be an error to throw away the advantage thus obtained.

The line of fire of a gun in Ferdinand's Battery would form an angle of less than 8° with the deck of a ship at 1500 yds., while the ship would require to be 3000 yds. distant from the gun α before the line of fire of that gun would diminish to the same angle; yet the comparative distance would be but a very little greater, while the gun in Ferdinand's Battery would not be secure from the fire of a ship at that comparatively short range. Why, therefore, reject the higher site, where absolutely no protection for the gun itself would be needed?

Positions of magazines.

I view with alarm the positions of the magazines, as now being made near the 9-inch guns. The idea of so placing them seems to be, that as a gun is no use without its ammunition, should the magazine be blown up, the gun may as well go too! The magazines throughout the Rock are not so well chosen as to give confidence in the infallibility of our Engineers in choosing positions for these structures, and it would be well if the arm of the service which is chiefly called on to work in their dangerous proximity, should have a leading voice in the matter. The rapid working of the gun would not be curtailed if the cartridges were deposited at some little distance—a distance which should be sufficient to prevent the gun from being more than temporarily disabled in the event of an accident to a magazine. Barrows on rails would bring up ammunition from thence as quickly as a gun is now supplied by hand from a less remote magazine; and this applies to projectiles also. The magazines being some way from the guns and well hidden, would be free from the ill effects of the heavy fire directed at the gun itself in action.

Built-up batteries.

Attention might be directed also with advantage to the system of sinking the guns as much as possible in the solid rock, instead of, as at present, building up stone batteries. Strength would be gained and expense saved.

A PROPOSAL

FOR THE

DRILL OF GUNNERS OF FIELD BATTERIES

AT OTHER THAN REGIMENTAL EXERCISES.

BY

CAPTAIN AND BREVET-MAJOR H. L. GEARY, R.A.,

ADJUTANT 14TH BRIGADE (FIELD).

In submitting the accompanying proposal for the drill of field battery gunners in action, the intention is by no means to abrogate the present field exercise, which appears well adapted to provide efficient drivers and well-trained horses. The necessity for a more special drill for the gunners has been suggested by the experiences of the present Franco-Prussian war, and the great advance made of late years, both as regards the accuracy and range of artillery fire and rapidity of manœuvring.

From these considerations we may expect: (1) that the limbers as well as the gun carriages will be exposed to a more accurate, and therefore more damaging fire; (2) that a greater amount of ammunition will be expended.

To meet this, every effort should be made to husband the wagon limbers, which would be required to replace disabled gun limbers; and a precise method appears to be desirable of replenishing the gun limbers whilst in action.

Inasmuch as the equipment of field guns with axle-tree box seats has been recommended by two separate committees of artillery officers, who, from their experience and attainments, may be said to have commanded the concurrence of the regiment at large, we may assume that in future wars axle-tree seats will be provided. We have, therefore, a gun detachment consisting of the mounted No. 1, 2 and 3 on the gun limber, 4 and 5 on the axle-tree seats—total 5 men, who, sufficient alone to bring the gun into action and commence firing, will be able to accompany the gun for any distance, at any pace it may be required to move.

It is proposed that the usual position of a gun detachment be as at present in order of march. At the command "trot," 2 and 3 mount on the gun limber, 4 and 5 on the axle-tree seats; the remainder of the detachment, at the word "march," wait for the gun to clear them, then, closing inwards on the centre detachment, are marched by the serjeant-major, by the shortest and most direct route, to overtake the battery and rejoin their subdivisions.

The wagons should invariably be under the command of an officer—usually a 2nd Captain. This is most necessary, as the experience of the Waterloo campaign showed that wagons may be for days separated from their batteries, when the absence of an officer has led to their being hustled to the rear and obstructed on a narrow line of march.

In action, the 2nd Captain, having taken up a position with his wagons in as sheltered a situation as a due regard to supplying the battery with ammunition will permit, should, after say 10 rounds a gun have been fired, send forward one wagon per half battery. Each wagon, having one mounted non-commissioned officer, and two gunners on the limber, should reverse, and then halt in rear of 2 and 5 subdivisions, and the two gunners proceed to replenish the limbers, commencing with the rear boxes of the wagon body; and when emptied, return immediately to rejoin the second line of wagons, their places in the first line being taken by those covering them in the second line. The object of this is to preserve the wagon limbers as much as possible from the enemy's fire.

It is suggested that the foregoing be adopted as a frequent exercise, so as to teach the men a system of working in action, and to accustom the gunners to handle with rapidity and accuracy the various projectiles, fuzes, &c., used by a field battery.

The absence of *a system* similar to this has hitherto left the supply of ammunition to a battery in action entirely dependent upon the exertions and ability of the officer or non-commissioned officer in charge of the wagons; and should that individual be put *hors de combat*, confusion and uncertainty must inevitably be the result.

The foregoing is suggested as the drill for field batteries when manœuvring with other troops; for notwithstanding that no axle-tree seats have yet been fitted, the drill, with the omission of carrying Nos. 4 and 5, can still be practised, though of course with some sacrifice of efficiency.

For the better instruction of the gunners, it will be advisable sometimes to leave part of the limber ammunition in quarters, and to change the numbers at the gun, so that every man may have an opportunity of becoming experienced at packing and unpacking the ammunition with rapidity and care—a knowledge which is too frequently confined, except theoretically, to the non-commissioned officers and Nos. 2.

It seems expedient that the four men mounted on the gun and limber should be selected men, capable of taking the No. 1's place if requisite. If Captain Strange's scheme be adopted, they would be selected from the marksmen of the battery.

It has been proposed that men should be mounted also on the off-horses of the guns—drivers, sufficiently instructed in the duties of a gunner to assist in serving the gun. They would likewise be available to replace casualties occurring in action amongst the regular drivers. This system obtained in India for many years, until the amalgamation of the Indian with the Royal Artillery; and under it the Bengal Horse Artillery achieved a world-wide fame. Several continental armies copied it, with more or less success.

It is believed that our field batteries must do so eventually, in order to keep the field against European rivals.

SOME OBSERVATIONS

AMONGST GERMAN ARMIES

DURING 1870.

BY

COLONEL H. A. SMYTH, R.A.

HAVING been enabled through the kindness of General Von Zastrow, commanding the 7th corps of the Prussian army, to be present at the bombardment of Thionville, to examine the fortifications and neighbourhood of Metz, and to make some observations of novelties in Prussian tactics, I beg to offer my account of the first, together with my remarks on the remainder, to the consideration of such officers as may be interested therein.

Thionville,

Situation. a fortified town of about 5,000 inhabitants within the walls, and some small suburbs outside the "zone of clearance," is situated astride the Moselle at a point where the valley of this river, generally some five miles wide and remarkable for its fertility and extreme plainness, is narrowed, by the intrusion of the prevailing hilly country, to within two miles; and was no doubt originally intended to control the passage up and down the valley, as the hills are of a somewhat mountainous and difficult character: at the present day it commands two lines of railway as well as a slight navigation on the Moselle, on which small steamers ply upwards as far as Metz. The configuration of the ground furnished the cause for the origin of this fortress, the incentive to its sieges, and, in these last days, the means for its capture.

Fortification. Having around it, for a mile more or less, an almost theoretical plain, fortified by Vauban somewhat after his first system, but with the addition of a labyrinth of counterguards and outworks, having more recently been girdled with an advanced glacis with permanent lunettes, and last of all having had the body of the place finished with large earthen traverses and raised batteries à l'Haxo,—all the ditches and the space between the inner and outer glacis being susceptible of alternate flooding and draining at the will of the garrison,—well provisioned and armed with the newest cannon,—the place must be regarded, according to old methods of attack, as capable of a very protracted, and perhaps, considering the lateness of the season, (the besiegers opened fire on the 22nd of November), a victorious resistance. But it was reduced to capitulate by 2½ days' easy firing from rifled guns placed on the neighbouring hills.

Investment.

Thionville was first loosely invested on the 25th of August by a regiment of lancers (about 600 troopers), assisted originally by 12 pioneers, and afterwards by some 300 hussars: the garrison was supposed to contain more than 1,000 regulars and several thousands of the Garde Mobile, (the numbers at the capitulation were found to be about 2,000 regulars and 3,000 Mobiles); and the work on the hands of the lancers was very arduous. The country being much intersected, the line of communication joining the various posts round the place was about thirty miles long; and though at night the vedettes were pushed forward, occasionally as far as the foot of the glacis, the troopers were in reality little qualified to meet any active hostility on the part of the garrison, who ought undoubtedly to have driven them quite away. On one dark night the garrison did restore a part of the railway which had been torn up, and so receive a train of munitions from Luxemburg, but this seems to have been their only exploit; and the cavalry, armed with lance, sword, and old pistol, by means of intense assiduity, the maintenance of an imposing appearance, and extreme boldness, assisted always by the 12 pioneers, who fortified various farm-houses and were multiplied in effect by having a four-horse coach contrived for their conveyance to threatened points, succeeded in imprisoning 5,000 men armed with Chassepôts and not without some cavalry and field-artillery.

Infantry was added, during October, to the investing force, which increased during November to some 12,000 of all arms; and siege artillery was brought up in large quantities by railway to a station about four miles from the town: so that on the morning of the 22nd the besiegers were prepared to open fire from about fifty heavy pieces (with a reserve of, apparently, about half that number, and ammunition which appeared to be about 500 rounds a gun), which were to be assisted by some 30 field guns, to which various horse and field batteries of the investing force, though posted with regard to serious sorties, might be considered a reserve.

Siege Train.

The heavy pieces were all, (with the exception of two bronze 12-inch mortars of French construction brought from Metz), what the Prussians call 24-prs., throwing shells of 56 lbs. weight, breech-loading, of two patterns, viz. of wrought iron weighing 50 cwt., and of steel about 40 cwt., mostly of the wedge system, but some of the cylindrical. The charge of the gun was 4½ lbs. of powder, of the shell 3 lbs.; the fuze was invariably percussion, of a very simple pattern, wherein the plunger with the needle was quite loose but for a transverse iron pin passed through it from outside; this pin, on discharge of the gun, is thrown out laterally by the rotatory force of the shell.

Moreover, with the reserve was a battery of what they called the New Mortars, from which very great effect was anticipated. They would be more strictly described as "cannon for vertical fire," inasmuch as their charge remains fixed, and their elevation varies with the range. It is claimed for them that their shell always descends point foremost, even when fired at 80° elevation; they are breech-loading, of bronze, with some 20 grooves resembling the original Armstrong, hardly three times as long as their shell, and weigh about 32 cwt.; the lead-coated shell weighs 160 lbs., and appears to have a diameter of 8 or 9 in., and a length of 2 ft. 6 or 8 in. Their wrought-iron carriages were much like those of the other siege guns.

The field guns were 4 and 6-prs., throwing shells of 10 and 15 lbs. weight with a charge of one-tenth.

The heavy guns were mounted on the same carriages on which they had travelled hither, (some, I was told, all the way from Spandau), a few of wood, but more of wrought iron, weighing 30 cwt., very similar in form to our own siege carriages, but having the important innovation that the firing trunnion holes were raised above the brackets on two strong iron arms, so as to carry the trunnions, when in action, at 6 ft. above the ground. The advantage of this height, in connection with breech-loading siege-guns, is very remarkable; the lowest part of the parapet being kept at least 6 ft. high, no man of the detachment is ever under the direct fire of the enemy, with the exception of the very trivial exposure of the No. 1 in laying, who stands on a step of the carriage, and of course, in order to see, must be seen; and as these guns are almost invariably used at angles of elevation, the breech comes conveniently down within reach of the proper numbers.

Siege Batteries.

The position of the batteries was perhaps the most noteworthy thing in the whole transaction. On every wooded knoll that jutted into the plain, all round the town except on its north side, at distances varying from 1,400 to 3,500 yards, was prepared a battery for 4 heavy guns, the trees between it and the place being only taken down at the last moment; generally rather behind the crest of the knoll, so that moderate excavation for the terreplein left the natural surface of the ground for a parapet: the distance, the woods, and this use of the natural surface rendered them all but invincible to the garrison. Only one battery, for six 24-prs., was in the plain, in order to perfect the convergence of fire: it was about 2,000 yards from the town, and was arranged behind an old embankment some 20 ft. high; in action the pieces were laid by points similar to those used with mortars.

The batteries for the field-guns were adjacent and subsidiary to those of the more advanced heavy guns.

In most cases no embrasures were used, the elevation of the guns allowing them to be fired over a solid parapet; but in some of the batteries nearest to the place, owing to the depression of the line of fire, shallow and open embrasures, perhaps 1½ ft. deep, had to be cut. The field-guns, in order to enjoy somewhat similar advantages of parapet, were raised on planks laid under the wheels and trail.

The platform arrangement included two inclined planes to take the wheels in their recoil. Each gun takes these with it from its original arsenal. They are made of stout plank faced with sheet-iron; are 8 or 9 ft. long, and rise about 1 in 6. On discharge of the piece, the wheels quietly ran up the ascents for about two-thirds of their length, and then as quietly returned to their former place. The remainder of the platform consisted merely of planks laid across under these planes, and receiving the trail of the gun; there is so little stress on them that planks picked up in the neighbourhood are generally good enough.

The magazines offered little peculiarity beyond that they were very small; they were generally in the epaulement; but a great deal of ammunition was kept in the cellars of adjacent houses out of the line of fire.

In loading, the shell was put into the bore of the gun by means of a cradle fitting on to the breech; after each discharge the gun was sponged out, a bucket of soapy water being at hand to dip the sponge in; and twice in the 24 hours the breech-closing apparatus was taken to pieces and oiled; but these two precautions, the commanding officer told me, might be omitted without inconvenience for an indefinite time.

In laying, the guns with much elevation (some had 14°), got the line first point-blank and the elevation afterwards; the others were laid at one operation.

Opening fire.

The bombardment had been ordered to commence at 7 A.M., and at that hour, objects being still but dimly visible, the harsh crack from a steel gun broke the stillness, and after some seconds a little cloud of smoke and dust in the town declared the effect and sent back a muffled report; then a gun in each of the next batteries right and left took it up, acknowledged after a like interval by each battery successively in the circle. But the second gun in the first battery did not give its first fire till 4 minutes after the first gun; and such was the rate of succession in each battery; for the (to me, very curious) order on the subject was, that each gun should fire but once in a quarter of an hour by day, and each battery (of 4 guns) once in the same time by night.

Whether the continued and regular recurrence of a crash amongst the houses of the town, at unswerving intervals, was supposed to bring a more effectual strain on the nerves of the inhabitants than the full roar of destruction from 80 or 100 guns in full play, as the dropping of water sometimes effects more than a stream; or whether, as was no doubt the case to some extent, it was humanely desired to let the garrison see well how many, what, and where, were the batteries environing them, and recognise their own powerlessness to resist, the rule was steadily adhered to; nor only that, but even from 12 o'clock till 1 each day the firing ceased, and the men got their dinners: partly, perhaps, to give the governor of the place time to reflect, but certainly allowing him unusual opportunity to repair damages.

I am aware that the Luxemburg people, listening to the reports, recorded the rate of firing at eighteen discharges a minute; they must have added in the discharges from the fortress, as well as the actual explosions of the shells, thereby doubling the number of rounds. The only projectiles fired which did not explode were the shells from the two French mortars in Prussian use; it is worthy of notice that the time-fuzes of these shells could not be got to act properly by their new masters; the shells would either fall blind or else burst at the muzzle, so that the Prussians quickly gave up using them altogether.

The fire was principally directed on barracks, arsenals, and other military buildings in the town, their position being well ascertained from the maps in possession of the Prussians; only when some particular work of the fortress forced itself into notice by continued efforts to disturb the besiegers, would several batteries attend to it conjointly and soon quiet it; but always with the same deliberation, and at the prescribed rate of fire. The gunners were of the Landwehr, formed men, mostly fathers of families I was told, broad, stout, and lasting-looking; rain fell more or less continuously, and many of the batteries became literally ankle-deep in mud, but the methodical manner of the men took no count of external circumstances. They were divided into two reliefs, of twelve hours each; but many of their officers chose to remain at the batteries the whole time; for which choice I failed to find satisfactory reason.

The little fire that came from the French was wild, and their fuzes were very irregular; but every shell from the Prussian batteries declared itself home in its appointed spot by its jet of smoke and dust; and as the afternoon wore on, the dark cloud which had been forming above the town began to show the red light of flames, though as yet no incendiary shells had been used; but as evening came down, and as yet no message had arrived from the place, the order was given to use incendiary shells (explosive, but containing also incendiary composition) exclusively, so that the town at night began to light up the neighbourhood; and all the next morning the same relentless pounding was continued. It had been intended to get some of the new mortars into position during the night, at a sort of advanced work or parallel which the Prussians had constructed about 1,000 yards from the place; and formal siege works from thence were proceeded with to aid the bombardment in convincing the garrison; but, owing to the rain and the plain, the trenches got full of water and the country so deep that the pieces could not be got across it, either that night or the next; though it appeared to me that no contrivance beyond main force had been applied.

In the afternoon of the second day a flag of truce was shown by the town, the firing ceased, and an envoy arrived about 4 P.M. at the Prussian head-quarters, asking for a cessation of hostilities, for the purpose of sending away the women, children, and old men; this the General refused, alleging the difficulty of seeing it fairly carried out; but he said that firing would not recommence before six o'clock, and that such as chose to get out in that short time, might: he also gave notice that the next display of a white flag by the town would not procure a cessation of fire, but only the actual arrival of an envoy empowered to propose terms. And the French officer took his leave, gallantly assuring the General, "At 6 o'clock we shall be prepared to receive your fire."

Nobody appears to have left the town during the very short interval allowed, and the Prussians, thinking they had been robbed of a little time, increased the night firing up to the day rate. The town consequently burnt fiercely in many places (but without serious explosions) until about 11 A.M. next day, when the tricolor flag on one of the towers of the principal church (which was used as a granary), was replaced by a white one; too late, however, to save the roof of the church, which burst out in flame shortly after, and fell in during the negotiations which followed.

Capitulation.

There was very little delay over the terms: "the conditions of Metz and Sedan," the sole offer of the Prussian general, was soon accepted for the garrison, and it was arranged that the next day at noon the troops should march out of the town by its eastern gate, pile arms in the plain, and place themselves at the disposal of Prussian escorts as prisoners of war: after which the besieging army would march into the town. Next morning, however, the Governor sent to beg the Prussians to take over the various guards in the town forthwith, as his men were in such disorder that he could not otherwise answer for the fulfilment of the stipulations,—or even against treacherous attempts on the magazines. The guards were sent in accordingly, and instituted order in parts; but it seems to have been a rough night in the town, with a great deal of drunkenness and danger: some rejoiced at the capitulation, some were in despair; but all, soldiers, mobiles, and inhabitants, concurred in condemning the Governor, though for opposite and incompatible reasons.

The Prussian army was formed to receive the prisoners at 11 A.M., in two lines nearly perpendicular to one another, and meeting in a re-entering angle about a mile on the road from the town, some batteries of artillery forming part of one of the lines close to the angle. Only a little before 1 o'clock the lively French bugles were heard at the head of their column, which then emerged from the gates and marching smartly and very quickly, right up to the re-entering angle, descended from the road, piled arms fifty yards off, returned to the road, and stood easy. These were the regulars; then came battalions of the Garde Mobile, more slowly, with enormous gaps and many stragglers; they were very tedious, but as each battalion after piling arms arrived at the re-entering angle, it was taken charge of by its escort, and its officers returned, wearing their swords, to the town to surrender themselves individually afterwards. Long strings of country people, mostly women, passed and repassed in rear of the Prussians to the angle of exit, where, many of them convulsed with sobbing, they took leave of their relations, sons and brothers, in the Garde Mobile, probably expecting never to see them more; the men concerned wept and wailed quite as demonstratively as the women: next morning, however, at a moment's notice, they were all released to their homes, on condition of serving no more against Germany during the war; they mostly belonged to neighbouring villages, and the roads were covered with joyous lads in red trousers, half "Prussifiés" in spirit already. The regulars had mostly left by railway trains for the East the night before.

As soon as the prisoners were all received, the German troops filed through the town, to see what they had done and what they had won, and, leaving sufficient garrison in the place, passed to their various billets in outlying villages, many of them receiving orders the same night for their onward movement towards Paris, Montmédy, &c., the next day. The streets were densely crowded with people, who, after the French manner, had flocked into the fortress on the original approach of the invaders; provisions had been plenty with them, but their wild and haggard faces, still set with the stare of confronting mortal peril, together with the panorama of shattered buildings, with black ragged holes, some as large as doorways, in all directions, masses of still burning ruin, and other ready to fall, gave one some idea of the consternation which must have prevailed in such a crowded centre of fire.*

It is true that inhabitants as well as soldiers (fire picquets excepted) lived mainly in cellars during the bombardment, and in such wine-growing countries the cellars are plentiful and substantial; but they felt each shock and heard each explosion, and feared to be eventually buried alive by the burning ruins. Therefore they prayed

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* I happened to be detained a night in Thionville about a week after the capitulation, and found the condition of the houses not much restored, but that of the inhabitants nearly entirely so: owing to the movement of troops westward, many soldiers were billeted on all such houses as remained efficient, and I could not but be struck by the easy and confident relations existing between the householders and their guests: these latter were as good-tempered and orderly as if amongst their own people; cramped up for space, I saw children, too young to act a part in such matters, already playmates with enormous cuirassiers: and I take this occasion to declare, that everything that I saw and heard from either side at all places which I visited, causes me to believe that the German armies in this war have been more moderate, orderly, and civilised, than ever was invading army before; and to look with intense distrust on all tales attributing to them wanton outrage or irregularity.

the Governor to surrender, and not because, as was stated by some papers, the rising Moselle drove them up from below, for the management of the river was in their own hands; though it is true that rain-water did collect in some of the cellars. The story was current amongst both French and Germans that the Governor, having married a Prussian lady, and having been accordingly denounced by local patriots as quite likely to make a treacherous capitulation, had declared that he would never surrender till the inhabitants on their knees should beg him to do so; and that they thus obtained two days more bombardment than would have been otherwise necessary, as the Governor himself was sufficiently convinced by the first manifestation of the number and nature of the besiegers' batteries. But this statement I had not opportunity to verify.

Effect produced.

The actual damage inflicted on the besieged amounted to 8 men killed and 66 wounded (two only of these being civilians): on the ramparts, where most of the casualties took place, from enfilading shells descending at very rapid angles, a few gun-carriages were knocked about by fragments of shell, but I did not see any guns actually dismounted: in the cellars nobody was hurt.

Of the houses, hardly one escaped without some serious injury; about a quarter of the town was burnt, including nearly all the Government buildings; and much of what remained standing would have to be taken down and built up again. A great many splinter-proofs of timber had been set up in front of the ground-floors of the houses, but they were of not much avail against the fire employed.

Where shells had fairly met the brickwork escarps, the effect was small, generally a shallow excavation of 3 or 4 feet in diameter, with a funnel-shaped hole in the middle between 2 and 3 feet deep; but the houses, with stone walls averaging about 2 feet in thickness, seemed exactly calculated to call forth the best powers of these projectiles. I only saw or heard of one blind shell, though the inhabitants for a week after were busy collecting relics.

Expenditure.

The expense to the besiegers was 27 men killed and wounded, and 7,000 or 8,000 rounds of ammunition, or about 100 rounds a gun. I think it must be allowed that the application of this "ultima ratio regis" (so it is inscribed on some Prussian guns), was neat and effective, and more convenient to both sides than any other argument known, whether regular siege, storm, or starvation.

Observations.

The result might have been opposite if, on the first news of the German approach, the Governor had sent all civilians away from the fortress, and devoted the remaining energies and material to the construction of bomb-proof accommodation—the one want of the place; but the French custom has been the reverse of this. He might, moreover, have broken up the earlier investment by the active use of his infantry; though it is probable that would not have much altered the end; he explained afterwards that his troops, when first collected, had been very unformed and unreliable.

As the dénouement was so thoroughly artilleristic, I may perhaps here remark, without intruding my opinion on the general question of muzzle and breech-loading, that the working of *these* breech-loaders with this projectile and fuze, against this object, and at the rate here ordered, seemed nearly perfect: the ease of loading and security to the men could hardly be equalled, and the smoothness and clock-work regularity of the whole operation not easily surpassed.

I may add, as details, that the copper ring gas-check in the breech-closer answers perfectly, and seems as good as ever after 100 rounds (*slow* ones); and that the lead coating seems to adhere firmly to the shells; I did not hear the sound of any detached pieces on discharge, and I noticed in the town various shell-fragments which had passed through stone walls and kept their lead complete.

Metz,

in itself a kind of magnified Thionville, that is to say, fortified by Vauban in his first manner, with more added outworks, with higher ramparts and deeper ditches, finished with more commanding cavaliers and more massive traverses, enclosing a very much larger and remarkably handsome city of 30,000 to 40,000 inhabitants, having the same unlimited command over the running water of its ditches,—all which contributed to its name for impregnability in the old days,—possesses, in addition, the following advantages of vital importance in the present day, and probably also for the future;

It is furnished with a fair supply of good bomb-proof accommodation;

It can inundate and drain at will a large part of the adjoining country;

On the ground not inundable, it is protected by a chain of mutually supporting permanent detached works, (amongst them the original D'Arcon's lunette), forts, crown-works, redoubts, &c., of very important size and profile;

Advanced Forts.

Lastly, on the commanding heights which approach the town and constringe the valley at this point, there are established self-supporting advanced forts of the newest French design; four principal ones, St. Quentin, Plappeville, St. Julien, and Queuleu, at an average distance of 3,000 yards from the enceinte, and at heights of 500, 470, 190, and 150 ft above it, with two subsidiary ones at heights of 130 and 50 feet. Until two adjoining forts from amongst those four be taken, Metz cannot be regularly attacked, nor even much seen; and the ground before them is rather unfavourable to a besieger; though much more nearly level with them than is that behind, it generally falls away so as to leave but a narrow front for the attack: yet there is nothing at all impossible about the place, to a besieger with plenty of time and means.

These forts were yet unfinished when the German armies drew near to Metz; their escarps were complete on all but some of the more retired faces, some of their counter-scarps, and the bulk of the earthwork: on the approach of the enemy they were rapidly completed by various field expedients, and armed with a profusion of guns, all rifled, and all of bronze, as usual in the French service: these were of all calibres and patterns, throwing shells of from 100 down to 8 lbs. weight, and curiously intermingled in many instances where I could discern no purpose to be served by the mingling, unless to please some taste the reverse of ours.

As these works must be considered the very latest examples of French permanent fortification, I may describe that the prevailing design encloses within an irregular bastioned fort of good relief, a raised earthwork of simple trace parallel to the principal fronts, and which, serving as cavalier, central traverse, or keep, is of such enormous proportions as to discourage any idea of levelling it by fire and at the same time to exercise very important command over any possible approaches: for example, I reckoned the interior work in Queuleu to have its terreplein 40 feet above the level of the country, with complete exterior and interior earthen slopes at 45°, and on the top a full parapet finished with many massive traverses, and here and there Haxo batteries. Within its earthen mass was built a bombproof stone barrack of 3 floors, fitted for some 500 men, which, fronting the gorge of the fort (where the cavalier was discontinued), commanded a charming view of the city and of the valley of the Moselle, and appeared more cheerful and salubrious than the casemate of ordinary experience. The outer bastioned trace is so fitted to the ground as to present its greatest frontage to the enemy; it is of moderate depth, with no outworks but a small ravelin to cover the entrance on the side next the Place (where the revetments are counterarched with extensive casemate accommodation), and it has a demi-revetment all round with chemin-des-rondes and guérites.

With such forts, become, as they had, keeps to the connecting lines of strong field fortifications erected between them by the French army, I could find but little fault, though the Germans condemned, as usual, the bastion trace: of the Fortress proper I may observe that the multiplicity of its works must be in some cases rather an inconvenience than a strength, and that a large portion of them, either interior or exterior, might be fairly razed with advantage to the communications, accommodation, and sanitation of the place.

Circumvallation.

The French field-works were everywhere beautifully constructed, like models from plates on field fortification, of good profile, and very abundant. Passing from what had been their outposts to the German works of circumvallation, I found the latter certainly less pretty, and not very formidable, taken individually, but possessing, when grouped together, from their disposition with regard to successive increments of strength and of mutual support, a kind of elasticity which would enable them, without rigidly resisting the first shock of attack, to receive it within their meshes, gradually to absorb it, and eventually with combined force to throw it back as fast as it came. This system, on the level plain from Metz towards Thionville, was 2½ miles in depth, from the first slight shelter trenches of the advanced posts opposite Ladonchamps, through many intermediate supporting works of increasing development but always of easy communication in all directions, with lines of gun-pits and roads prepared for the rapid advent of field-guns nearer home, up to the main strength of the well-prepared position which rested on the fortified village of Mézières. This waiting method of defence, coupled with the amount of notice of large movements necessarily yielded by the bareness of the ground between the hostile lines, enabled the investing army, though guarding a circuit of thirty miles, invariably to collect troops enough to the point of pressure to ruin the fierce efforts of the beleaguered to break out.

Bazaine.

There is no doubt (in the German army, at any rate) that Bazaine did his best to get his forces away, though by the time when he attempted it, the preparations against it had left him no chance: the Germans believe that he could not try earlier than he did, owing to the disorganisation of his army by its enormous losses. They *know* that his army was starving at the last; and that though some quantity of provisions had been privily hoarded by the citizens, the amount would have made but little difference if divided amongst all the besieged. They believe that, though Bazaine may have desired to unite certain political conditions to his capitulation, he was no traitor, the use of which epithet they assign to the French manner: and they think that the patriots of Metz would have scolded but little at the capitulation if Bazaine had only billeted a few soldiers in every house with orders to share and share alike.

As I had previously read the statement of a correspondent of one of the daily papers that he had seen, after the capitulation, vast quantities of provisions in one of the advanced forts, I inquired of various staff officers if they had known of this untouched store of the enemy's; they told me that, though in the confusion of the latter days of the defence some special batches of provisions might have been overlooked or even forgotten after storage, they knew that nothing of consequence for 180,000 men had been found. With regard to the correspondent's vision, (as the Governor of Metz told me that I was the first Englishman who had received permission to enter the advanced forts), I think it possible that his zeal may have led him to observe what he could from the outside; everywhere tall traverses of sandbags and revetments of casks would have met his eye, and quickly filled, by inventive wit, with flour and pork, have become crushing evidence of the treachery of the unfortunate French Commander.

The Battle-field of Gravelotte,

Topography.

to the west of Metz, offers a region of rolling hills with large woods and ravines interspersed; one principal ridge, its nearest point about three miles from the advanced forts of Metz, extends from south to north about eight miles, and dominates, by 100 feet more or less, the nearest approaching hill-tops on the west, from 2,000 to 3,000 yards away. On this ridge the French were in position on the 18th of August, having been pushed back from their line of westerly retreat by the battles of Vionville and Rezonville on the 16th; their left flank, almost in contact with the Prussian advance, was protected by a deep wide and wooded ravine, and by the Moselle, which united it to Metz; the greater part of the front was covered by the same difficult ravine; and the right, which might be considered to be much refused from their former east and west line of battle, rested on the strong village and ground of St. Privat. In rear, some hundred yards from the crest, the ground fell away steeply into ravines and woods, with a good road from each flank into Metz.

The French had slightly intrenched themselves along most of the ridge; and in front of their intrenchments, descending at gentle slopes to the difficulties in front, lay an unbroken tract of bare and even ground, 1,000 yards wide on the left, 2,000 on the right: this arrangement, appropriate to the action of the Chassepôt, turned out to be the real strength of the position.

Operations.

At noon the German right (being the 7th corps), which had been feeling its way and the enemy since the 17th, having first occupied the village of Gravelotte with some hussars, and massed supports in the neighbourhood, threw up on to the adjoining plateau, 2,000 yards from the French left, and 100 feet lower than it, battery by battery as fast as they could get up from the head of the ravine at a gallop, the whole of their 84 guns, into action against the French artillery, which in somewhat similar numbers was in position opposite. The German batteries were not exactly in line, but rather, alternately, 100 yards in advance or rear of one another; the pieces were also somewhat crowded together, in order to avoid extending in front of Gravelotte and drawing the enemy's fire that way, as it was intended to use the village as a field hospital; (the design was successful; I saw Gravelotte quite uninjured, whilst the farm buildings on the opposite French position were cut down nearly even with the ground by the Prussian fire). As the batteries gallopped up, vast numbers of French shells burst short in the air, or on the ground in rear, but struck nobody; a continuous rain of mitrailleuse bullets also fell into one particular hollow behind them where nothing was; but the German commander of the first three batteries in action directed their whole fire to be given together on the first French mitrailleuse on the right; thereupon a confused storm of explosions was seen to spring all over where that mitrailleuse had stood, succeeded only by a vacant space with some wreck on the ground: the same treatment was adopted with the second and third mitrailleuses, on which the fourth vanished of its own accord, and the process of successive concentrations of fire was carried on upon the guns: with such effect that by 2 P.M. the French artillery of the left wing was completely silenced.* Then the German infantry, prepared in the ravine between the two positions, were sent on, and tried in their steady determined manner to reach the French lines; but, exposed to the full effect of the Chassepôt, were brought to a stand and driven back shattered, to be reinforced in the wood, to try again, and be again and again utterly overpowered by the fire: a corps which had been sent round farther on the right, under General Manteuffel, to try to turn or shake the French left was quite unable to get on, owing to the difficulty and defence of the narrow ground between that left and the Moselle: and towards 4 P.M. the gloomy aspect presented itself to the Germans that their most costly efforts failed to make the slightest impression on the hostile infantry in their intrenchments. Some cavalry also, massed in the ravine below, had tried to get into effective action against the French position, ascending by a good road which led across the ravine, but the head of their narrow column was received with such a fire that they were immediately ordered down again.

At 4 o'clock General Von Zastrow ordered some batteries across to try the effect of case shot at 600 yards: the first that got up, a field battery, had so many men and horses struck down that it could only get two guns into action, to be withdrawn again as soon as practicable. The next battery, of horse artillery, getting some little advantage from inequalities of ground, opened fire at between 700 and 800 yards from the French intrenchments and kept it up till 6 P.M., with great gallantry and loss to itself but with doubtful effect on the enemy: it was just in advance of some small quarries cut into the side of the hill which concealed its horses, and in the sudden advance of the French (hereafter described), two of its guns which could not be got away quickly enough, were thrown over into these quarries to prevent the French taking them. This was supposed by some of my informants to be the origin of the tragic history of German losses in the quarries of Jaumont.

The result arrived at by the German right was, at 4 P.M., generally the same for all the rest of the line; and at St. Privat in particular (opposite to which the left had arrived after a very laborious march, being on the outer flank in this change of front of the whole line of battle, and having, by its arrival in position, given the signal for the others to engage), the long exposed slope of bare earth had proved insurmountable; and from 4 o'clock till nearly 6 there was generally silence except where, on the extreme left, the artillery still ham-

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* The guns about Gravelotte also silenced some artillery of the French centre posted rather strongly in the farm called Leipsic, at a range of from 3,000 to 3,200 yards; this distance would have been considered too great, but that no nearer point afforded a satisfactory view, and that there was urgency to quell the artillery defence thereabouts by artillery. There were many very long ranges on that day; men and horses were killed by Chassepôt bullets which must have travelled at least 1,400 yards; but such hits were neither purposed nor perceived nor utilised by their authors: of all the far-ranging missiles, only the large percussion shells from the German guns, bursting with unmistakeable evidence, enabled their distant masters to recognise and to follow up or to adjust their action.

mered at the tough village of St. Privat. But as dusk was settling down a little before 6 o'clock, of a sudden an enormous and continued roar of fire burst from the French lines, a storm of bullets, such as had not been all day, whistled through all parts of the German lines, the French infantry leapt from their intrenchments, and, shouting and running their utmost, and loading and firing all the way, rushed in an immense but irregular swarm, with astonishing speed and noise and fire, towards the ravine held by the German infantry. Thereabouts they met the latter, no ways disposed to go back though hitherto unable to get on; and for a short time these opposite masses fired volleys into one another at close range. Just about this period however, an additional corps d'armée was brought up from the rear to the left of the 7th corps, and the whole German line thus reinforced, receiving the order to advance (the left being at last enabled to do so by the action of a Hanoverian corps which, having gradually forced its way round the French right, had established batteries playing on the flank and rear of St. Privat), pressed forward in imposing numbers and drove the French infantry back to and past their intrenchments and headlong down the reverse slope of the hill.

By this time darkness had arrived, which saved the French from enormous losses in their descent of the tortuous roads towards Metz; but their army was so disorganised that the Germans, who commenced some sort of works of investment the same night, had time to get everything prepared for them before they could make any fresh attempt to break away from the place.

These movements of the troops were detailed to me by various officers of the staff of the 7th corps, partly on the field and partly over maps; the account of the ground I am myself responsible for.

The Hill of Spicheren,

three miles west of Saarbrück, stands out at the turning-point of a ridge of hills from 300 to 400 ft. high, of which the right branch (as the Germans looked at it, nearly end on), retiring westwardly towards Forbach, overlooked the road thither from Saarbrück, whilst the left branch, directly facing them, extended for two or three miles, wooded and somewhat steep, nearly to the Saar river on the south.

On this ridge the French had taken up position, apparently to check German pressure on their own westward retreat from Saarbrück, whence they had hurriedly broken up during the night, in consequence of the discomfiture of the right of their grand line at Weissenburg, and the threatening advance thence of the army of the Crown Prince of Prussia. Their left, on the retiring branch of the ridge, was rendered difficult of access by their occupation of some villages in front; but the hill of Spicheren, the salient point of the position, rested mainly on its own merits, viz., its bold sides, at inclinations of from 30° to 40°, and its perfect command of the bare plain in front, which, for the last 1,000 yards of its approach, had sufficient ascent in it to moderate the pace of any assailant; a small breastwork was made all along its exterior crest, and it received some flanking defence from guns on either, but principally on the left or retiring, side.

The German forces on the opposite side of the Saar, on finding Saarbrück evacuated, crossed at once in pursuit, and coming upon the French position before noon, immediately attacked, and, as their forces gradually arrived, assailed it about 2 or 3 P.M. along its whole front; they advanced with a thick line of skirmishers supported by company columns, and lost very heavily whilst crossing the plain, so that the first columns that got up on to the slopes of the hill, being too shattered to go on, lay down waiting for reinforcements and breath, the fire of the defenders passing over their heads; and with reinforcements which arrived they tried and tried again to get to the top, being always stopped with heavy loss but not driven back: until at last, pushing persistently everywhere, getting always more and more men to the work, and a Prussian field battery having, with the loss of more than half its men and horses, got into a kind of flanking position amongst the wooded hills on the left and begun to make itself felt, the columns finally rushed over the crest and cleared the whole hill-top with the bayonet. The ground in rear was very defensible by the French, and they did, assisted by the approach of evening, make fight enough on their retreat to get all their guns away; but their pace was continually quickened by the German pressure, and before nightfall the whole of them had become disordered fugitives, who, falling precipitately back on Forbach, found there, instead of succour, a fresh German attack mastering the whole of that strong position. As this was on their left flank and rear, the complete rout of everything French in that connection was the immediate result: night and the fatigue of the victors saved the whole force from being taken.

It is probable that at Spicheren the assailants lost many more men than the defenders, but the success was well worth buying dearly, as it rendered practicable, and also utterly decisive, the isolated yet concentric attack delivered by the neighbouring German corps upon Forbach. This corps was called, during the action, from a day's march distance, and measures concerted with it, by field telegraph.

The storming of such a bold height with the bayonet in broad daylight is, in these days of improved musketry, a remarkable feat. How much the credit is due to mere perseverance and courage, how much to the arrival of the battery on the enemy's ground, (one of the aides-de-camp engaged told me that the French began to give ground directly that the shells from their own level began to flash amongst them), and how much to the gradually increasing development of the German right, I could not precisely learn; but as I looked from the commanding crest to the bare slopes below I was convinced that English infantry, of the present kind, would never have been stormed away from it as long as they had a cartridge remaining.

In Tactics,

Cavalry.

the Germans declare the theory that regular cavalry, so far from having had its scope diminished by the power of the new musketry, has become more than ever necessary in pitched battle: for since the unsupported attack of infantry, by infantry, has become almost impossible, owing to the assailants suffering such loss during the time of transit as to become inefficient before they can arrive, the speed of cavalry offers the most ready means of delivering an attack in a fraction of the time and consequently with a fraction of the loss. *Good* cavalry, they reckon, attacking formed infantry in the open, will, in its charge, leave half its numbers on the ground, but *will arrive* to the infantry, and there dispose of it: a grave measure, only to be adopted in emergent cases; but then, though expensive, beyond all price.

In this connection, Count von Schmettow, who led the charge of the Bismarck Cuirassiers at the battle of Vionville-Resonville, told me that he would feel confident of being able to deliver a cavalry charge home to any French infantry (such as it had then become) in the open, commencing from the farthest range of their weapons; but that he would not feel so sure against infantry such as it was at the beginning of the war, with its *morale* yet unshaken. As to the particular charge named, on the 16th August the one German corps that had struck Bazaine's retreating army being exhausted and sorely pressed, orders had been issued for all the cavalry that could be got forward anyhow to attack at once wherever it could; the Count, with a regiment of cuirassiers and one of hussars, passing along a hollow perpendicularly through his own lines, emerged forming to his right about 1,000 yards in front of them, and at once led, across the front of the army, for a French force coming into position opposite to its right; he had 800 or 1,000 yards to go, a wood full of French skirmishers touching his left all the way, but he got on to the first line (guns, as it happened) before more than two or three of them had been brought fairly to bear on him, and sabred the gunners, a line of French infantry some 300 yards in rear of the guns firing at best speed into the mêlée of friends and foes; he had soon ridden over this infantry also, (which partially got up again and opened fire on him when past), and on over another line of guns which was ready for him about 600 yards off with infantry behind it of the same distance, behaviour, and fate as the first: he charged back again over the same two lines, receiving a damaging attack from French cuirassiers on the way and having now the wood full of skirmishers on his right instead of his left, and regained his original position with the loss of half his rank and file, and with only one officer uninjured in person or in horse; but having achieved the object of relieving, for the time, the German right from French pressure: if that right could only hold on there until the arrival of the other corps hastening up from the rear, Bazaine's army must stop, must go back, and must be shut up in Metz.

I heard also, that in the cavalry attack next on the left of this, a regiment of cuirassiers with one of lancers rode down two formed squares of French infantry; but I had not the good fortune to converse with any of the officers actually concerned.

It may be remarked, with regard to the first of these affairs, that the multiplicity of the hostile lines certainly facilitated the cavalry exploit; and with regard to the second, that squares hardly appear to be the most effective formation nowadays for resisting cavalry: and, as to the success, generally, of the attacks by the German cavalry in this war, that the latter universally accuse the French of firing too high when the assailant begins to close rapidly: it is noticeable that the charge so gallantly delivered at Sedan by the French cavalry upon Prussian infantry utterly failed: and against fire like that of the English infantry, the experiment remains a very questionable one for any cavalry to essay.

The opposite idea of the use of cavalry, as mounted rifles, or real dragoons, is not very popular in the German army, owing to the supposed difficulty of training short-service men to the double action. A Prussian major of lancers, who had served in the Russian dragoons in Asia Minor during the Crimean war, stated that the system had the best chance with the Russian 26 years' term of service; but that even there, the men, being first made good cavalry, could never be got beyond the most helpless condition as infantry. This may be true of Russians; but the Prussian hussars are trained to act, and have done good service in the present war, both mounted and dismounted.

Infantry.

In infantry tactics they have less novelty: they incline to the opinion that good infantry with fair space for the play of its weapons can hardly be successfully attacked by infantry, without combinations; and that, if the assailed have a breastwork, something more than direct artillery fire is needed to help the attack home to it.

But the German infantry advance is very steady and slow; meant to be quick at the finish, but it may happen that none of them reach it: they blame the French for the opposite extreme, of running up from such a distance as to be quite exhausted on arriving at the decisive ground. And it must be remembered that their usual front line of battle is simply a very strong line of skirmishers, supported by battalion columns of companies, all with a strong idea towards using the bayonet, which they invariably carry fixed. Perhaps when they are armed with improved muskets they will adopt an order more powerful in, and less vulnerable to, musketry fire, will carry the bayonet in its scabbard, and get rid of the short sword so many of them carry in addition. They carry large loads now, and march very lastingly.

Artillery.

In field artillery the main idea seems to be to move quickly and fire accurately, concentrating the fire if possible. They appear to consider it proven that their own system, including the breech-loading, is superior to any other, and refer triumphantly to effects produced; which, however, must also be much attributed to the bold handling of batteries in this campaign, whereby the production of a certain effect has been made of more importance than the security of the battery. And I think it cannot be denied that their system, including, as it does, but the one most appropriate projectile to breech-loading, viz., a capacious percussion common shell, (appropriate because it demands only accuracy, not great projectile force, nor even ignition of fuze, from the gun), if it never yields any astounding results, yet allows a certain average satisfactory effect to be fairly reckoned on, (except of course on boggy ground). They say that nothing ever goes wrong about their guns; the shells, held fast by screw fittings, are carried loaded and fuzed with the exception of the small igniting cap, securely kept apart to be added at the last moment; trial shots with these shells are more definitive of the range than with anything else; and the guns are very handily worked behind small cover—but they desire to use some form of shrapnel. There trouble and change loom in their future: they believe that they possess already a very perfect time fuze (not yet issued on service), and that the reason the English have so much difficulty with fuzes is, that they do not insist sufficiently on having them always newly made.

They carry 10 rounds of case per gun, of which, however, they have no opinion: also a proportion of small cartridges with special charges for pitching shells just over covering crests—a practice in which they have some confidence.

Their guns (field) will by-and-by be all of bronze, instead of iron and steel, partly for convenience of manufacture, and partly because it "allows some use to be made of guns captured from an enemy."

Mitrailleuses.

Of mitrailleuses the Germans have a high opinion, especially against cavalry attacks, horses, they say, being more alarmed by its horrid noise than by any other; but they have not made up their minds as to their fit place with an army: they are decided that, in fortresses, they are exactly suited for the flanks, permitting of very long lines of defence: and some officers desire to see them adopted as battalion guns in the field; which, however, appears to me to be throwing them away, in a place where they are not wanted.

General observation.

Finally, it is very worthy of notice that the Germans all seem to agree in assigning their success generally to two causes,—the exactness of their drill, and their superior discipline: the French their reverses (when not repeating the popular cry of "treachery") to their own in-discipline; which they declare to have sprung mainly from the efforts of the higher officers to gain popularity amongst the private soldiers at the expense of the authority of their subordinates, and also from the determined efforts of the Press to wield power within the army. I, as a looker on, cannot but put in the first place the moral forces acting beneath the above causes, to wit, the German love of truth and the French addiction to romance, generating respectively, in war, determination and excitability: after which, as to details, I agree with the above.

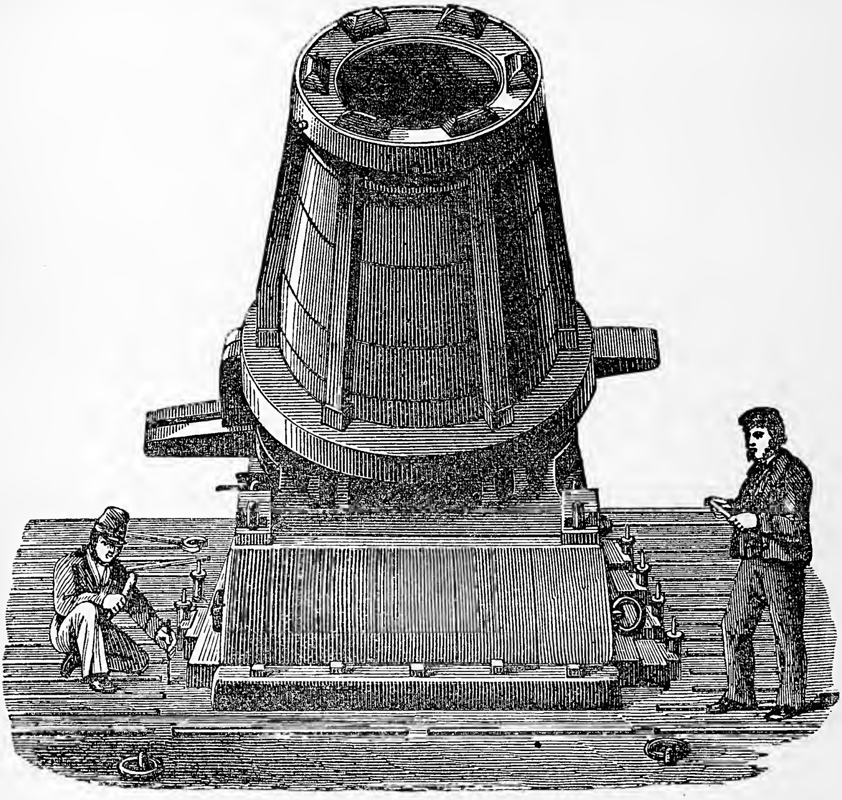
To compare our army in the above particulars, I would say that our system of drill has much in common with that of the Germans, and that in steadiness we may become equal to them, in quickness superior: but that in military discipline—that spirit in which all, from the prince to the peasant, give immediate and entire supremacy, in all service matters, to pure military authority, without prejudice whatever to their social or private relations,—even the English, as well as all the other armies of the world, may learn something from the system of Prussia.

LONDON, *December* 17, 1870.

ERRATA.

Page 186, 3rd line from bottom, *for* "invincible," *read* "invisible."

,, 194, the side note "Bazaine" should not have appeared.



MALLET'S 36-INCH MORTAR.

Front Elevation.

[The author is indebted to the kindness of the Council of the United Service Institution for the use of this block, and of the side view at p. 212.]

THE

STORY OF THE 36-INCH MORTARS OF 1855-1858.

BY

MAJOR-GENERAL LEFROY, C.B., F.R.S., R.A.

> 1. "I AM SO FULLY SATISFIED OF THE PROBABLE SUCCESS OF MR. MALLET'S SCHEME, THAT I AM WILLING TO TAKE UPON MYSELF, AS FIRST MINISTER OF THE CROWN, THE FULL RESPONSIBILITY OF CARRYING IT INTO EXECUTION; AND I THEREFORE REQUEST THAT YOU WILL, WITHOUT THE SLIGHTEST DELAY, TAKE THE NECESSARY STEPS FOR THE IMMEDIATE CONSTRUCTION OF TWO MORTARS UPON THE PLAN PROPOSED BY MESSRS. MALLET AND BARRY.*
>
> "TIME IS AN ESSENTIAL ELEMENT IN THIS MATTER, AND MONTHS HAVE ALREADY BEEN LOST IN NEEDLESS HESITATION."

Such were the memorable words, addressed to the Lieutenant-General of the Ordnance, May 1, 1855, by which Lord Palmerston broke through the obstructions of routine and the cautious counsels of his usual advisers, to take upon himself the responsibility of a step which was worthy of the mechanical pre-eminence of Great Britain, and the energies she developed in the Crimean War. It is a fact hardly known that had a similar decision been exerted on another occasion, we should have had a field battery of rifled guns before Sebastopol in the same year; for its equipment was ordered by Lord Panmure, although the order was subsequently cancelled.

2. It is somewhat remarkable that, with such an historical interest attaching to them, we should still be without any account of the 36-inch wrought-iron mortars of 1855, except the paper read by Mr. Mallet before the United Service Institution in May, 1858. As part of the practice made with one of them was subsequent to that date, this paper is necessarily incomplete. It is needless to dwell on the military interest of the subject. They not only eclipsed all previous monster mortars—such as the long range 13-inch mortars employed by the French at the siege of Cadiz in 1810, one of which may now be seen in St. James's Park, and the Liège 24-inch mortars employed at the siege of Antwerp Citadel in 1832†—but they remain unsurpassed as pieces of ordnance, in respect to the weight of metal they were intended to throw, and did actually throw in the course of the experiments,

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* See Mr. Mallet's note subjoined, as to Mr. Barry's connection with the subject.

† This piece had a calibre of 24 ins., but weighed only 7 tons.

to a distance exceeding a mile and a half. This weight reached 2986 lbs.; in the shells thrown furthest it was as much as 2400 lbs.

3. The following paper is prepared from notes which have long been lying by me, extended by consulting the original records, and by information kindly given to me by Mr. Mallet himself, and Sir Charles Wheatstone, who in his then official capacity of member of the Ordnance Select Committee, took, as will be seen further on, an important part in the experiments. I propose to record the facts exactly, and then to see what conclusions can be based upon them.

4. It will first be convenient to say something of the origination of the mortars—a matter which gave rise to a warm controversy between the late Captain Blakely and Mr. Mallet, in 1860, on the claim to priority by the former as the alleged inventor of "ringed structure" in guns.[*] The latter gentleman expressed himself thus, in controverting the claims of Captain Blakely:—

> "Now as to the dates of my own proceedings. The general principles of the construction of built-up guns—the fact that an enormous accession of strength could be attained by external rings with initial tension—were known to me from about the year 1850, and were first suggested to my mind by reading certain passages in Mr. Edwin Clarke's book on the Britannia Bridge, where (Vol. I. p. 306, and note to p. 311) facts may be found containing the germ of the whole theory. I, however, gave no publicity to my notions until the year 1854. In October, 1854, I made my original design for the 36-inch mortars since constructed by Government. That design, made and then dated by my own hand, lies now before the Academy."[†]

The mortar as designed (See Fig. 5, p. 227) was composed of a massive cast-iron base, containing a chamber of comparatively small capacity, hooped externally with wrought-iron, in one thickness of 9 or 10 ins., upon which rested a chase in three lengths, each of two thicknesses, tied down to the base by longitudinal bars. The resources of the day were unequal to the production of rings of such size and thickness, and the contractor actually contemplated at one time cutting them out of thick hammered plates. Happily for his reputation and the success of the mortars, this was not

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[*] See "Proceedings of the Royal Irish Academy," Vol. VII. p. 355.

[†] "Proceedings, Royal Irish Academy," Vol. VII. p. 334. The provisional specification of Blakely's Patent, No. 431, of August 14, 1855, bears date February 27, 1855. His first pamphlet appeared in July of that year. Sir W. Armstrong's provisional specification is dated February 11, 1857; but Professor D. Treadwell, who submitted a plan for the construction of cannon to the British War Office in 1855, was so satisfied that the ground was then preoccupied, that in a letter dated May 28, 1855, addressed to the author, he says:—"After you mentioned to me at our interview last week, that the Government were already pursuing experiments upon the construction of cannon on a plan similar to that proposed by me, I abstained from occupying your time with many mechanical principles and details connected with it which would go far, I believe, to strengthen the design that I proposed, and amongst others those that form the subject of the accompanying paper."—*To Captain Lefroy, R.A.* These dates, while confirming Mr. Mallet's claim to priority, are important in any review of that epoch of mechanical activity, and are in no degree inconsistent with the claims of Professor Treadwell to the employment of coiled wrought-iron over steel barrels as early as 1842. These claims, after a full investigation by the American Academy of Arts and Sciences in 1865, were recognised by the award of that rare honor, the Rumford gold medal—the fourth only which that learned body had awarded in seventy years.

permitted by the designer, who then resorted to the plan of building up the component parts of rolled iron, the billets composed of old rails, piled alternately with "puddle bars," lap or double $\overset{\mathrm{Y}}{\mathrm{A}}$ welded into hoops, with a species of dove-tailed joint, which hoops were shrunk over one another to the requisite thickness.

The mortar to which the present paper refers, may be described as follows:—

(1) There was the cast-iron base, 30 ins. thick, weighing about 7½ tons, which carried the trunnions, and the flange for holding the longitudinal bars, and the chase for the quoin wedges, forming at that side of the axis the fulcrum for elevating. A hole 37 ins. in diameter and very slightly coned was bored through this base, and enlarged by a recess at the top to 48 ins., forming a recess about 13 ins. deep.

(2) There was a wrought-iron chamber or breech-piece, nearly 70 ins. long, formed of a solid forging, much after the manner of the Mersey Company's great cannon of the same epoch.* Its largest external diameter was 36 ins., reduced by three steps to 24 ins. It was strengthened externally by two layers of wrought-iron hoops over the body, and one heavy ring towards the mouth, the whole turned with a slight cone, to fit the cast-iron base. The chamber proper, which was bored in this, was 48·5 ins. deep, and coned from a diameter of about 14 ins. at the cup to 9 ins. at the further end. The front was cupped to fit the shell. This piece weighed altogether about 7 tons.

(3) There were three great compound rings of wrought-iron, which, together with a muzzle ring, made up the chase 80 ins. long. They were built up respectively of 21, 19, and 11 sectional hoops, so disposed as to break joint—the inner or *A* tube of each being in one length, the remainder in two or three. The largest of these hoops was 67 ins. in external diameter, made out of a bar about 19 ft. long; the smallest was 40 ins. in diameter. The greatest thickness of the chase was 16 ins., the least 9 ins.

(4) A heavy muzzle ring and moulding, having a sectional area of about 78 square inches. It was turned with a flange to fit over the top of the chase.

(5) Six wrought-iron longitudinal bolts, nearly square in section, connecting the above-named ring with the cast-iron base. They had a sectional area of 21 square inches each, and were secured at the bottom by gibs, and keys (*cotters*). The top of each bolt was provided with a head, resting on a sort of circular iron washer; and to prevent the transmission of a violent jar on discharge, a thin ring of wood was interposed between the exterior

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* Two experimental malleable iron guns of 13-inch bore were ordered of Mr. Nasmyth in the early part of 1855. One of them was actually welded up, to a weight of upwards of 31 tons, when insuperable difficulties in the then state of manufacture compelled its gifted projector, with bitter reluctance, to give it up. Messrs. Horsfall were more successful, and in the summer of 1856 completed and presented to the Government the 13-inch gun of 22 tons now mounted at Tilbury Fort. The Royal cypher and a commemorative inscription were cut on this gun by order of Sir John Pakington, Secretary of State, in 1868, and it is to be regretted that Mallet's mortars have not yet been similarly honored.

ring and the muzzle ring. The subsequent fracture of one of the longitudinal ties was partly attributed to the employment of a wood so hard and inelastic as beech for this washer, in one of the repairs of the mortar, instead of elm. The longitudinal bolts were fitted into square recesses cut in the muzzle ring, and to keep them in their places an external *clip ring* went round all. The entire weight was 42 tons.

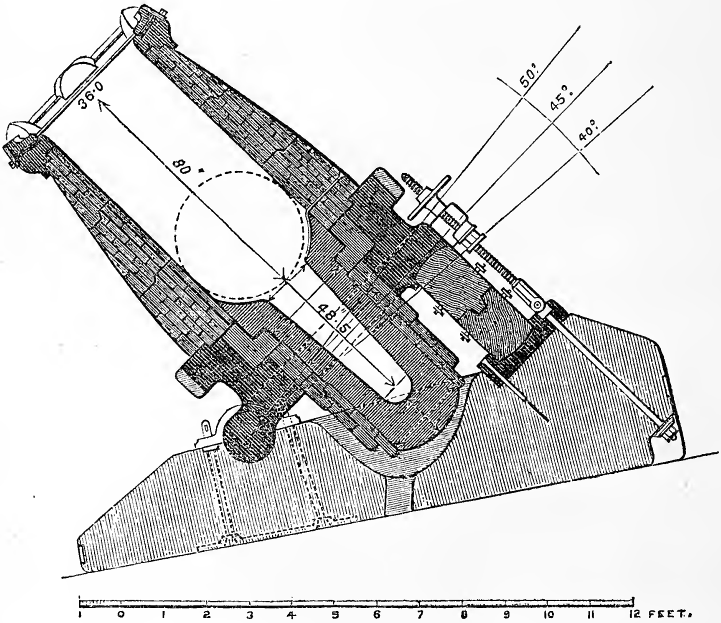
(6) The axis of the trunnions was 3 ft. from the end of the piece. This hinder portion went into a cavity in the wooden bed.

(7) The mortar bed carried an iron plate, which served as a bed plate to two heavy beech-wood quoins, which permitted any elevation between 40° and 50°. A strong elevating screw served at once as an attachment and as a means of adjustment. The centre of gravity of the shell in the loaded position, at 45°, was vertically over the axis of the trunnions, and the centre of gravity of the system was behind it, so as to counteract the tendency of the mortar to topple forwards from the reaction of discharge. The platform had a slope of 12°, and the recoil never exceeded 15 ins.

All these details will be readily understood by referring to the subjoined woodcut.

Fig. 1.

Mallet's 36-inch Mortar No. 1, of 42 tons, tried at Woolwich, 1857–8.



Note.—The hatching of the chamber-piece should have denoted longitudinal fibre in the iron, and of the rest circumferential fibre. The trunnion-piece is cast-iron.

5. Mr. Mallet read a paper before the Institution of Civil Engineers in 1859* on the coefficients of Elasticity and Rupture in massive forgings (T_e T_r), in which we find much information respecting the metal used in his mortars. A sum of £50 had been granted by Lord Panmure in 1856 towards the expenses of the investigation. The samples tested are described as follows:—

Class I.

"Mark 3 H., No. 1.—Wrought-iron, fagotted, forged slabs, drawn out under the steam hammer, 11 ins. by 2·5 ins. rough section; prepared for the chase rings of mortar No. 1.

"Mark 4 H., No. 2.—The same, drawn out under the steam hammer for the chase rings of No. 2.

"Mark 1 R., No. 3.—Wrought-iron, rolled slabs of the same iron as Nos. 1 and 2, of the same dimensions, and for the same purpose. Mortar No. 1.

"Mark 2 R., No. 4.—Wrought-iron, rolled slabs, the same in all respects as No. 3. Prepared for mortar No. 2.

"All these irons were prepared at the Thames Iron Works, London. Specimens Nos. 1 and 2 were intended for the internal rings, and Nos. 3 and 4 for the external rings of mortars 36 ins. in diameter. The slabs were welded into rings or hoops of various sizes, from 7 ft. diameter down to 3 ft., reduced to equal thicknesses of 2 ins. Eight plies of these hoops, shrunk one upon the other, according to a determinate law of tension, constituted the thickness of the chase of these mortars.† The object in testing the iron of these hoops was not only to obtain absolute measures of the ultimate resistance of the material employed; but also to determine whether the same malleable iron afforded a greater resistance to forces of tension and compression, when prepared by means of hammering or by means of rolling, the dimensions being the same in both cases. . . .

"Mark 1 O., No. 5.—Fagotted and forged slabs, prepared for exterior reinforce hoops, or rings shrunk upon the central core pieces of the chamber of the mortars. The iron for these was prepared from puddled balls of the best selected Scotch and North Wales pig iron. The rough bars were hammered into slabs, which again were piled and welded up into the required size under the hammer. Each slab, when complete, was about 5·5 ft. square by 1 ft. thick. The test bars were cut out parallel with the broad surfaces of the slab."

Class II.

"Mark P 2, No. 6.—Fagotted, forged bars, welded and drawn under the steam hammer, and prepared for the purpose of being again fagotted and welded into the great masses intended to be used for the Mersey Company's gun, and for the central or core pieces of the chambers of the mortars of 36-inch calibre. This iron, constituting the integrant material for all the large forgings, has, therefore, comparative reference to both Class II. and III. It was piled and prepared in the following manner, and was fagotted into rough bars averaging about 10 ins. by

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* "Minutes of Proceedings," Vol. XVIII. p. 296.

† This is apparently a clerical error. The drawing only shows seven.—J. H. L.

3 ins. in section. Puddled rough bars were made from the best selected Scotch and North Wales pig iron, and were worked as little as possible before being sent to the forging department. The puddled bars were hammered, then rolled into No. 1 bar iron, and that was cut up, piled, and again rolled into No. 2 bars.

"Mark C 1, No. 7.—A bar, cut by the planing machine from the exterior of one of the large cylindrical masses forged for the mortar chambers (but which turned out to be defective in the interior), in a line parallel with the axis of the mass.

"Mark C 2, No. 8.—A similar bar, cut in the same way from another mass, defective in the interior, for the other mortar chamber. These specimens afford measures of the longitudinal strength of great cylindrical forgings. . . .

"Mark C 3, No. 9.—A hoop of about 3 ft. in diameter, cut out in the lathe from the circumference of one of these massive forgings. The hoop was cut through transversely, gradually made red hot, and then opened out straight by bending back, without hammer blows, so as to give a straight bar that should afford measures of the circumferential or tangential strength of the mass.

"Mark C 4, No. 10.—A hoop similarly prepared in all respects to the preceding, but from another forged mass—viz., that from which No. 7 was cut. Sections were, in fact, obtained from massive cylindrical forgings in three directions—viz., on the outside parallel with the axis, across the end transverse with the axis, and circumferentially by an annular ring from the end."

CLASS III.

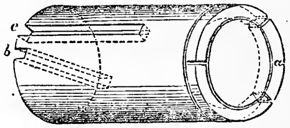
"Mark L 4, No. 11.—A bar, cut by the planing machine from the muzzle-end of the surplus length of the cylindrical mass, forged for the Mersey Company's 13-inch gun. This bar was cut transversely, or square to the axis of the cylinder, and in a line parallel to the diameter; it therefore gives a measure of the strength of the mass in a radial direction, or in the normal, in a piece of ordnance exposed to bursting strains.

"No. 12.—A bar, carefully fagotted in a charcoal fire, from the heavy cuttings out of the interior of the Mersey Company's gun."

The subjoined woodcut explains the manner in which the various specimens above referred to were cut out of the masses subjected to test.

Fig. 2.

Diagram to shew the three directions in which Test Specimens were taken.



a. Circumferential specimen.
b. Transverse specimen.
c. Longitudinal specimen.

6. The paper proceeds to explain at length the mode of building up the

great forgings, and to account in a highly instructive manner for the transverse fissures developed in cooling, the result of contractile strains :—

> "These powerful contractile strains within the mass in cooling, exercise considerable influence upon the arrangement of the crystalline axes and planes of separation of the iron. Bearing in mind the general law, that the principal axes of the crystals of a cooling, and therefore a contracting mass, are found to arrange themselves in the direction of minimum internal pressures, it will be obvious that the grasp of the external rigid ring upon the internal nucleus will tend to place the crystallising axes of the former in tangential directions, and those of the nucleus—if at a temperature sufficiently low for its crystallisation to take place—in radial directions, during the first periods of cooling. When the contractile forces of the external ring have ceased to be tensile circumferentially, and have become tangentially compressive (in virtue of the radial pull of the contracting nucleus), and when, at the same time, radial compression of the nucleus by the exterior has given way to the contractile tension of the former, pulling away from the latter, as also from itself, then the tendency will be to arrange the external crystalline axes radially, and the internal ones tangentially. The change of sign or direction of the respective tensile and compressive forces, tends to alter the directions of all the crystalline axes during the cooling process. This is the cause of the varied directions in which the integrant crystals are found in the vast mass of such forgings, when broken into, or otherwise examined.
>
> "The remedy for this unfortunate play of molecular forces, which was adopted with respect to the large forgings at Liverpool, and was at last in a great degree successful, was to build up and work them hollow from the commencement. When a cylinder has a large concentric cylindrical hole along its axis, it cools at the same time, though not equally, on both the internal and the external surfaces; and thus the extremes of internal strains are avoided, and the hollow centre yields more readily to the forcible compressive grasp of the exterior."

7. The value of this quotation will be an apology for its length. Mr. Mallet's results are given in six tables, from which I extract a few of the particulars as bearing directly on the structural strength of the mortars, and interesting for comparison with similar data since made public, for the irons in use in the Royal Arsenal at the present day. See for example the elaborate tables printed in "Extracts of Proceedings of the Department of the D.G.O.," Vol. VII. p. 234, from trials made by Mr. Kirkaldy in 1869, with iron and steel, from 9-inch gun No. 281.

"The coefficients T_e and T_r were designed by Poncelet, to express the 'work done' by an extending or compressing force upon any elastic prismatic body at the point where its elasticity becomes permanently impaired and its form distorted, and the further point where rupture occurs." ("Minutes, &c.," p. 298).

$$T_e = \tfrac{1}{2}\,Pi\,;$$

where i = extension in terms of length, assumed to be uniform throughout its range.

P = force in lbs. applied per unit of section.

T_r is arrived at in the same way.

TABLE I.

Physical data for the Irons employed in Mallet's 36-inch Mortars, 1856, compiled from Tables I. to VI. of his Paper on the coefficients of Elasticity and Rupture in Massive Forgings. ("Min. of Proc. Inst. of C.E., Vol. XVIII.")

Mark.	Mallet's tables.	Iron from which the sample tested was cut.	Specific gravity of specimen.	Extension per square inch section.					Compression per square inch section.				
				Tension at elastic limit.	Tension at rupture.	Extension on 12 ins. at elastic limit.	Extension on 12 ins. at rupture.	T_e	Pressure at elastic limit.	Pressure at complete distortion.	Total compression on 12 ins. at elastic limit.	Total compression on 12 ins. at complete distortion.	T'_e
				tons.	tons.	ins.	ins.		tons.	tons.	ins.	ins.	
3 *H*	I.	Hammered slab or bar, 12″ × 4″	7518	15·312	24·062	0·0143	2·2166	20·579	25·00	28·58	0·36	0·64	42·00
4 *H*	〃	Hammered bar	7546	14·219	22·969	0·0240	1·6333	31·850	25·00	28·58	0·36	0·67	42·00
1 *R*	〃	Rolled slab or bar, 12″ × 4″	7457	10·937	22·969	0·0333	1·8290	33·993	22·32	27·68	0·31	0·49	32·50
2 *R*	〃	Rolled bar	7537	10·937	22·969	0·0200	2·1667	20·416	23·22	27·68	0·36	0·54	39·00
1 *O*	〃	Faggotted forged slab, 48″ × 48″ × 12″...	7610	8·750	18·594	0·0156	0·0924	22·740	20·54	27·68	0·32	0·70	29·90
P 2	II.	Original faggot bars for the Mersey Company's gun	7649	12·031	21·875	0·0292	0·6600	32·789	21·42	27·68	0·36	0·64	36·00
C 1	〃	Longitudinal cut from forged mass......	7772	9·844	19·688	0·0240	1·0400	22·050	17·86	24·20	0·37	0·70	31·00
C 2	〃	do. do.	7640	10·937	17·900	0·0110	0·5200	11·229	16·08	23·22	0·26	0·66	19·80
C 3	〃	Circumferential do.	7632	6·562	16·406	0·0100	0·0772	6·125	17·86	25·00	0·32	0·73	27·00
C 4	〃	do. do.	7614	5·470	16·716	0·0152	0·1040	7·758	16·08	25·00	0·28	0·76	20·70
L 4	III.	Transverse do.	7673	3·281	6·562	0·0040	0·0424	1·225	16·96	25·00	0·26	0·65	20·90
(3)	〃	Charcoal rolled bar........................	7634	5·470	22·321	0·0800	0·9280	40·833	19·64	25·90	0·30	0·59	27·50
—	—	Puddled steel	7795	14·219	42·300	0·0288	0·6700	38·220	53·6	66·00	0·91	1·91	428·00

8. Puddled steel—which is introduced for comparison in the last line, and which is frequently met with in Iron-plate and other Reports of the same date—was at the time a new material; so far, at least, as regards its application in England to constructive or artillery purposes, and was considered to possess very remarkable properties. Mr. Mallet regarded it as "precisely the material wanted for the production of artillery of the largest calibre;" and the anticipation has proved correct if we regard the material and not the mode of production. The puddling process has long been abandoned. Bessemer's and other processes produce a mild steel which is essentially the same thing, but far more uniform in quality, and cheaper in manufacture.

9. The late firm of Mare, of Blackwall, tendered on May 7, 1855, to supply the two mortars in accordance with Mr. Mallet's drawing and specifications, within ten weeks of the date of order, for a sum of £4900 each, including the mortar beds; any weight in excess of 35 tons was to be paid for at the rate of £140 a ton. The offer was accepted by the Board of Ordnance the very next day—an instance of promptitude for which we probably have to thank the vigorous interposition of Lord Palmerston, as related at p. 203. But alas for good intentions and contractors' vows! The mortars were only reported on the eve of completion in March, 1857, nearly a year after the unexpected termination of the war, and ninety-six weeks after the order. They were really delivered in May. The bankruptcy of the contractors, and the physical difficulties encountered in the execution of parts of the order, combined to produce this great disappointment. They were then partly the work of Mare & Co., partly of Horsfall & Co., of Liverpool, and partly of Fawcett, Preston & Co. The latter did the turning, boring, and finishing of the large forgings supplied by Horsfall & Co. Some delay was due to the unsoundness detected in one of the largest of these when it came to be bored. No one who recollects the constant failures in the Royal Arsenal some years later than this, while the use of Yorkshire iron was persisted in, will feel any surprise at such mishaps; on the contrary, it is to the honor of all parties that the mortars were produced at all.

10. With them—or, properly speaking, before them—were delivered fifty shells, contracted for by Messrs. Hood at £16 a ton, and a couple of steel gauges at a cost of £25. The shells were tested, by Mr. Mallet's advice:—

(1) As to their gauge, and marked H.G. or L.G. The windage varied between 0·38 and 0·40 in.

(2) As to the perfect sphericity.

(3) As to soundness of casting, by trial with blows of a heavy hammer, especially at the parts opposite the fuze hole.

(4) As to weight.

(5) As to the true position of the interior cavity, according to specification. The failure of many of the 24-inch cast-iron shells fired at the siege of Antwerp suggested a doubt to some officers whether that material could be trusted for 36-inch shells; and to meet this objection, a plan was devised for casting them over wrought-iron cores, made of two hemispheres, rivetted to a flat ring; the lower half was to have been of 0·5 in. iron, the upper of 0·25 in. This intention was, however, abandoned, and they were made wholly of cast-iron; but the core was placed in the mould so as to give a greater thickness at the bottom of the shell than at the fuze hole. The latter dimension was 2·0 ins., the former was about 5·0 ins. in the heaviest, and 4·6 ins. in the lightest shells; and at 30 cubic inches to one pound of powder, their internal capacities would have varied between 405 and 487 lbs. Mr. Mallet calculated to throw a bursting charge of 480 lbs. If we suppose that the sand and sawdust with which they were filled set up or consolidated as much as gunpowder does, we shall have a degree of eccentricity of the shells when fired which must have materially influenced their flight.*

11. The following extracts from a letter of Mr. Mallet's, dated 2nd May, 1857, will explain some of the difficulties attending the actual completion of the contract:—

"I submit the following *resumé* of that part of my own views which refers to mode of delivery, and of the primary trials, &c.:—

"(1) Each of these mortars weighs about 40 tons; the heaviest pieces upwards of 12 tons.

"(2) They will require strong and peculiar tackle to put them together, and they will be endangered if attempted being put together by even skilled persons, if not familiar with their construction. The same applies to taking asunder.

"(3) They will require a firm foundation or platform to be made to put them together upon, wherever done.

"(4) The shells (50) and the two cranes for loading them into the mortars are all now at Woolwich.†

"(5) The contractor for the mortars is bound to deliver and put them together once at Woolwich Arsenal, but only once. Subsequent taking asunder will cost a considerable sum.

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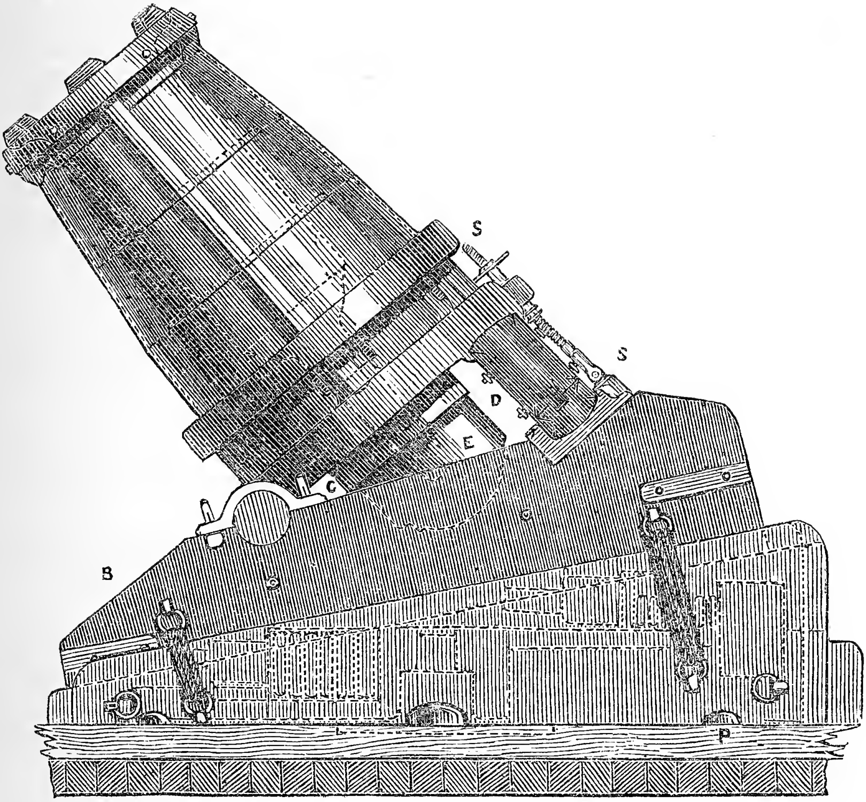
* The centre of gravity of the empty shell would be 1·5 in. from the centre of the outer sphere, and the compression of the bursting charge on firing the mortar would add to this eccentricity about 0·2 in.; so that the centre of gravity of the shell when fired would be as much as 1·7 in. distant from the centre of the sphere.

† The cranes were supplied by Messrs. Fox, Henderson & Co., at a cost of £150 each.



Lateral Elevation,

"It therefore appears to me that much waste of time, labour, and money would be avoided by now deciding that these mortars shall be delivered, and at once put together by the contractor, upon two suitable platforms to be immediately prepared for them in the Practice Range, Woolwich Marshes. This will avoid taking down and a subsequent second putting together, and will retain the contractor still responsible for any possible defect in work, material, or fitting, upon the first preliminary proofs, with small charges, but from which he would be relieved if the mortars be handled or put together by any other parties.

"(6) The peculiar construction of these mortars makes it likely that some parts may, after the first round or two, require some slight readjustment demanding lathes, &c. These are at hand at Woolwich (as are the contractor's tools) but not at Shoeburyness, to or from which the delay and cost of carriage of such masses would be serious.

"(7) The preliminary proofs of these mortars should be made with low charges, and not with live shells, nor at ranges exceeding half a mile, if so much; so that no difficulty or danger can arise in conducting such trials at Woolwich."

Mr. Mallet proceeded to remind Lord Panmure of a stipulation he had already made that the control of these proofs should rest with himself, as the designer of the mortars, and that no experiments should be made with them until after their final proofs, without his having previous due notice and being present.

12. The Commanding Royal Engineer at Woolwich reported that it would cost about £300 to lay a foundation of Dartford gravel for one platform. The platform was estimated by Lieut.-General, then Lieut.-Colonel Tulloh, R.A., Superintendent of the Royal Carriage Department, to cost £150, and it was finally decided by the Minister for War—very much against Mr. Mallet's remonstrances—to limit the experiments to a trial of one mortar, for which the preparations were not completed until the 15th October, 1857. It will be convenient to give the practice in its entirety, before referring to successive accidents which caused interruptions, and led to its being discontinued at so early a stage, premising that it was fired by a piece of Bickford fuze passed in through the vent and inserted into the neck of one powder bag in the centre of the charge, and ignited by the usual method. The vent was bored through the lower chase-ring in advance of the chamber. The charge itself was at first introduced in 5 lb. bags, afterwards in 10 lb. bags; and it was not the least curious part of the spectacle to see the artilleryman standing in the mortar to arrange these bags.

The shells were provided with a metallic fuze, which was well primed, and ignited separately by the flash or by a leader of Bickford fuze. It was supposed possible that in consequence of the comparatively small charge and the large diameter of the shell, the flame might fail to do so. This return to a practice of the infancy of artillery is one of the many singular circumstances attending the trial.

13.—Table II.

Abstract of all the Rounds fired from Mallet's 36-*inch Mortar No.* 1. (*No importance attaches to the deflections, as there were no means of directing the mortar. See p.* 218 *as to the shells*).

No.	Date. 1857–8.	ϕ	Charge.		Shell.		t.	Range.		Deflection.		θ
										L.	R.	
		° ′	lbs.	kilos.	lbs.	kilos.	secs.	yds.	metres.	yds.	yds.	° ′
1	Oct. 19	48 20	10	4·53	2376	1075	?	370	338	—	—	—
2	″	″	20	9·05	2362	1069	13·0	900	823	5	—	—
3	″	48 30	30	13·57	2596	1174	17·0	1277	1168	11	—	—
4	″	″	40	18·10	2352	1064	19·0	1711	1565	6	—	—
5	″	″	50	22·62	2986	1351	20·0	1732	1584	5	—	—
6	″	″	60	27·15	2604	1178	24·0	2270	2077	78	—	—
7	″	″	70	31·67	2548	1153	—	2644	2418	94	—	—
8	Dec. 18	42 30	40	18·10	2660	1204	17·3	1623	1484	—	15	52 0
9	″	″	40	18·10	2660	1204	17·5	1681	1537	12	—	64 52
10	″	″	40	18·10	2940	1330	16·9	1525	1394	—	13	65 58
11	″	″	40	18·10	2940	1330	16·1	1491	1363	—	35	59 55
12	″	″	40	18·10	2940	1330	15·0	1468	1342	—	24	58 55
13	″	″	40	18·10	2940	1330	16·8	1439	1316	19	—	49 52
14	July 21	45 0	40	18·10	2419	1093	17·75	1700	1554	—	60	65 30
15	″	″	50	22·62	2403	1087	21·5	2120	1938	—	11	52 0
16	July 28	45 0	50	22·62	2373	1074	20·0	2100	1920	—	68	58 0
17	″	″	60	27·15	2385	1080	21·0	2323	2124	—	115	65 0
18	″	″	70	31·67	2400	1086	24·5	2758	2522	—	123	—
19	″	″	80	36·20	2395	1084	23·0	2759	2523	—	72	62 0

14. Rounds 1 and 2, with 10 lbs. and 20 lbs. respectively, produced no effect on the piece.

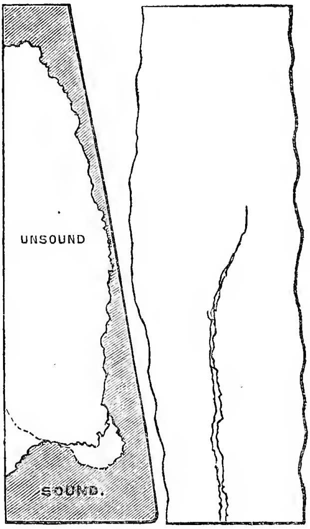
At round 5 it was seen that the rear retaining screw was not strong enough to resist the shock it received. It was slightly bent, and some of the threads cracked. At round 7, charge 70 lbs., a crack 4 ins. long appeared externally in the second hoop of the outside ply of the centre ring, and the Committee, as a measure of precaution, and as there was no urgency of time, deemed it necessary to have this ring removed and repaired, or replaced by a new one, before the practice should proceed. Mr. Mallet would have preferred to disregard the accident. The mortar was now minutely examined. The crack above referred to was found to run through the hoop, a thickness of 2·4 ins., and was about ·03 in. wide. There were no other defects of any consequence, but numerous small and superficial marks or striæ, such as forged iron always developes, had been brought to light by the gas. One of six 0·875-inch diam. screw pins, by which the clip-ring at the muzzle was attached, was broken, and the wedges or cotters of the longitudinal bolts were generally bent, some of them as much as 0·6 in.

Mr. Mallet claimed the fracture of an exterior ring as a satisfactory proof that the bursting strains were actually transmitted truly through the whole thickness of metal in the chase, so that the outside bore equally with the interior, and it was found on examination that the lap-weld of this ring was very imperfect. It had, in fact, hardly any attachment. A superficial longitudinal mark now shewing in the chamber on both sides, about 16 ins. long and ·05 in. in greatest depth, he regarded as the last trace of one of those transverse fissures referred to at p. 209, which are apt to occur in the heart of all large forgings. Much difficulty, he remarked, had been experienced in obtaining sound forgings for the centre piece of the mortar chambers, and in every forging a rent extending more or less across a diameter in the axial plane, was found to exist when the forging was bored into. The gibs and cotters had been, he said, intentionally reduced in strength to a minimum, that they might spring a little, and so ease the jar of recoil upon the holding-down bolts; but this had been carried a little too far. He attributed the bending of the rear retaining screw to the misfit of the quoins, which had warped and shrunk in the many months that had elapsed since they were fitted, and only bore at one end, being free about 0·3 in. at the other.

Fig. 3.

Lower outer ring ply. 2nd segment of chase.

Examination made on 26th October, 1857, after firing of the 19th October, and mortar taken asunder.

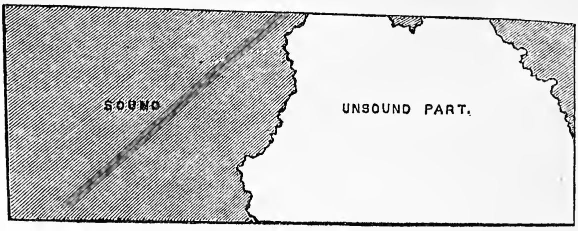


Scale one-third.

15. The mortar was repaired, at a cost of £56, in about two months, and the practice was resumed on the 18th December, when two medium and four heavy shells were fired, with a charge of 40 lbs. (Table II.) After the sixth discharge it was found that the centre hoop of the exterior ply of the bottom ring of the chase was broken through. This hoop was 3·9 ins. thick and 8·75 ins. wide. The joint between the bottom and centre ring was a good deal opened, to a maximum width of 0·125 in., and filled with hard fouling. A few more superficial marks had appeared, but in other respects the mortar was uninjured.

Fig. 4.

Middle exterior ring ply, lowest segment of chase, broken 18th December, 1857.



Scale one-third.

The section containing the defective ring, which weighed nearly 7 tons 6 cwt., was again removed, and Lord Panmure sanctioned its repair, at Blackwall, at a cost of £156. He sanctioned also the casting of twenty lighter shells, of about 2400 lbs. each, in the Royal Laboratory, at a cost of £11 each.

This is the place to remark that the great weight of some of the shells first fired was not intended, and arose altogether out of the unusual density of the Lowmoor iron—a fact not familiar to Mr. Mallet when he designed the shells. A curious illustration of it was presented when the Royal Gun Factories first began to make cast-iron 68-pr. guns in 1858. They mostly turned out to be 2 cwt. lighter than the Lowmoor patterns. (See the Report of the Ordnance Select Committee, dated 29th December, 1860, on this subject. No. 1339.)

The practice was resumed for the second time on 21st July, 1858, and nothing unusual occurred except the fracture of one of the wedges, or cotters, at the second discharge, and a crack in the slot, or keyway, through which another of them passed. These damages having been repaired in the Royal Gun Factory, and a wrought-iron cotter substituted for the broken steel one, the practice was, for the fourth and last time, resumed on the 28th July, 1858.

At the second discharge, charge 60 lbs., another steel cotter broke, and was replaced by a wrought-iron one, driven home forcibly by an extemporised ram. At the third discharge, charge 70 lbs., two other cotters were found bent and loose; it took thirty-five minutes to tighten them.

At the fourth discharge—charge intended to be 80 lbs., but perhaps only 70 lbs., as the range was not increased—one of the six longitudinal ties broke short off through the cotter hole, and started forwards 10·25 ins. This caused necessarily a discontinuance of the practice.

16. Mr. Mallet urged the repair of this injury and a renewal of the practice, at least so far as to ascertain the greatest practicable range of these shells; but "a King had arisen who knew not Joseph." General Peel had succeeded Lord Panmure as Minister for War, and although his estimate for the repair and the practice asked for was only £150, General Peel refused to sanction any further expenditure. A year later Mr. Sidney Herbert—who had in the meantime succeeded to office—directed the Ordnance Select Committee to reconsider the question, and the Royal Gun Factories furnished an estimate amounting to £214 for a complete repair,

including six additional longitudinal bolts, at Mr. Mallet's suggestion. This would have doubled the longitudinal strength of the chase, and they would still have been about 13 ins. from centre to centre. The Committee, however, reported their opinion that no practical advantage to the public service was likely to be obtained by the continuation of the experiments. They expressed no opinion as to the interest or value of any theoretical results to be expected, and the Secretary of State decided to proceed no further. There was a probable reason assigned for the breaking of the tie. In driving in the new wedges already referred to, the workmen extemporised a ram, slung from the loading crane; the position of the particular tie which broke was such that its wedges received a more direct and therefore more violent blow than any of the others, and it was probably overstrained. The effect was analogous to what has been since observed on some occasions from overstraining armour-bolts in screwing home the nuts.

17. With regard to the other 36-inch mortar, it was, after some interval of time, put together in the Royal Arsenal, of which it still forms one of the most conspicuous objects. It has never been fired.

18. I have said nothing of the service of the mortar, or of various minor mishaps that befel the bed and platform. The latter are quite unimportant. The platform, as before stated, had a slope of 12°, and the mortar recoiled on it 15 ins. with the largest charge. The momentum of so great a mass naturally tried all attachments, and some of them proved insufficiently strong, the cardinal rule of providing at first strength in excess, having been, as it so frequently is, neglected. The entire detachment detailed on the second occasion amounted to four non-commissioned officers and twenty gunners, who were able to load and fire about four shells per hour.

19. The platform was destined, however, to be heard of again; for it had fallen into such a state of decay by 1869, that it was thought necessary by the Control Department to take some steps to prevent its giving way under the mortar. It is not so obvious what harm would have happened in that event; but "as it would have entailed considerable expense to dismount the mortar, and then to remount it on a new bed and platform, it was decided to destroy the decayed bed by means of a small charge of gun-cotton, and thus allow the mortar to subside on to the ground." "The mortar" (after a discharge of gun-cotton) "swayed for an instant or two, and then fell slowly forward on its muzzle. The great feature of novelty connected with this operation was the accomplishment of great mechanical work by perfectly unconfined gun-cotton, the force of which was instantaneously developed through the agency of a small initiative detonation. The total amount of gun-cotton used in the operation was 7 lbs. 6·5 ozs., the cost of which was 12s. 10d."* Whether the mortar is injured or not, is unknown to the writer. The operation was attended with the complete destruction of valuable iron work connected with the bed.

20. It will have been noticed in Table II. that the 19 shells fired are to be distributed in three classes—as heavy, medium, and light—and do not vary in weight within those classes more than about 1½ per cent. The ballistic coefficient *C* for each class is as follows :—

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* See a fuller account, "Short Notes," No. 62, p. 83. 1869.

	Mean weight.	In English measure. C.	In metric measure. C.
	lbs.	ft.	metres.
Five heavy shells	2949	12,883	3926·0
Five medium shells	2614	11,420	3480·3
Nine light shells..........................	2385	10,419	3175·3
Mean of all..................................	2594	11,332	3453·1

These weights include in each case a charge of sand and sawdust of about equal weight with the proper bursting charge of the shell, viz. 405 lbs. to 487 lbs. (p. 212). If the resistance of the air to masses of such weight, projected with low velocities, were negligible, we should expect to find the ranges of shells of dissimilar weight projected at the same angle and by equal charges, as exactly proportionable inversely to their weights. For in vacuo, if X and X_1 represent the ranges of two shells, whose weights are P, P_1 and V, V_1 their respective initial velocities, then

$$\frac{X}{X_1} = \frac{V^2}{V_1^2}; \text{ but } \frac{V^2}{V_1^2} = \frac{P_1}{P}.$$

We have the data for four comparisons of this nature; but as the angles of elevation were not identical, a correction must first be applied to reduce them all to 45°. If the resistance is *nil*, or very small,

$$\frac{X}{X_{\prime}} = \frac{\sin 2\phi}{\sin 2\phi_{\prime}}.$$

Table III.

Comparison of Ranges of Shells of different Weights fired with the same Charge.

Charge.	Shell.	Angle ϕ	Observed range.	Range reduced to 45°.	$\frac{P_1}{P}$	$\frac{X}{X_1}$
lbs. 40 40	lbs. 2352 2416	degs. 48½ 45	ft. 5133 5100	ft. 5153 5100	— —	— —
Mean......	2384	—	5116	5126	1·233	1·146
40 40	2660 2660	42½ 42½	4869 5043	— —	— —	— —
Mean......	2660	—	4956	4993	1·105	1·116
40 40 40 40	2940 2940 2940 2940	42½ 42½ 42½ 42½	4575 4473 4404 4317	— — — —	— — — —	— — — —
Mean......	2940	—	4440	4473	1·000	—
50 50 50 60 60 70 70	2403 2373 2986 2385 2600 2400 2548	45 45 48½ 45 48½ 45 48½	6360 6300 5196 6969 6813 8274 7932	— 6330 5213 6969 6839 8274 7962	— 1·250 1·000 1·092 1·000 1·061 1·000	— 1·214 — 1·019 — 1·039 —
Means ...	—	—	—	—	1·150	1·107

With one exception the ranges decrease in a less ratio than the weights of the shell increase, indicating a less mean resistance to the heavier and slower shells, and proving an appreciable effect of resistance by the fact. On the mean of the five comparisons,

$$\frac{X}{X_1} = 0{\cdot}962 \frac{P_1}{P};$$

the differences of weight ranging from 6 per cent. to 25 per cent.

21. There is another criterion of the existence of an appreciable resistance afforded by the observed times of flight. If the resistance is *nil*,

$$T = \sqrt{\frac{X \tan \phi}{\frac{1}{2} g}};$$

and if it is appreciable, this quantity requires to be multiplied by a coefficient (D) greater than unity, which has been computed by General Didion for all the cases which usually occur in practice.* The observed times of flight are rather irregular, and present discrepancies which prevent our relying implicitly upon them. Thus we have $t = 15$ secs. for a range of 1468 yds., and $t = 16{\cdot}8$ secs. for a range of 1439 yds. at the same elevation. The former is certainly an error, perhaps for 16 secs. And on one occasion, when Professor Wheatstone's chronoscope was employed, it gave, on the mean of five good comparisons, a time of flight of 16·30 secs. as against 16·95 secs. observed by the watch. Nevertheless, if we suppose the watch intervals uniformly 4 per cent. too long, there will still remain an appreciable retardation of the shells, due to the resistance of the air.

TABLE IV.

Observed Times of Flight compared with the Times due to the same Ranges in vacuo.

Range X.	ϕ	Observed time.		$\sqrt{\frac{X \tan \phi}{\frac{1}{2} g}}$.	D.	Range X.	ϕ	Observed time.		$\sqrt{\frac{X \tan \phi}{\frac{1}{2} g}}$.	D.
		By watch.	By chronoscope.					By watch.	By chronoscope.		
yds.	degs.	secs.	secs.	secs.		yds.	degs.	secs.		secs.	
900	$48\frac{1}{3}$	13·0	—	13·73	0·947	1711	$48\frac{1}{2}$	19·0	—	18·98	1·001
1277	$48\frac{1}{2}$	17·0	—	16·40	1·034	1732	$48\frac{1}{2}$	20·0	—	19·10	1·057
1439	$42\frac{1}{2}$	16·8	16·0	15·68	1·071	2100	45	20·0	—	19·78	1·011
1468	$42\frac{1}{2}$	—	16·1	15·84	—	2120	45	21·5	—	19·99	1·075
1491	$42\frac{1}{2}$	16·1	16·0	15·96	1·009	2270	$48\frac{1}{2}$	24·0	—	21·88	1·097
1525	$42\frac{1}{2}$	16·9	16·6	16·14	1·047	2323	45	21·0	—	20·81	1·009
1623	$42\frac{1}{2}$	17·3	16·3	16·65	1·039	2758	45	24·5	—	22·67	1·081
1681	$42\frac{1}{2}$	17·5	16·6	16·95	1·032	2759	45	23·0	—	22·68	1·014
1700	45	17·75	—	17·80	0·998	—	—	—	—	—	—

D = ratio of the observed time of flight to time in vacuo taken as unity.

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* See "Traité de Ballistique," Table XIII., or Table CXXXVII. of Captain W. H. Noble's Second Report on Ballistics. 1865.

22. The recorded ranges in Table II. are, as a series, confused by a slight difference of angle, and by considerable differences in the weight of the shells; but by correcting, as we have already done, for some of the former, and expressing the charges in proportionate parts of the shells they fired respectively, we reduce the whole to one series, as follows:—

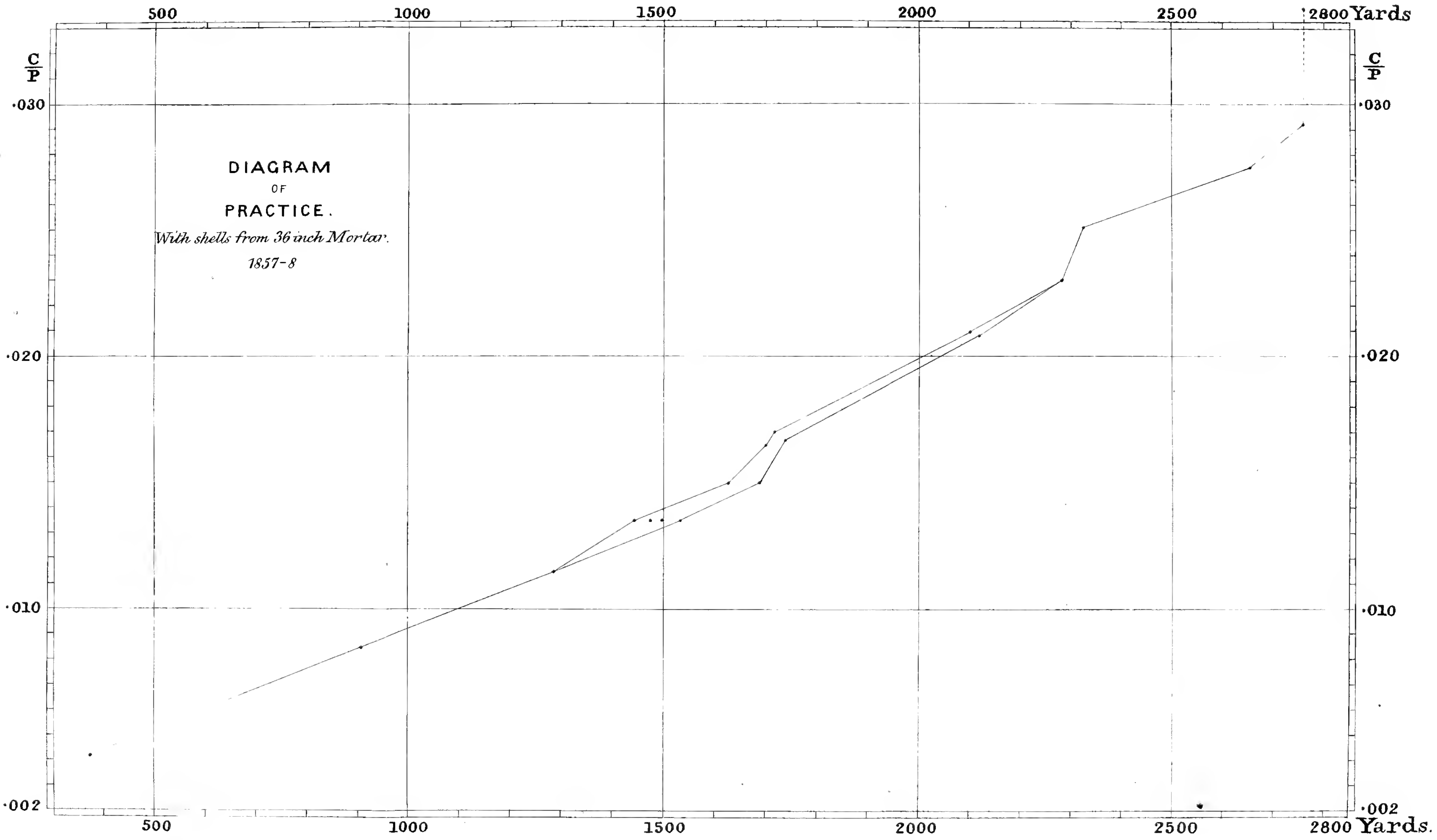
Table V.

Ranges of Shells of 35·6 *ins. diameter, and an average weight of* 2594 *lbs. at* 45°, *for charges bearing given proportions to their weights.*

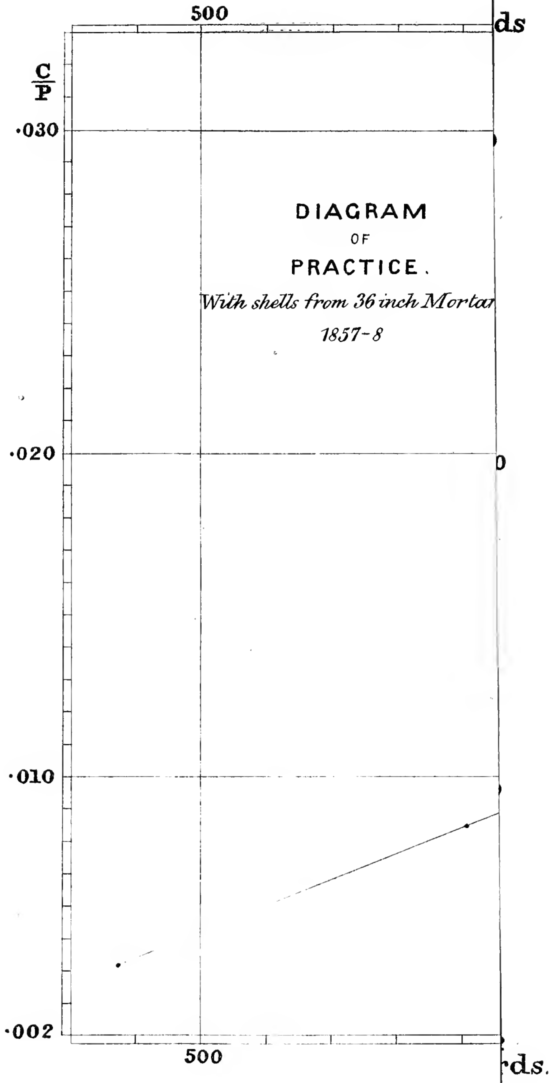
Round.	Weight of shell.	Charge.		Range reduced to $\phi = 45°$	Observed t.	Observed θ
		Weight.	Prop. $\frac{C}{P}$			
	lbs.	lbs.		yds.	secs.	degs.
1	2376	10	·0042	373	—	—
2	2362	20	·0085	907	13·0	—
3	2596	30	·0115	1287	17·0	—
10	2940	40	·0136	1531	16·9	66·0
11	2940	40	·0136	1497	16·1	59·9
12	2940	40	·0136	1474	15·0	58·9
13	2940	40	·0136	1444	16·8	49·9
8	2660	40	·0150	1629	17·3	52·0
9	2660	40	·0150	1687	17·5	64·9
14	2416	40	·0165	1700	17·75	65·5
5	2986	50	·0167	1738	20·0	—
4	2352	40	·0170	1718	19·0	—
15	2403	50	·0208	2120	21·5	52·0
16	2373	50	·0210	2100	20·0	58·0
6	2604	60	·0230	2280	24·0	—
17	2385	60	·0251	2323	21·0	—
7	2548	70	·0275	2654	—	—
18	2400	70	·0292	2758	24·5	—
19	2395	80	·0338	2759	23·0	62·0

23. The range of the first shell, with only 10 lbs. of powder, which astonished every one who witnessed it, is greatly out of proportion. It should apparently have been about 290 yds. only. The range of the last shell, with a nominal charge of 80 lbs., is also unaccountable, except on the supposition that a mistake was made in the number of cartridges counted in, which, on consideration of all the circumstances, I believe to have been the case. The charge was contained in serge bags, each containing 5 lbs. or 10 lbs. of powder; the space left in the chamber was filled with sawdust, and a rope wad or mat was placed at the top for the shell to rest on. The pressure on the sawdust would have a tendency to compress it into a solid wad; and it is conceivable that a charge of 10 lbs., overcoming very slowly the inertia of a mass of 2376 lbs., would produce this effect, and close all escape of gas more perfectly than any larger charge. With these two exceptions the observed ranges fall into a very regular series, beyond what could be expected from single shells, with such small increments of velocity.

24. The angles of descent (θ) were measured on a plane 14½ ft. below



Scale of yards, for Ranges due to the proportionate charges marked on either side.
Thus, Charge one hundredth the weight of the shell, or about 25 lbs, Range 1100 yds.



DIAGRAM

OF

PRACTICE.

With shells from 36 inch Mortar

1857-8

Sca

Thu

the muzzle of the piece. The soil was so soft that most of the shells penetrated to great depths.

No. 1 was found entire at 6 ft. 6 ins.

No. 2 was not found on digging down 12 ft., and could not be felt with a 9 ft. probe.

No. 3 was not found on digging down 18 ft., and could not then be felt with the 9 ft. probe.

No. 4 was found broken into 44 pieces, one of them only 5 ft. 9 ins. from the surface, but the great bulk of it at a depth of 14 ft. 6 ins.

No. 14 was not found on digging 20 ft. 3 in., but was thought to be felt with a 9 ft. probe.

No. 15 was found at a perpendicular depth of 19 ft. 4 ins., giving a penetration of 28 ft. No others were found, and the Commanding Engineer, Colonel Walpole, estimated that they had buried themselves fully 30 ft. It would have cost about £21 each to recover them, and there they remain, to astonish, perhaps, geologists hereafter. The angles θ entered in the table were determined approximately by the apparent inclination of the passage made by the shell.

25. I do not attempt to base any conclusion on the lateral deviations of the shells recorded, as the mortar was imperfectly sighted, and the means of preserving uniformity of direction were also imperfect. If we refer the seventeen observed ranges—rejecting the first and last (*vide* Plate)—to a mean curve drawn through them on a large scale, their mean difference of range is ± 36 yds., for a mean range of 1808 yds. This is a considerable degree of regularity for single shells.

26. An attempt was made by Professor, now Sir Charles Wheatstone—at that time a member of the Ordnance Select Committee—to determine the initial velocity of some of the shells fired on the 18th December, 1857, with an electro-magnetic chronoscope of his own invention; and although the results were not entirely satisfactory, they deserve the fullest record, as the first application of electric agency to this purpose on any practice ground in England. The apparatus consisted of a delicate clock motion of Breguet's carrying two hands, which were started and stopped by the breaking in succession of two circuits produced by induction coils. The start was given by the shell displacing an iron rod placed across the mouth of the mortar. This was effected when the shell had travelled about 4 ft. The second was effected by a key acted upon by the tension of a cord of 100 ft., attached to the shell. The arrangement failed in rounds 8 to 10 (Table I.), in consequence of the cord snapping; it succeeded in rounds 12 and 13, which gave respectively

Round.	Seconds.
12	0·266
13	0·277

for the time occupied by the shell in travelling 100 ft., and gave as the mean velocity at a point about 50 ft. from the muzzle—

Round.	Feet.
12	376
13	440

As the charges and weights were identical, this large difference must be mainly attributable to the imperfection of the instrumental arrangement, and makes a reduction to the muzzle—which at the most would amount to an additional foot or two—of no importance. It is probable that the longest interval, giving the slowest rate of translation, or least value of V, is nearest the truth. There is so much that is historically interesting in this part of the story that I shall be excused for going a little more fully into it.

27. The subject was brought before this Institution so early as July 17, 1841, when Professor Wheatstone, on the introduction of the late Captain Chapman, R.A., F.R.S., delivered a lecture, Lieut.-General Lord Bloomfield being in the chair, upon the properties of his electro-magnetic chronoscope, "and the likelihood of its application to the practical purposes of artillery—viz., to ascertain the time of flight at different ranges, as also the initial velocities of shot." There were twenty-two officers present, and I extract an account of the instrument from the unpublished minutes of that year, which is anterior to the first volume of published "Proceedings."* The invention of the instrument only dates from the beginning of 1840, and this was very nearly its first publication. The only earlier account will be found in the Bulletin of the Academy of Sciences, Brussels, for October 7, 1840.† Not long after—in April, 1843—one of the chronoscopes was presented to the physical cabinet of the Royal Military Academy. It cannot now be found.

That the enquiry made no progress at Woolwich, at that time, was no fault of the Professor's; the causes would not be difficult to unravel, but no useful purpose would result from the attempt. The first actual application of one of these instruments to a ballistic purpose seems to have been in Sir James South's grounds at Camden Hill, October 6, 1842, when a number of determinations were made of the velocity of a bullet fired with a single and a triple charge, from a pistol furnished by Purday, of Oxford Street, which gave respectively 630 ft. and 1177 ft. per second. Unfortunately, the memorandum before me does not state the weight of the charges or bullet; the velocities deduced are, however, not far from the ratio of $\sqrt{3}$ to 1 if we take the higher velocity as standard.

28. The instrument employed in 1857 was not identical with that of 1842, being a great improvement on it, but it resulted from the development of the same idea. It was tested previously, by observing the time of falling of a body in air through spaces of 1·5 ft. and 6·0 ft. respectively. These times, by the well-known formula, are 0·30527 second and 0·61054 second. The instrument gave on different days the following measurements :—

	6 ft.	1·5 ft.
September, 1857, before Sir J. Burgoyne and Sir W. Reid, R.E.	605 div.	$300\frac{4}{6}$ div.
October 15, 1857, before the Ordnance Select Committee. Eardley-Wilmot observer	$611\frac{1}{6}$ "	$305\frac{3}{4}$ "
October 24, 1857, before Mr. Mallet	$607\frac{3}{6}$ "	$303\frac{2}{6}$ "
November 3, 1857, before Prof. H. Lloyd and Major-General Cator	607 "	$311\frac{1}{2}$ "

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* See Appendix to this paper.

† See "Handbuch der Angewandten Electricitätslehre," by Karl Kuhn, Leipsig, Voss, 1866, for a chronological abstract of the successive applications of current electricity.

The means are generally of six records, and the mean error of a single observation varies between one division and three divisions, according to the observer. On the whole, it is about 1·66 divisions, or 0·0015 second—a large quantity compared with the precision since attained; but we are discussing the infancy of the subject, when it was regarded as very close observation. It would be foreign to the subject of the present paper to enter into any of the controversies to which the invention of the chronoscope gave rise. A single extract from a declaration of Lieut.-General Konstantinoff, dated July 11, 1847, may be given, to show that the genius of our countryman was not long in finding appreciation among scientific officers abroad:—

> "En 1842 M. Wheatstone me livra un appareil de son invention pour mesurer le temps du mouvement d'un projectile entre deux points de la trajectoire. C'etait un appareil à echappement pouvant etre rendu dépendant du mouvement d'un projectile par l'effet d'un electro-aimant faisant partie de l'appareil et de courants voltaïques. Ce fut le premier appareil basé sur l'application des electro-aimants dont je me servis dans mes recherches balistiques que d'abord n'eurent pour but que la determination empirique de la loi de la resistance de l'air."

The rest of the paper—which is a vindication of the priority of Sir C. Wheatstone against M. Breguet, of Paris, who had been subsequently employed by Konstantinoff to make him an apparatus—is scarcely connected with our subject, and I proceed with the experiments of the 36-inch mortar.

29. The slow and majestic motion of these great globes through the air, suggested irresistably to all who witnessed it the possibility of laying down their trajectory in some graphical manner. Accordingly, on the 18th December, Mr. Cooke, Secretary to the London Photographic Society, attended with his camera, and made several attempts. The weather was most unfavourable for the purpose—the temperature low, the light dull; but he succeeded partially with one shell during a momentary gleam of bright sunlight, as it was passing across a patch of clear sky. The impression was extremely faint, and of no practical value, but it encouraged a belief that, under more favourable circumstances and with apparatus specially prepared, the thing would be feasible. The same gentleman tried another method with better success. He divided the ground-glass plate of the camera into squares, and with the point of a fine pencil tried to follow the path of the shell. In this manner two foreshortened curves were obtained, nowhere (as was thought) more than two diameters of the shell in error. The camera was considerably behind the mortar, but if its place had been exactly central and perpendicular to the plane of the trajectory, it seems probable that real representations of it might have been obtained, although it would have required much greater quickness of eye and hand. These experiments were but preliminary, and are an example of the many highly interesting enquiries which were cut short by the decision of the Secretary of State not to repair the mortar.*

30. On comparing the ranges in Table IV., where the charges are expressed in terms of the weight of the shell with those of the 13-inch land-

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* A sort of open-air screen of larger squares mounted on a stand, was also prepared, on Mr. Mallet's suggestion, but I believe not tried.

service mortar, a remarkable difference will be noticed. 5 lbs. with the latter is almost the exact equivalent to 60 lbs. with the former; but the tabular range for a 13-inch shell of about 204 lbs. weight due to 5 lbs. is only 1520 yds., whereas 60 lbs. gave a mean range of 2300 yds. to two shells averaging in weight 2466 lbs. There is, however, no occasion to refer to the tables. Six 13-inch shells were actually fired for comparison, on the 18th December, 1857, with the following result:—

Table VI.

Comparative Practice with a 13-*inch Land Service Mortar of* 36 *cwt. Length of bore* 2 *ft.* 8·5 *ins.* $\phi = 45°$.

Rounds.	Weight of shell.	Charge.			Observed range.	t.	Deviation.		θ
		lbs.	oz.	$\frac{C}{P}$			L.	R.	
	lbs.				yds.	secs.	yds.	yds.	degs.
1	204	5	8	·0247	1846	—	57	—	57·9
2	206	5	0	·0243	1574	18·0	70	—	47·0
3	204	5	0	·0245	1610	17·9	10	—	48·9
4	204	5	0	·0245	1609	—	—	11	59·9
5	203	5	0	·0246	1660	18·8	—	40	54·0
6	205	5	0	·0244	1537	—	2	—	50·0

31. The velocity due to a 5 lb. charge is by calculation 428 ft.[*] If we may place confidence in the mean of Professor Wheatstone's two results, the velocity given to a 36-inch shell of 2940 lbs. by a charge of 40 lbs. was 408 ft.; and consequently the initial velocity of a mean shell of 2495 lbs. with 60 lbs. (Table IV., rounds 6 and 17), which bears the same proportion to it as 5 lbs. to 204 lbs., would be 547 ft. This immense excess of initial velocity in the larger shell for the same proportionate charge, fully accounts for its greater range. It is the velocity due to a charge of 8·18 lbs. in the 13-inch, for which the tabular range is 2600 yds., and may doubtless be attributed to the following causes:—

(*a*) Windage of the 36-inch shell, in relation to the sectional area of the bore, less than that of the 13-inch shell in the proportion of ·01 to ·03.

(*b*) Partial stoppage even of this reduced windage, by the use of sawdust in the chamber.

(*c*) More complete combustion of the powder.

(*d*) A smaller relative resistance from the air.

Comparing the observed time of flight of the 13-inch shell with the time due to the same range in vacuo, it is greater whichever equation we employ.

$$t = \sqrt{\frac{X \tan \phi}{\frac{1}{2} g}} = \overset{\text{secs.}}{17 \cdot 35} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

$$t = \frac{X}{V \cos \phi} = 16 \cdot 02 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

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[*] See W. H. Noble, 2nd Report on Ballistics, p. 18, for the data.

where V is taken as 428 ft., and X is 1615 yds. A slight decrease of range in (1), or of velocity in (2), would bring the two equations to agreement. The observed time was 18·2 secs., making $P\ (X.V)$ or $D = 1{\cdot}05$ in one case, or 1·14 in the other.

32. It is almost idle to speculate on the effects of shells weighing from 2300 lbs. to nearly 3000 lbs., and with bursting charges of 487 lbs. to 405 lbs. The experiment was not tried, and in the interests of humanity we may hope that it never will be; but few will doubt that if the mortars had been completed in time, and Lord Palmerston's intention to send one to the Baltic and another to the Black Sea been carried out (and designs for mortar rafts had been actually prepared by Mr. Mallet), it would have been perceived that a new power had entered the European arena. Those heroic soldiers who prolonged the defence of Sevastopol against a *feu d'enfer* had no resources which could have prevented all the defences on the south side, up to Dockyard Creek, from being devastated by a succession of such mines sprung within them, or those on the north side, including the North Fort and Battery No. 4, from sharing the like fate, without the exposure of the mortar vessel to any destructive fire. The casemates of Cronstadt, like everything else of masonry, probably, which the hand of man has put together since the Pyramids, must have crumbled under bolts as irresistible as those which "*fulminantis magna manus Jovis*" discharges; bolts which, according to Horace, only the soul of the upright man can defy.

My admiration for the bold policy of Lord Palmerston, *ultimus Romanorum*, and for the energy and skill of Mr. Mallet, has led me to enter more fully into the history of this great experiment in artillery than I at first intended, but I venture to hope that artillerymen will find it worth narrating. That gentleman has at my request related in the subjoined note some particulars which do not appear in the papers I have consulted, and which will complete the narrative of an enterprise which must always be memorable in the history of British artillery.

J. H. LEFROY.

January, 1871.

APPENDIX.

Description of the electro-ballistic chronoscope, exhibited and explained before the Royal Artillery Institution by Professor Charles Wheatstone, F.R.S., 17th July, 1841. Extracted from the unpublished Proceedings of the Institution:—

"The first hand of the instrument makes 73 revolutions in a second of time; and as the dial is divided into 100 equal parts, the $\frac{1}{7300}$ of a second (·000137 sec.) is indicated.

"The second hand performs one revolution while the first makes ten, and in like manner the third hand performs one revolution while the second makes ten. Thus 10,000 units of time are registered, each unit being, as above stated, $\frac{1}{7300}$ of a second.

"The expense of this instrument (the first that has been made) has been £10; a more accurate one might be made for £20. The gun and butt being provided, about £5 would defray the expense of adapting the instrument to projectile experiments.

"In an instrument so totally new as mine, many proof experiments will be required, and probably some alterations in the construction, before its minute indications can be relied upon; but the principle is capable of great accuracy, and I am confident that, when everything is properly arranged, the error in a single observation would not attain the $\frac{1}{1000}$ part of a second.

"Perhaps an instrument which would record the time in tenths of seconds, and in which the error in a single observation should not attain the tenth of a second, would be sufficient for most practical purposes. I could construct such an instrument, which would require no proof experiments, and could be used by any person with ordinary care.

"The chronoscope for measuring the duration of flashes, such as those produced by the ignition of powder, is an instrument constructed on a principle entirely different from the preceding. By its means the $\frac{1}{10000}$ part of a second may be estimated."

Such was the description given by Sir Charles Wheatstone of his chronoscope in 1841. The instrument of 1857 so far resembled it that it was also a delicate clock movement, started and stopped by successively breaking two currents, as already described in the text; but it differed in its details. An account of the latter has been given by Professor Pepper, of the Polytechnic Institution, in one of his popular works, and a similar one was employed by Mr. Mallet in his experiments on the rate of transmission of earthquake waves. Sir Charles Wheatstone has not published it.

NOTE, APPENDED BY MR. MALLET.

20th January, 1871.

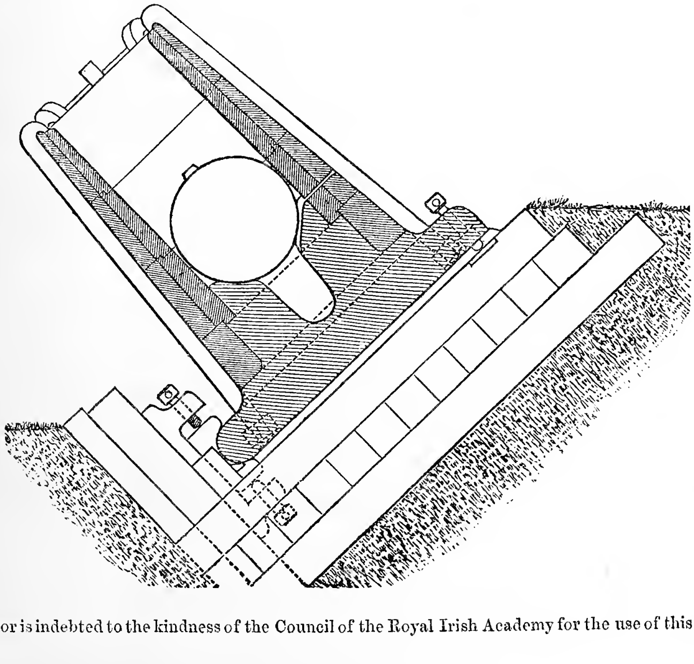
I avail myself of the permission of the Committee of the Royal Artillery Institution and of General Lefroy, R.A., to record a few facts less directly within the cognizance of the distinguished author of the preceding paper, with a view to removing obscurity and making more complete the early history of the 36-inch mortars.

In the passage above quoted from Lord Palmerston's letter, 1st May, 1855, to the Lieut.-General of Ordnance, the words occur: "two mortars upon the plan proposed by Messrs. Mallet and Barry." At the commencement, however, his Lordship rightly attributes the scheme to me. At about the above period I had arranged to take as a partner Mr. Frederick Barry, then Ass. Ins. C.E., and he accompanied me on, I think, three occasions when I waited on Lord Palmerston; hence his Lordship's expression.

I am alone responsible for the conception, designs, and direction of the execution of the 36-inch mortars, to which Mr. Barry contributed nothing. His brief connection of a few months with me terminated before the mortars were completed.

My original design for those mortars was completed prior to October, 1854; and the original drawing, made and dated by my own hand (October, 1854), was laid before and scrutinised by the Royal Irish Academy in June, 1860, upon the occasion of the controversy referred to by General Lefroy. The engraved transcript of this, produced by the Academy, is subjoined.

Fig. 5.



[The author is indebted to the kindness of the Council of the Royal Irish Academy for the use of this woodcut.]

It will be seen that at that period I purposed placing the mortar, without any bed, directly against a platform formed of three layers of crossed baulks, bedded at a slope of about 45° against a bank scarped into the ground.

The chamber is shown small; for my earliest notion was that these mortars could be established within a few hundred yards, and that by a very small charge these great shells could be easily "lobbed" in over the parapets of Sebastopol. The construction shown presents essentially, however, every feature to be found in the design as carried out.

The cast-iron chamber and base are ringed with wrought-iron, shrunk on. The chase, in three segments, consists of two plies of wrought-iron rings—the outer shrunk or driven down upon the conical inner ones, and all held together by eight longitudinal bolts, hooked over the muzzle. This design was exhibited by me in December, 1854, to Captain Boxer, R.A., to the late Colonel Portlock, R.E., and to several other authorities at Woolwich.

I am not aware that any design for the adoption of ringed structure with initial tension to ordnance, with a clear conception of its value, can be shown to have been produced earlier than this. As to the late Captain Blakely's claims, I refer, for the complete refutation of them, both as respects Dr. Hart's, F.T.C.D., priority in mathematical investigation of the laws, and my own priority to the method itself of "ringed structure," to the "Proceedings of the Royal Irish Academy," Vol. VII. p. 316, *et seq.*, May and June, 1860.

Mr. Longridge's, C.E., wire-wrapped gun dates, I believe, from early in 1855; and Professor Treadwell's, United States, claim as a proposer of "ringed structure," by a letter in my possession from himself, dated Cambridge, U.S., December 3, 1857, dates from February, 1856. The late Mr. Brunel's communications to Sir W. Armstrong would appear, from the biography of the former, lately published, to date from April, 1855. (Life of I. K. Brunel, Civil Engineer. By his Son, Isambard Brunel. London, 1870, p. 453.) Letter to James Nasymth, April 1855:—

> "A cylinder of hardish material, wrapped round with iron wire, laid on with a certain amount of tension proportioned to the diameter—such a barrel ought to be strong; whether practically successful is another thing."

Mr. Armstrong's earliest gun in ringed structure was, I believe, posterior to the design and even to the construction of the mortars.

Captain Tierry, of the French artillery, in a work published as early as 1834, appears to have been the earliest to propose strengthening cast-iron guns by wrought-iron rings shrunk upon their exterior in one ply. He does not show himself, however, to have clearly grasped the value of the principle of initial tension, as distinct from a mere superposition of additional material, which alone was the notion of the fabricators of the ancient ringed "bombards," thus constructed by them as a matter of necessity.

Early in January, 1855, I had seen the importance of being able to employ these mortars at sea, and with greater convenience and with extended ranges on land, and therefore designed a movable bed for them, with means for altering the angle of elevation, &c.

My first communication as to those mortars, accompanied by a rather full memoir on the powers of 36-inch shells, was laid before the Ordnance

Select Committee at Woolwich, on the 8th February, 1855; but although this was acknowledged, and an interview I believe took place early in March, nothing was done; and finding no likelihood of a speedy decision, I wrote for the first time to Lord Palmerston on the 24th March, 1855, and within a day or two had my first interview. On that occasion I presented my design for the 36-inch mortar and bed, full-sized sections of the shells, and the model to scale of the design, which is still in my possession.

Lord Palmerston, with great readiness, grasped the leading features and the value of the proposal, realised to himself the scale of the mortar, by causing me to measure the height against the wall of his study that its muzzle would reach from the floor, and used a term for the shell that has since become common. He said, "What you propose to throw is a flying mine, that by its fall shall bury itself and explode." He appointed me to wait upon him the next day but one, and he then stated that the late Prince Consort, to whom he had mentioned my scheme, was desirous I should wait upon him with the design, which his Lordship requested me to do without loss of time.

Within a day or two the Prince gave me an audience at Windsor, and devoted more than two hours to a searching and patient investigation of almost every point bearing importantly upon the project.

It may not be impertinent that I place here on record the strong impression left upon my mind as to the clearness of thought on mechanical questions, and the range and extent of technical knowledge evinced on that occasion by PRINCE ALBERT.

On my next interview with Lord Palmerston, it was evident to me that he had decided upon having the mortars tried, and that his intention was that their construction should be carried out through the ordinary channels of the Board of Ordnance.

It would be useless now to trace the causes of the great and needless delay that occurred in those channels, and which at length caused Lord Palmerston to write the official letter with an extract from which General Lefroy's memoir commences. But as ignorant newspaper writers and others subsequently ventured to comment upon the alleged rashness, &c. with which his Lordship passed over routine in favour of a project then and since supposed chimerical, and maligned through ignorance or prejudice, I may also be permitted to place upon record some proof of the genuine combination of caution and courage with which Lord Palmerston really acted. Corroborated in his own first conceptions by the carefully formed favourable conclusions which he told me Prince Albert had expressed, he was yet not satisfied to go on without better scientific advice than the very meagre Report at last obtained by himself from the Ordnance Select Committee.

I had mentioned to him that I had laid my designs and calculations before my venerable friend, Dr. Thomas R. Robinson, F.R.S., Astronomer Royal, Armagh, who had carefully considered the subject with me. Lord Palmerston requested that I should produce to him Dr. Robinson's written opinion upon certain points, as well as generally upon the design, and his judgment as to the correctness of my views relative to the extent of range that might be obtained with these great shells; and it was not until I was enabled to present him with that formal document that, under the peculiar and urgent circumstances which precluded any other course for rapid action, he took the bull by the horns, and commanded the mortars to be instantly proceeded with, and under my entire control. All honor be to his memory.

The original design for these mortars, as above described, was that laid before Mr. C. Mare, then of the Thames Iron Works, Blackwall. Those works at that date (1855), with the exception of the Mersey Steel and Iron Company (now Messrs. Horsfall), at Liverpool, possessed the largest and best forging appliances in England. It was for other reasons desirable, if possible, to execute the work in the Port of London.

The work being explained to Mr. Mare and to his forge manager, Mr. Hardy, and rapid execution urged as essential, it was represented by them that the making, bending, and welding of these broad and heavy rings must prove a work of difficulty and delay. They proposed to forge great square slabs, and to cut the rings out from these in one piece, and avoid bending and welding; and intimated that they would only undertake the work in that way.

With reluctance I consented to this being tried; and upon this basis the contract for execution was made, 11th June, 1855, and the work at once commenced.

After two or three weeks had been spent in attempts to forge the huge slabs out of which the rings were proposed being cut, and to forge one of the chamber pieces, during which I was frequently present, it was obvious to me that the contractors were quite in error as to their notions of producing these large pieces of wrought-iron, and that their method must be abandoned.

Not long after, the contractor's bankruptcy occurred, and it became necessary to arrange with his assignees for the completion of the contract. The beds, &c. were in progress, the cast-iron base pieces cast, other work done, and instalments paid on account prior to the above event. I now therefore reverted, as regarded the construction of the chases of the mortars, to my original design, with this modification—that to obviate any difficulty as to bending and welding the rings of heavy scantlings, and to hasten the production of the rings themselves by *rolling* the iron for them in place of *forging* it, and so at the same time to improve its quality and fibre, I reduced the thickness and width of the rings, and built up the entire thickness of the lowest segment of the chase in seven plies in place of only in two, there being four plies at the muzzle. The rings, from their now manageable scantlings, all admitted of "scarph and lap" welding under the steam hammer, thus embracing the best conditions for sound welding.

The execution of all parts of the mortars in this way was then entrusted to Mr. C. Mare's assignees under a new contract, which included the fitting into place of the chamber pieces—a contract for the production of which was made, as stated in General Lefroy's memoir, at Liverpool, and was efficiently carried out there.

In reviewing after this lapse of time these changes, and this mode in which these mortars have been built up in so many thin plies, it must be borne in mind that we were then in pre-armour-plating and Fraser gun days; that forge work upon the scale now familiar, was but just coming above the horizon; and that, besides the limited forging appliances then to be had, there were none of those Herculean tools for bending and shaping, as well as for rolling enormous masses of wrought-iron, now become common.

Hence I was compelled to adapt my designs, not as the best conceivable for their final object, but having regard to how they should be executed with rapidity, or at all.

Were I now called upon to design a 36-inch mortar, I should not only modify its proportions, but greatly simplify its details, and construct its chase, as I first designed it, in not more than two or three thicknesses.

And here is the place where I ought to mention how it came to pass that the chases of these mortars were designed in three separable segments, and separate from the base, and the whole of these held together by bolts. Before I ever put pencil to paper I had conversed with several friends, military and otherwise, as to the effect of shells of a yard in diameter on the forts of Sebastopol, and said I thought I could make a mortar to throw them that need not exceed some 30 or 40 tons weight, which I also thought might, without insuperable difficulties, be got to the front from Balaclava. All my military Engineer and Artillery friends, however, seemed to concur in the view that to move such a mass was out of their way at any rate, and that nothing heavier than say two 8-inch (smooth-bore) guns together, need be thought of as of any practical utility.

Upon this I proposed to dissect the mortar—make it in pieces, none exceeding 10 or 11 tons—and so carry it to the front piecemeal. At every stage I found amongst military authorities this same view as to transport maintained. The result, however, was greatly, and as I am now satisfied most needlessly, to complicate the construction of the mortars and weaken their endurance.

Now-a-days, probably, even military men would not attach so much importance to the difficulty of transport of heavy masses; and for myself, I should, if called upon now, construct a 36-inch mortar in one permanently united whole, and find no difficulty in providing the means for transporting it over any country over which heavy siege artillery can be passed. As to transport by sea, of course there is no difficulty.

There are great advantages in the form of base plate adopted, in relation to the mortar bed. The forward trunnion running right across the bed in advance of the axis, and the coin wedges right across in rear of it, well diffuse the powerful shock of recoil upon the material of the bed itself, and greatly simplify the construction of the latter. The bed, as shown in Fig. 1 of General Lefroy's memoir, and as actually constructed, is only the top portion of the complete bed as designed by me; the lower portion was a sort of inclined slide or racer, upon which the top portion was to run between guides in recoil, the lower portion resting upon a level platform. For the trials at Plumstead the top portion was deemed sufficient, resting upon an inclined platform. This platform, as described in General Lefroy's memoir, proved very insufficient to withstand the component of the recoil perpendicular to it. The gravel became compressed and the baulks sprung into the hollow beneath, after the first three or four rounds. This placed the mortar at a great disadvantage, and unquestionably was a potential element tending to the fracture of the longitudinal tyebolts and cotters.

The stress upon these bolts is not that due to the projectile force of the charge, but is simply that due to the mass of all parts of the mortar *above the cup* in which the shell rests. The *inertia* of this mass, bolts included, has to be overcome and motion suddenly given to it, *at the velocity* with which all parts of the mortar *below the cup* with the bed are driven backward and downward on discharge. If the material below the cup, the bed included and the platform, were perfectly rigid and unyielding, then the stress upon the longitudinal bolts would be a *minimum;* but with a springing and yielding platform, the mortar approximates to the same state of things as if it were fired suspended in mid air, when the stress on these bolts would be a *maximum.* Platforms on land for such mortars, should consist of at least three layers of well fitted and united whole baulk timber, very solidly laid upon uniformly dense material well compacted beneath them.

In another point, also, those mortars were placed at a great disadvantage. In 1855–6 the coarsest grained powder known in our service—I believe also then in any other—was the L.G., or large grain cannon powder. Its rapid combustion and *brisante* qualities I was not ignorant of, and saw how much these must be exaggerated when such then unexampled charges as from 40 to 80 lbs. were fired. I accordingly made application through Colonel Pickering, R.A., Secretary of the Ordnance Select Committee, to have some of what is now known as "pebble powder" made specially for the trial of these mortars; but I found that if the tedious routine of application were formally gone through, that then probably this coarse powder might after much delay be directed to be made at Waltham Abbey works; but that in the end, unless the mortars could be served with the ordinary cannon powder of the service, they probably would not be deemed satisfactory. I was therefore reluctantly obliged to use a powder far too fast burning either to give fair play to the mortars or the best ranges to the shells.

As a palliative, I proposed and was permitted, to divide the charges into 5 or 10 lbs. flannel close bags, as stated in the memoir; but at the intensely high temperature of flame produced by such heavy charges, the rate of burning did not appear to be sensibly diminished by this mode of subdivision.

At the present day, no artillery officer would propose to fire charges such as those of these mortars, unless composed of pebble or of prismatic powder.

It is necessary I should also offer a few words of explanation as to how and upon what principles the superimposed integrant rings of these mortars were shrunk upon each other, so as to give the required initial tension. This was called into doubt, for his own objects, by the late Captain Blakely, who unauthorisedly published, in appendix E to his pamphlet "On constructing Cannon," Ridgeway, London, 1858 (see also "Proceedings Royal Irish Academy," Vol. VII. p. 338), a private note in reply by Dr. Hart to a letter from Capt. B., in which Dr. Hart rather incautiously and quite incorrectly states that he believed I had "utterly neglected to apportion the tensions of the successive rings to calculation."

The circumstances will be best explained by subjoining a copy of a letter addressed by me to Dr. Hart himself:—

(*Copy*).

DELVILLE, CO. DUBLIN,
September 9, 1858.

My dear Sir,

I have sent you by this post (open ended) a copy of a pamphlet by Captain Blakely, R.A., which I recently chanced upon in London. I know not whether you have before seen it.

In a letter bearing your name (Appendix E, p. 50), some injustice is done me. If the letter be yours, unintentionally I am quite sure.

The statements therein which I have marked are to the effect that my 36-inch mortars are not constructed at all upon the principle of graduated compression of the inner and tension of the outer rings, the theory of which you investigated for me, but the general principles of which had been known to me a long time—before even the first day that Professor Downing, C.E., and I called upon you on the subject. Let me assure you that you are quite mistaken in supposing that I have utterly neglected the principle of graduated strain, &c. in those mortars. The graduation, however, was not effected by difference of temperature in the successive rings, as you proposed, and which I soon saw would be quite impracticable to carry out, but by the requisite nice adjustment of the diameters, when cold, of the successive rings, so that when all heated to about the same temperature they should grip differently, as required.

That the effect has been practically pretty much what was intended, the last day's practice showed, when a charge of 80 lbs. of powder, which threw a shell about a mile and three quarters, produced no effect upon chase or chamber.

I may have myself led you into this error (which, however, I am sorry to find published), for I recollect telling you that I had shrunk on all the rings at one temperature. May I ask if you gave Captain Blakely permission to publish your letter? He don't say so.

Believe me, dear Sir,

Very truly yours,

ROBERT MALLET.

Dr. H. S. Hart, F.T.C.D.,
Trinity College, Dublin.

It is impossible within the limits of a note already too long, to enter fully upon the complicated question of the relations that take place between all the parts in a system of rings superimposed with initial tension, keeping in view *all the conditions which in nature* are operative.

The mathematical investigations which have been made all neglect some of the most important of these conditions, and the laws of successive tensions and compressions as thus fixed are, in fact, impossible to be realised *rigidly* in practice.

For a statement of some of the reasons of this, I may refer to my work "On the Physical Conditions, &c., of Artillery," p. 152–156, and to note W, p. 266; but there are many other circumstances besides those there referred to, which render uncertain the mutual strains brought into play between such superimposed rings, some of which Mr. Longridge ("Const. Artill." Proc. Ins. C.E., Vol. XIX., p. 301), has well pointed out.

If two equal rings only, each of some considerable thickness, have the internal diameter of the outer so adjusted to the exterior of the inner—both being cold—that after heating and superposition of the external one a very moderate tension, say not exceeding one ton per square inch, shall result, it will be found that not only is the actual compression of the interior ring less than corresponds to the assigned tension of the outer, but the circumferential tension of the latter is less than would be assigned by the differences of diameters of the gripping surfaces. The rings, in fact, cling together at their opposed surfaces. As the absolute strain is augmented, the transmitted compression seems to approximate much more nearly to that due to the tension.

Every ring, after it has been shrunk on, has its thickness altered (like a stretched piece of india-rubber), and the amount of alteration is not always uniform or certainly predictable. As is the case in all extended prisms of a metal, its density is diminished, and with that its compressibility orthogonal to the line of tension is increased. Hence the next outer ring, if previously bored to a size to give an assigned tension (on the supposition of unaltered thickness and physical condition), gives less than required.

In large rings, errors in dimensions below those capable of being always avoided in the best and most careful practice, materially affect the result. In very large rings, differences in atmospheric temperature, in the workshop or outside it, may have sensible effects. From these and other such considerations, Sir William Armstrong, with his habitual acumen, soon saw that any attempt at great precision in apportioning the strains upon the successive rings was practically impossible, and publicly stated in 1860 (Proc. Ins. C.E., Vol. XIX. p. 419) that in his guns "the outer layers and rings were not put on with any calculated degree of tension; they were simply applied with a sufficient difference of diameter to secure effective shrinkage."

As respects the 36-inch mortars, I did not so completely cast aside theory. What I actually did do was as follows:—Having fixed, partly by theory partly by judgment, the assumed maximum strain of discharge and the possible maximum excess of temperature that might arise between the interior and the exterior of the mortar; and ascertained, by a few tolerably accurate experiments made at the works, Blackwall, most of the disturbing elements that hinder intended tensions and compressions in a number of superposed rings from being precisely attainable in practice; I then, starting from the middle point in the thickness of the chase, determined the *theoretic* compressions within and tensions without that, for each of the plies of rings, and the successive differences of dimensions which, if given the rings, should upon that theoretic view produce these respectively; I then modified the results empirically, or by a mere exercise of judgment, in every case, so as to eliminate at least some of the dirturbances, and more or less considerably to *increase* the tensions and compressions.

In this I chiefly had regard to—1st, presumable errors in workmanship; 2nd, stretching of the substance of the ring reducing its assumed grip; 3rd, alterations in the cross sections of the rings after shrinking on.

The dimensions when cold—*i.e.*, at the atmospheric temperature of the time—inside and outside for every ply, were then tabulated, and steel gauges made by this, to which the rings were bored or turned. The whole of the rings were heated to a low red heat, visible in daylight, and were permitted to adjust themselves, being cooled rapidly by a stream of cold water, to prevent another source of disturbance—viz., the heating of the ply in the act of being hooped, by heat radiated first and then conducted to it from the red hot ply in the act of being superposed.

With every precaution taken, some three or four of the rings, when struck by a light hammer, were found to be too loose, and had to be cut off and readjusted; and in one or two others it turned out that the want of grip was due to defective welds. The result of the operation has been that, although with most probably some inequalities, the tensions and compressions have so adjusted themselves that the whole thickness of the chase is more or less effective, and that *perhaps* a somewhat undue strain of the explosion is transmitted to the exterior plies; a far better fault than that it should be concentrated towards the interior.

In April, 1855, whilst those mortars were in progress, Lord Palmerston sent for me and asked what was doing as to mortar vessels to carry them. No orders for anything of the sort had been given. His Lordship directed me to consider the design of mortar vessel I should propose, and to place myself in communication with Sir Charles Wood, Bart., then First Lord of the Admiralty, which I did on the 20th April, 1855, having a good while previously worked out the scheme of mortar float which I then designed and submitted, and as to which I had several interviews with Admiral Sir Baldwin Walker, R.N., and Mr. Watts, Constructor to the Admiralty, resulting from which I was requested to obtain tenders for the construction of two of these floats.

Obstacles of official routine prevented anything further being done until so late as nearly the end of July, 1855, when I deemed it right to inform Lord Palmerston of the fact. Peace soon after put an end to the matter.

No account of these large mortar floats has before been published. A model of one of them, as well as an accurate model of the 36-inch mortars themselves, as finally constructed, have been placed by me, on loan, in the museum of the United Service Institution, Scotland Yard, London.

The general idea of one of these floats may be conceived as a hollow, flat-decked, square slab, built of iron, made up chiefly of horizontally aggregated hollow cubes, each of 8 ft. on the side, the outer ranges all round these being of half cubes, with prismoidal spaces outside these again to be filled with sand and sawdust mixed. The mortar in the centre of the deck, ranging diagonally, and its bed, with elastic material beneath it, bearing not upon the deck but upon the keelsons at the bottom. In rear of the mortar and below deck a pair of high-pressure engines, with independent twin screws, their shafts set at angles of about 35° to each other, so as either to propel, steer, or shift in azimuth only.

The following is the general description of those designs submitted by me:—

(*Copy*).

General description of Floating Mortar Batteries, upon a new construction, proposed to carry the 36-*inch Mortars now preparing. Submitted to the Admiralty by Robert Mallet, C.E.*, 1855.

Each mortar battery may be viewed as a square redoubt afloat, 75 ft. square over all; armed with one very powerful mortar, and with five 32-pr. long guns; having a draught of water, in fighting trim—with engines at work, fuel, stores, ammunition, armament, and crew on board—of only 7 ft.

The principal objects held in view in designing this form of floating battery have been:—

1. The greatest obtainable steadiness upon the water, so as to admit the best practice at long ranges with the 36-inch mortar.

2. The lightest possible draught of water, to enable this powerful weapon to be brought into very shoal water in shore or in shallow seas.

3. Perfect impossibility of foundering at sea through any combination of causes.

4. Being so constructed as to be shell-proof from any but the largest shells; and so that if pierced right through from top to bottom in several places, the vessel shall still float safely, and be capable of continuing in action.

5. A construction such that, at the distant range intended for the use of the 36-inch mortar, the sides and bulwarks of the vessel will be practically shot-proof; that below water, where capable of being reached by shot, the sides will be *perfectly* shot-proof;[*] and that even if pierced with shot, no serious damage will be sustained.

6. That while her bulwarks rise a sufficient height efficiently to protect the men on deck, the whole mass lies so low in the water as, at the distance required for mortar practice, to present a very thin line to the enemy; and the hull being painted of a greyish sea-green colour, will be scarce discernible as a mark; and as respects the liability of the deck to receive shells, as compared with the floating batteries ("Meteor," &c.), the actual surface exposed to such vertical fire is less than that of the "Meteor" in the ratio 5560 to 6678, or presents about one-sixth less area.

7. The battery is so arranged as to present two of her sides and one angle always to the enemy, so that all shot reaching her from thence will strike her sides at an angle of 45° to the surface of the hull, and hence have small penetrative power.

8. As the long range of the 36-inch mortar precludes the necessity of ever bringing the battery within suitable range for effective horizontal fire, so it is not proposed to arm her with any very heavy guns.

Five long 32-prs., however, form part of her armament, for the purpose of giving an efficient defence to attempts at boarding or capture by gunboats. These guns, however, might occasionally also be serviceably employed in battering, or might be exchanged for an equal or smaller number of heavier guns.

9. It is proposed that the battery be always attended by one or more tug-boats, to tow her into and out of action, or rapidly change position, &c.; and hence the engine-power put on board is very moderate—its action upon the two screws with which she is provided being chiefly intended to be used in shifting the mortar battery (when at anchor) in azimuth, so as to avoid the labour and loss of time in changing the direction of the heavy mortar itself. The engine-power and screws, however, will probably ensure a speed of from three to four knots an hour unaided.

10. The surrounding bulwarks[†] being higher than the men's heads above the deck, and standing rather more than 7 ft. above the deep water-line, free from all standing rigging or any other thing upon which a grasp may be maintained, render the battery extremely difficult to board, more especially from light vessels which are low in the water; and the bulwarks may be most efficiently defended by musketry from loop-holes, or from the top, by a wooden "banquette" running round. Such of the ports as may not be in use are provided with stoppers of a peculiar construction, which will be equally shot-proof with the rest of the bulwarks.

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[*] Against 68 lb. round shot, the most powerful projectile *then* in use.

[†] The bulwarks were of heavy scantlings of teak, iron-plated.

11. There is no top gear or standing rigging of any description to be cut by the enemy's shot. Nothing stands above the level of the bulwarks, except a small part of the muzzle of the great mortar, and the upper part of the crane for loading it. The latter (provided in duplicate) is so secured by secondary guy ropes, that in the event of being cut down by a chance shot, the parts would not fall upon the men around it.

12. Although the great strength and stability on the water, and incapability of foundering, by division into water-tight compartments, together with the extremely light draught of water, amounting (when light, or with only the large mortar, crew, and stores on board) to no more than 5 ft. 6 ins., are obtained by the use of a wrought-iron hull, yet the disadvantages incident to iron vessels when exposed to shot are in this instance fully met and provided against. The whole of the ironwork is below the heavy timbered deck, and within the timber sides and bulwarks; so that torn or splintered iron can never injure or touch those on board.

13. The vessel is so constructed that it is scarcely possible to burn her, while in possession of her crew; and even if all her woodwork were burnt off, the hull would float and carry her mortar safely, and be capable of perfect restoration—and of a temporary restoration, with means at hand, in a very short time.

14. As the bulwarks stand so high above the deck that a man standing thereon cannot see the horizon, a special instrument has been devised for the purpose of directing the 36-inch mortar, consisting of a telescopic sight, so combined with an azimuth compass of power and accuracy that shelling can be carried on at night as well as by day, when the distance and azimuth of the object have been once got by daylight. The telescopic sight is such that the directing officer sees his mark without being exposed to fire.

15. The extreme outside range of water-tight compartments, all round and immediately inside the timbering of the sides, is filled for the upper half of its depth, or to 3½ ft. below the load water plane, with three-fourths sawdust mixed with one-fourth of sharp sand by bulk, which, while much lighter than sand alone, being only 45 lbs. to the cubic foot, appears to resist shot nearly as well as sand alone.

Within this, the next range of water-tight compartments form a continuous wing or passage all round the vessel, of 4 ft. wide and 6 ft. high, divided by a bulk-head at every 8 ft., provided with a water-tight door, and forming a ready means of access to any perforation, if made by shot, and to all the separate compartments in the inboard side forming the

Two magazines,
Shell rooms,
Bread rooms,
Store rooms,
Armouries,
Cordage and cables, &c. &c.

The spaces between the iron beams beneath the great mortar form the water tanks, and give storage for above 11,000 gallons of fresh water.

16. Any of the compartments below deck may be used as sleeping places, each being 8 ft. square by 6½ ft. in clear height; but it is proposed that these mortar batteries be considered as fighting platforms rather than as vessels intended for large crews to live on board for lengthened periods; and hence shelter under canvas for sleeping on deck at night might perhaps be found the best and healthiest mode in which the complement of men could live while on board.

17. The following are the calculations of weight and displacement:—

WEIGHTS FOR DISPLACEMENT.

Hull (including beams under mortar bed).

		Tons.
Bottom, ½″ thick, 69′ square, 4761 × 20 lbs.	=	43
Top, ⅜″ thick, 71′ square, 5041 × 15 lbs.	=	34
4 sides, ⅜″ thick, 71′ × 7′ 6″ deep	=	14
12 vertical divisions, ¼″ thick, 71′ × 6′ 3″ deep	=	24
8 ″ ″ ¼″ ″ 23′ × 6′ 3″ ″	=	5
10 ″ ″ ½″ ″ 24′ × 4′ 0″ ″	=	9
32 deck-connecting pieces, 3 × 1 × ⅜″ thick	=	1
Engine floor fastenings	=	2
Doors	=	2
9600 lin. ft. 3″ L iron, ⅝″ thick, at 12 lbs.	=	52
528 ″ ″ at 10 lbs.	=	2
Add for rivets $\frac{1}{10}$ whole	=	19
		207

Recapitulation of Timber.

844 cubic feet teak, at 35 cubic feet = 1 ton	=	24
11125 ″ oak ″ 37 ″ ″	=	301
7221 ″ fir ″ 64 ″ ″	=	113
Add for fitments	=	20
		458

Armament.

36-inch mortar, with buffing	45
5 guns, 32-prs	25
Arm for mortar	3
Anchors, chains	60
3 windlasses or capstans	6
2 boats and davits	5
2 cylindrical tubular boilers, 2-pr. engines, and 2 screws	75

Ammunition and Fuel.

50 shells for 36-in. mortar (filled)	85
Shot and powder for 32-prs	5
Coke, &c.	25
Crew	8
Sand and sawdust	27
	369

Calculated Displacements.

Draught. Depth. feet.	Superficial. feet.	Cubic contents. cubic feet.	Weight. tons.	Total tons. tons.
1	70	4900	136	136
2	71	5041	140	276
3	72	5184	144	420
4	73	5329	148	568
5	74	5476	152	720
6	75	5625	156	876
7	75½	5700	158	1034
8	75½	5700	158	1192

Iron in hull	207	In fighting trim.
Timber in decks, &c.	458	
Armament, power, stores, &c.	369	
Total tons	1034	

The battery will consequently draw 7 ft. water.

Iron in hull	207	In light trim.
Timber in decks, &c.	458	
Armament, power, stores, &c.	131	
Total tons	796	

The battery will therefore draw 5½ ft. water.

The naval Constructors of the Admiralty fully admitted the important advantages presented in several points of these designs.

It was objected, however, by one of the Naval Lords, that such large, square, flat floats would prove unmanageable in being towed out to the Black Sea and the Baltic. I could not myself coincide in this view, the futility of which, the experience since had in towing out to Bermuda and elsewhere far larger and heavier iron floating docks, has amply proved. With a view to meet the objection, however, I pointed out the readiness with which each float could be divided into three pieces, each of only 75 ft. by 25 ft. beam, which, with or without temporary bows and rudders, could be towed anywhere and united at the destination of the battery. This was admitted to have met the supposed difficulty.

This design for placing these mortars and guns upon low floating iron unsinkable rafts, was thus anterior in date by several months to that constructed at Woolwich Dockyard, from a design it was understood, of the late Captain Coles, R.N., which was not completed before nearly the end of 1855 (see the "Times," 14th Nov. 1855); and was long anterior to the proposal of rafts, in several respects the same, by Mr. H. Conybeare, C.E., which first appeared in the "Times" of the 10th October, 1855.

ROBERT MALLET.

January, 1871.

THE
REFORM OF PRUSSIAN TACTICS.

A LECTURE DELIVERED AT THE R.A. INSTITUTION, WOOLWICH, DEC. 13, 1870.

BY

LT.-COL. C. C. CHESNEY, R.E.

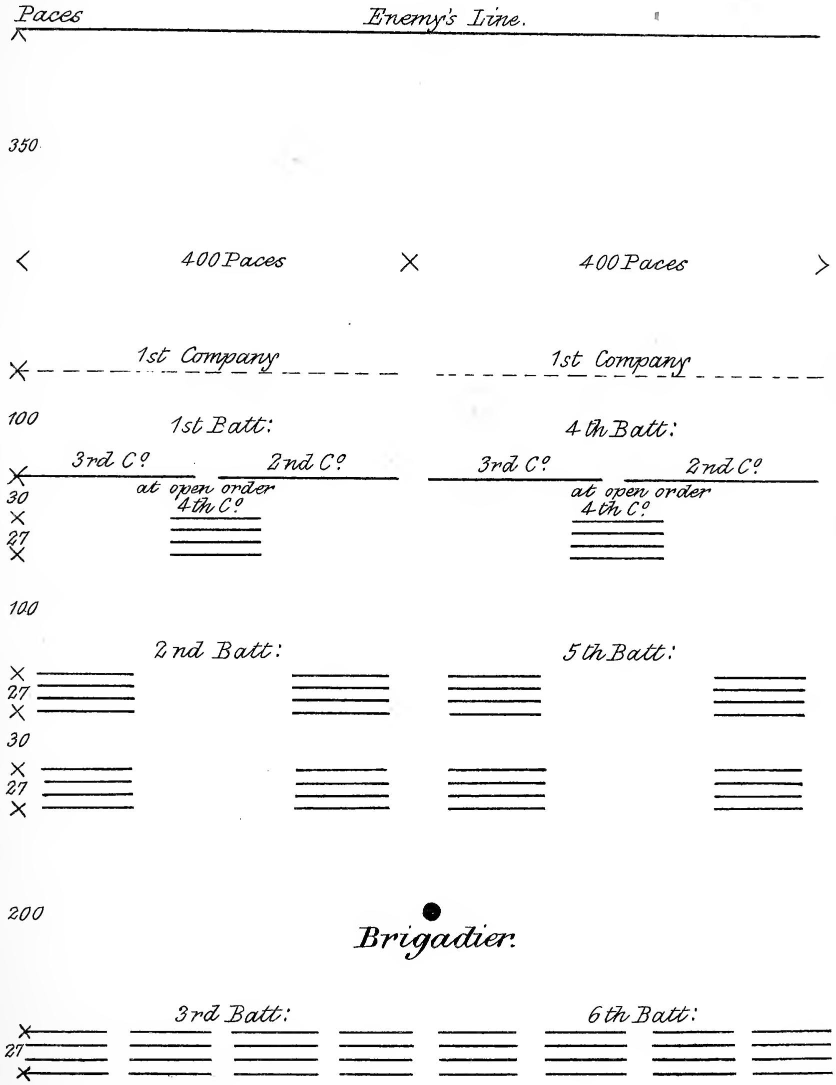
MAJOR-GENERAL F. M. EARDLEY-WILMOT presided, and expressed his regret at having to do so when there were present so many well known officers distinguished in active service. He was glad, however, to see so large a meeting to do honour to Colonel Chesney, who was personally known to many present, and who had been long and honourably esteemed through his writings and lectures. He was at present in the garrison, filling the post of an officer of artillery who was charged with an important duty among the sick and wounded abroad, and had consented to favour them with a lecture on a subject which would at any time be valuable and interesting, but was under present circumstances peculiarly so. The lecturer was most anxious that there should be some discussion on this paper, and that those who took an interest in the subject should make such remarks and enquiries as the occasion prompted, and thereby assist in the examination of the principles enunciated. One other observation he wished to make, and that was to remind the audience that, in speaking of the French and the Prussians in connection with this subject, they must be understood to refer to them simply as pawns upon the chess-board to illustrate the moving incidents in the great drama of war, without being supposed to entertain prejudice or predilection towards one side or the other. With this understanding to prepare the ground, he would introduce the lecturer, Colonel Chesney. (Applause).

Colonel CHESNEY commenced his lecture by saying that the Prussian nation had acquired a reputation in military matters before all others, chiefly because of the attention which its people had devoted to military science in preference to any other study. Nearly a hundred years ago (in 1772), Harris, first Lord Malmesbury, was impressed with the great devotion of Prussian officers of the day to their profession, using words which, though not accurately representing the circumstances of the present time, were still essentially true, in that the Prussians did now, as even then, keep up a closer acquaintance than others with all the higher details, and among the rest, with military tactics, the immediate subject of this evening. He would first say, speaking of tactics as a special subject divided from that of strategy, that the Prussians were fully aware of the impossibility of teaching tactics by rule. The well known Prussian writer, Von Verdy, had declared that tactics could not be reduced to any absolute and definite rule, but must vary in a great measure, according to the circumstances of the moment, the object sought to be attained, and the means at hand for the purpose. To demonstrate this, they had to take only the first case which suggested itself—the position of an officer in command of troops about to engage the enemy. It was a most difficult matter, without information, for an officer so placed to ascertain the strength of the force opposed to him, and upon the extent of his knowledge in that respect it was clear that his tactics must depend. It would be easy to quote more than one incident from the war of 1866 in which an Austrian officer in command had been led into the use of improper tactics by inferring that the number of the enemy was larger than it really was, because he was opposed to a better weapon, and possibly to better troops. If, however, they could not teach tactics by rule, Von Verdy had added, they could lay down certain leading principles which the military mind could acquire and apply in practice, according to circumstances. As, for instance, in that same war of 1866, at Sadowa, a General of Division (Fransecky) in the Prussian First Army, seeing the exact position of affairs, felt bound to occupy the enemy at whatever loss to his own division; and, on the other hand, another General of Division in the same service had not long before to do just the contrary—namely, to spread out his men as much as possible, and show a large front, so as to draw upon him the attention of the enemy, while, at the same time, he suffered no more loss than he could not possibly avoid. So, whatever principles were laid down for their instruction in this part of the Art of War, they must vary in application according to different circumstances.

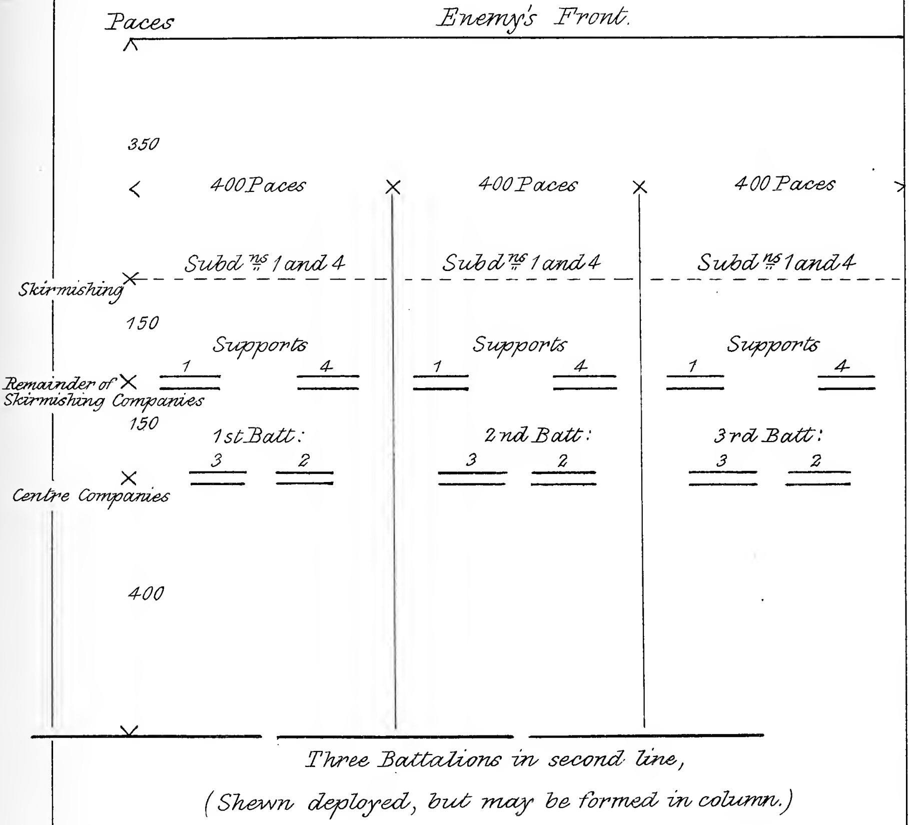
Passing now directly to the subject of his lecture, Colonel Chesney said he had been long in the habit of treating such subjects not theoretically, but historically; or rather, instead of following the whole course of history, he preferred to take one or two cases and discuss them minutely in all their details as affecting the question in hand, and that was the course he proposed to pursue in illustrating the "Reform of Prussian Tactics." He thought that any sound writer would lay down what Von Verdy has, as the chief great principles in moving great bodies of men, the two following:—first, clearness in what one sees; and secondly, energy in the conduct of the business. Neither of these could certainly be taught by rule, but the example of what others had done, and the experience of other men in certain circumstances must, if carefully studied, be of advantage to the soldier. In practice, one special condition must always be considered. If an officer commanding a division was acting as part of a corps, and receiving his orders from the General in command, he would have little independence or discretion; but if, on the other hand, he were acting independently with his division, the whole course of his tactics, under apparently precisely similar circumstances, might be very different.

They would now go back to the early history of their subject—the reform of Prussian tactics. The later school of Frederic had often been commented on rather harshly; but it was not so contemptible as was generally supposed. The extremes to which drilling and dressing were carried were a necessary consequence of the exercises then in vogue, and especially of the system of marching in what is now termed "open column of companies," absolute precision in distance being essential to bring the troops into line immediately at the word, and so find them ready for action. It was true that in Prussia, as well as in other countries which followed her, the system was carried to an absurd extent, even to the distance between a man's buttons and the length of his pig-tail; and so precise did we become in England, that it had been usual to rouse out the troops two, or even three hours before the time fixed for parade, because it was supposed to take that time to get the parade properly ready. However, the Prussian system, with all its defects, was the model adopted generally on the continent until the revolutionary wars, both in America and Europe, brought its well known collapse. The Prussians drew out of the war with the Republic before they had time to test their system of line and open companies against the French system of column; but after remaining at peace for ten years, there came the war of 1806 and the meeting of the two schools. One's mind naturally recurs to the battle of Jena; but the lecturer prefers selecting for illustration a skirmish which took place four days previous to that engagement at Saalfeld. The advance guards met in a small plain, and what happened showed how ineffectual were the tactics of the Prussians. The Prussian force was commanded by Prince Louis, a relation of the King of Prussia, who posted his main force in a line, with detachments to the right and left, sending a battalion and a half to occupy an eligible position on a hill to the right, and skirmishers to a small muddy stream which offered a kind of boundary on the left. Whilst he was so employed, Marshal Lannes, the officer in command of the French, saw his advantage, and prepared to overthrow the Prussians by a simple process. Deploying from a mountain pass to the right and left, he sent out skirmishers, who, having plenty of cover, kept up a good fire on the line until it was thoroughly shaken. In a short time the line was almost broken by their sharp fire, when the skirmishers ceased firing, and columns came suddenly up through them, captured the guns, and broke through the line. Louis being killed, his small army retreated with great loss. From that hour the Prussians adopted the French model, resorting to the use of skirmishers in every advance; and if the details of any battle (Ligny, for instance) were analysed, it would be found that, from May 1813 to the close of the war, there was practically no difference between the mode of warfare on the one side or the other. Taking another stride in history, the lecturer said that after the battle of Waterloo there was no further change, until the introduction of rifled artillery and the needle gun rendered certain alterations unavoidable. It was a singular fact that Dreyse discovered the needle gun, and presented it to the King of Prussia as early as 1830, as perfect as it now was; but he could not make way against the conservatism which is generally found to exist in military matters, and it was not until 1849 that his invention was practically adopted, and used with considerable execution against the Baden insurgents. That, however, was a small affair, and no great change followed in Prussian tactics, which remained much as they were left at Waterloo, until the French fought and won the battle of Solferino in 1859. That event, as far as he (Colonel Chesney) could judge from being amongst them as a traveller, made the Prussians feel anxious and uncomfortable—a feeling intensified by the fact that Prussia had just found considerable difficulty in mobilising her army. Then came the well known lecture of Prince Frederic Charles, who showed the principles upon which the French had acted, and how they might be adapted with advantage by the Prussians. The lecture filled a great want, and the suggestions were well received, not because they were the suggestions of a prince, but because they met the demand of the age. The Prince pointed out that the French

PROPOSED FORMATION FOR A BRIGADE OF SIX BATTALIONS.



COUNTER-PROPOSAL FOR FORMATION OF THE BRIGADE.



fought on apparently loose principles, but yet with a degree of design which was not at first apparent; and his argument was, "If we take the best of the French system and apply it to the best of our own, we shall infallibly beat the French whenever we meet them." That advice, "How to beat the French," as it was popularly called (though that was not the real title of the lecture), was put into practice for the instruction of the Prussian officers in tactics in 1861. In principle, the "Tactical Instructions" was essentially different from any drill-book hitherto published. The French, as late as four years ago, had a secret guide book in use among their staff, something similar in intention, but in execution totally different, and of an effete, antiquated type, as Colonel Chesney could assert from personal knowledge of it. Putting aside the minute details of drill in the field, instead of attempting to tell a man exactly what he was to do under all conceivable circumstances, the new Prussian tactics assumed that an officer in command of any force was possessed of certain intelligence, and gave him considerable latitude. He was taught to study and to reason, and to work out the result of his knowledge and his theories in practice. At the same time the drills, especially of the infantry, were modified, and made more elastic by breaking up the large and unwieldly battalions into four companies each, allowing the troops to work more independently, to manœuvre at times out of step, and the like. The increased elasticity was great, and the Prussians had made an improvement from which they saw no necessity to go back.

The new tactics were brought into practice with vast success in the Austrian campaign, but that was too short and too one-sided to afford a test of their efficiency. However, the Prussians made two remarkable failures, both on one day, the 27th of June, and in one case were fairly beaten by equal numbers of the Austrians. The other case was that of Langensalza; and in enquiring the cause of that failure they would find that the Hanoverians occupied three villages with three of their four brigades, having one in reserve behind a river running below a steep hill. In front, the Prussians approached to fight in their favourite company columns, and it was found that each officer naturally tried to get a good ground for himself. Thus, though they approached in regular order of battle, the main body and the reserve advancing together at the usual interval, it happened that when they came in contact with the enemy, and were in that fidgety state which men always were in under fire, the companies took up ground to right and left as they could, the reserve had dissipated itself, and the whole at last formed a complete line of single companies. The Hanoverians thereupon massed their troops, made a direct charge upon the centre, and in a few minutes the line was cut in two and the Prussians in full retreat. It was more difficult to understand how they lost the second battle of that day—the battle of Trautenau. The Prussian General, Bonin, was approaching Trautenau in two columns, with 30,000 men, expecting to meet the Austrians in the neighbourhood; and the Austrian General, Gablenz, with a similar *corps d'armée*, was coming to meet him in the other direction. The breaking of a bridge delayed the first of the Prussian columns, and the second waited some time for it to come up. The Austrians meanwhile pushed on to Trautenau, and the Prussians came forward to meet and drive them back with their first division. A portion of the other division was advancing to the south, and the commanding officer, seeing that the country was more open, advanced his force of eight battalions unsupported in a thin line in that direction. Owing to the delay, it was getting late in the afternoon. The Austrian General, getting his troops together, made a determined attack on the Prussian line, and drove it back over the ground so far that it got into confusion; it was too late in the day to alter the result, and it ended in a decided retreat.

In speaking of this event, the lecturer remarked as a notable fact in the Prussian system, that the General who suffered this defeat was now high in command in the Prussian service, and that the march before the disaster of Trautenau was taken by Von Verdy as a special object of study; showing that the Prussians were neither ashamed to acknowledge being beaten, nor above turning the lesson to their own advantage. It should be remarked also of Trautenau that the loss of the Austrians was immense, notwithstanding their victory, showing the immense superiority of the Prussian weapon; and the action led to nothing, because on the next day its result was decisively reversed by Benedek's inferiority elsewhere.

That these two defeats were due to special causes the lecturer said was evident from the different results of the same tactics in the rest of the short campaign, and he instanced the battle of Kissingen as a striking illustration to show how readily the Prussians developed their tactical plans. The town was defended by a brigade of Bavarians, with some cavalry, when the main force of the Prussians came upon them. A bridge across the river in a pleasure garden outside the town had been destroyed by the defenders, but the piles were left, and in a few minutes the engineers broke up the floor of a house and laid the planks across the piles, so as practically to rebuild the bridge. The infantry, profiting by their company formation, were able to cross the bridge and deploy beyond it rapidly, though they were shot down in numbers; and as soon as they got over they took ground by companies to the right, and with overwhelming force turned and drove the Bavarians out.

When the war was at an end, everyone in Prussia was well pleased with the new system. They thought they had got to perfection until the well-known work the "Tactical Retrospect" appeared, criticising freely the various events of 1866, and pointing out especially that there was still a great deal wanting in Prussian infantry tactics to accommodate them to the increased elasticity of the company formation. It was only natural that the anonymous author should be challenged to give his remedy for the defects he had indicated, and to state what he would substitute for the system which he had derided and condemned; and at length another pamphlet, also anonymous, under the title of the "Prussian Infantry in 1869," appeared from the same pen; and a translation by Colonel H. Aimé Ouvry, C.B., had recently been published in England. The author, the lecturer said, was plainly a man of really great talent, but he did not the least believe it was Prince Frederick Charles, as some asserted, for the internal evidence was entirely opposed to such a conclusion. The pamphlets certainly made the Prussian military authorities very angry, and an elaborate reply was published only last April by Colonel Von Bronsart—the tactical ideas of which, it was well understood, were those of Von Moltke himself—in which the writer made distinct proposals of his own in opposition to the plans of the anonymous author. The lecturer proceeded to explain, by two diagrams, the two systems; on the one hand that advocated by the author of the "Tactical Retrospect," and on the other that of Von Moltke. The plans of the former appeared (for they were not shown by any sketch of his own) to condemn columns altogether. He had thought it was impossible (writing last year) to bring troops into action in that form in the face of the breechloader; neither did he approve of the line formation, because no line could be effective without volleys, and volleys could not be expected now. What he proposed was, to open the ordinary line so as to allow two paces between man and man. Applying this to practice, he said that skirmishers were not effective enough for a charge, but he would have them approach to within 350 paces of the enemy and open fire; the leading company would throw out skirmishers, and he would have no supports, but at 100 paces behind he would have two companies in open column, and a fourth at 200 paces behind in close column. Opposed to this was the plan of Von Moltke, which would probably have been ere this adopted but for the breaking out of the war with France. Von Moltke proposed to throw out a line of skirmishers from the two leading companies, with two-thirds of each company in support, the remainder of the battalion forming double column 400 paces behind. The lecturer explained this part of his subject in detail by reference to the diagrams, and expressed his own opinion that, theoretically, reason was on the side of Von Moltke; but Colonel Bronsart's strong point was that the open order system would not work, for the open order line must (admittedly by the proposer's own words) close upon the centre in charging, just as skirmishers would have to do if used to charge under fire, and this attempt to close would be fatal. In fact, he showed that the plan had been tried in Prussia many years before, and that, as the closing on the centre would be disastrous to the forward movement, the principle had been condemned as utterly impracticable.

The Prussians made the behaviour of officers and men in action and on the march the subjects of careful study, and the lecturer cited Von Verdy's "Conduct of Troops" as a remarkable example of the careful study of staff duties. Von Verdy took as his particular subject the march leading to that disaster of Trautenau of which they had been speaking; and his most important point was, that subordinate officers in command of any body of troops should invariably be informed, as far as it could affect their own action, of what the enemy was doing, and also of what was in the mind of their own commanding officer. This was so much like the advice given by the Archduke Albert on the same subject, that they might have supposed Von Verdy borrowed the idea, but that we knew Von Verdy's suggestion was published in a lecture privately first; and the only conclusion they could come to was, that two able men, in pursuing the same subject about the same time, had arrived at similar conclusions.

The lecturer went on to say that there was as yet great difficulty in reviewing the tactics of the present war, owing to the impracticability of obtaining precise information; but there were, nevertheless, certain facts on which they might found certain deductions. At the first important engagement of the campaign—the battle of Woerth—they knew that columns were formed by brigades, probably nearly contiguous battalion columns; at all events there was good evidence that the Prussians did charge in large, heavy columns, and so carried their point. In some of the late actions it had been said that all that had been done was done by company columns; but at all the larger actions, and in a most important degree at Forbach, the companies were supported and fed from reserves behind. Forbach, indeed, was won mainly by company columns charging up a hill so steep that the men could not fire their muskets. At the more recent affair of the 30th of October, the infantry and artillery were combined by the Prussians with great effect. The plan was, to take the railway station and village of Le Bourget; and the General in command, although by no means a specially distinguished officer, afforded a remarkable instance of an officer's carefully preparing his tactics. He divided his force into three columns, one advancing direct for the scene of action, another to occupy some houses on the right, and the third advancing by a different road on the left upon the little village of Drancey, and making for the railway station behind the village, to cut off the French in that direction from Paris. In making this detail the commanding officer also divided his batteries between the columns. The lecturer proceeded to describe the successful attack upon Le Bourget and Drancey, which he said had been ably delineated by a correspondent of the "Daily News," from information gleaned from a Prussian officer, and which information Colonel Chesney said he had found, by comparison with other sources, was very correct. The admirable tactics displayed on the 30th of October he had quoted especially, because they were the work of an ordinary Prussian officer, no more eminent or able, perhaps, than other officers occupying similar positions in the same service, and therefore an illustration of the valuable training those officers received. The lecturer further showed, by a review of the action in which Garibaldi was repulsed, on the 26th of Nov., in his feeble attempt to get into Dijon, how carefully the plans of the Prussians, even on a small scale, were laid, and how skillfully they were executed. Those who had read the "Tactical Retrospect" would see how the criticisms of the anonymous writer had been fulfilled in this present war. It was especially due to the better combination of artillery, cavalry, and infantry, that the results of the war had been achieved; and more than one prophecy of the "Tactical Retrospect" had been thereby fulfilled in a remarkable manner. As the author of that work had predicted, artillery had not been used so much to beat down the artillery of the enemy as to weaken the opposing line, so as to prepare the way for the attack of the infantry, which would instinctively make for the weak point. In that respect the "Retrospect" had been right, though in others it was clearly quite wrong. The author had settled the right use of artillery, and experience had so far confirmed his judgment.

The lecturer said he need not go any further into details to illustrate his subject, but he would just say a word in defence of lecturing publicly at all on these subjects. It might be said by some that the officers of the British army had better not study the higher branches of military science, and a knowledge of tactics might possibly never be required of them; but for his part he could not help the conviction that their fleet upon "the silver streak of sea" around them could not be always depended upon for the complete protection of the land. It might be that they would have to resort to the army for ultimate defence, and if this were in any case so, the British army ought not to be behind any other army in any branch of knowledge. It ought not to be, if it ever had been, that Brigadiers should be found in command of mixed bodies of troops with the most trifling knowledge of artillery and cavalry, and utterly unacquainted with their uses in combination with infantry. It ought not to be that they should wait to learn these things until the enemy came upon them. Indeed, to completely avert invasion, England should be prepared, if necessary, to fight her battles abroad. The advice which Shakespeare had given her in "King John" was as true now as in the days of Queen Elizabeth :—

> "What! shall they seek the lion in his den
> And fright him there; and make him tremble there?
> Oh, let it not be said! Forage, and run
> To meet displeasure further from the doors;
> And grapple with him ere he come so nigh."

Colonel Chesney resumed his seat amid long-continued applause.

Major-General WILMOT then invited any officer present to discuss the subject, and after a few moments' pause, said the duty devolved upon him of proposing a vote of thanks to Colonel Chesney, with whom he was sure they all agreed as to the necessity for study in those higher branches of military science and organisation which this war was teaching us. England, however, in his opinion was, with regard to such matters, the most wretched country in the world. (Applause, and a laugh.) If we want to make any military change, we go to Prussia or France, or some other place, for our models, and we never had a man rise amongst us to take into consideration the peculiar features of our country, our national character, constitution, and requirements, and cause our army and national defences to rest upon one basis. (Applause.) He believed that the universal feeling in the service was an anxious desire that our defences should not rest wholly upon the army, but that the army should preserve an intimate connection with the nation—that the soldier, in becoming a soldier, should not cease to be an Englishman. (Applause.) What we required was some one to bring before the country a scheme of defence which should embrace in one head the army, militia, and volunteers, all intimately connected with and depending upon each other. There is a little nation in Europe, but little thought of, which offered us a great example in this respect—a nation which, small though it be, was able on the first rumour of danger to send an army of 40,000 men to the frontier, fully armed and equipped—a feat which he did not think that a nation which prided itself upon being one of the greatest in Europe could do. More than that, he believed that in six weeks the little nation he spoke of could, if the danger increased, have sent forward an army of 200,000 men, to do which the larger nation would, according to present indications, require a very considerable time. The country which had set us this example was Switzerland, where they had a national army always ready organised, without interfering with the national industry. (Hear, hear.) It appeared to him that in the organisation of any true military system, including one of defence, our ordinary industrial character must be taken into consideration. He did not think it was requisite for England to adopt (if he might use a strong term) a despotic system. She wanted a system of defence suited to her character as a commercial country, and there was no reason why a commercial country should not—and we know that it does—produce men as able and patriotic as any nation in the world, even where the people were all soldiers. (Applause.) He hoped the lecture they had heard would convince them, if they had any doubts, of the value of an advanced education for officers of the army. It was the extent of his knowledge which made the Prussian soldier formidable in the field; and he hoped that every officer present, and especially those who were young and would have to meet the requirements of future years, would take the lesson to heart, and make the army as perfect as possible. It was the duty of every officer personally to inform himself of every advance made in military experience at home or abroad, and by his conversation, his writing, and speaking, to make the national requirements thoroughly understood; so as to render it impossible for any Government long to delay in placing the defences of the country on a sound basis. There was a strong feeling in civil life that the officers of the army were opposed to all advancement. The military profession was to a certain extent conservative, not caring to be the frequent subject of the wonderful nostrums and experiments frequently tried and more frequently recommended. It was always jealous of any innovation which was bad, but its conservatism was not opposed to the introduction of anything that was good, and likely to be of advantage to the service and to the nation. (Applause.) He regretted that there did not appear to be a disposition to fully discuss the subject before them, but he desired to ask Colonel Chesney a question. In speaking of Le Bourget, the lecturer had commended the system adopted of breaking up the artillery into three divisions. Would that principle be generally adopted by the Prussians on a larger scale?

Colonel CHESNEY replied that at Le Bourget the artillery was divided because there were three separate attacks. In any engagement the arrangement of the attack and the disposition of the artillery must depend upon circumstances.

Major-General WILMOT asked, further, if there was not some advantage on the Prussian side in their system of keeping the artillery behind the infantry. It appeared to him that the French had always been in haste to bring up their artillery to the attack, while the Prussians, relying on their long range, kept their artillery more in the background.

Colonel CHESNEY said the Prussian tactics in regard to artillery certainly had the advantage, and posting the guns behind infantry was especially serviceable when fighting on a hill. In connection with this subject he invited the attention of officers to the question of percussion shells, in relation to which they had gained remarkable experience out of the present war. Thus, at Gravelotte, where they were firing up hill, the Prussians wasted a considerable proportion of their shells by their flying out of range before bursting; whereas at Sedan, which was fought in a hollow, every shot told.

In answer to Colonel WRIGHT, Colonel CHESNEY gave some further explanations of his diagram illustrating the propositions laid down in the "Tactical Retrospect."

Colonel DOMVILLE said he thought it should be noted that in the Prussian army the company consisted of 250 men, and the large and unwieldly battalions in which they formerly manœuvred having been broken up into half battalions of four companies each, it would become a question whether we, in the British service, had not in our present battalions of ten small companies each, a force in point of numbers about equal to the Prussian half battalion; one that would be found equally flexible, whilst at the same time it would retain that cohesion which, enabling the whole body to act in concert under one commander, would render a defeat from similar causes to those that caused the Prussian reverse at Langensalza to be impossible. He thought the principle of throwing out a line of skirmishers from the leading companies, with supports formed from two-thirds of each of the remaining companies, was one which would never work as well as the practice of forming the skirmishers entirely from one or more whole company, with the companies in support and in reserve unbroken. In the same manner, in covering the advance of a brigade or larger body, he thought entire regiments should be employed, and not parts of several. Unity of action would thus be obtained, and they would work under their own regimental officers, captains as well as field officers. In the Prussian system it would seem as if these latter officers are almost entirely ignored, and thus a very important link in the chain of responsibility appears to be wanting in field operations.

Colonel CHESNEY replied that the point raised by Colonel Domville was an open question. The object of taking skirmishers from separate portions of the line was to get a larger proportion of commanding officers among them; for the Prussians thought that with only one commanding officer to a very long line of skirmishers, there was more than one man could well do.

Colonel DOMVILLE said his opinion was that it was certainly better to have the line of skirmishers all under one commander, and they would necessarily have their due proportion of officers, whether the skirmishers be composed of one company or more.

Colonel WRIGHT said there was a pamphlet lying on the library table proposing a plan of skirmishing by sending out skirmishers right from the front, and thereby avoiding the delay involved in getting skirmishing companies out of the way of the advance.

Colonel CHESNEY said that was apparently merely theoretical; but he had not read the scheme proposed, and was not prepared to praise or condemn it.

Major GEARY said that in the pamphlet referred to by the lecturer, viz. the "Retrospect," of 1866, it appeared to be under consideration by the Prussians whether the escort for the artillery should not be formed of cavalry rather than of infantry, as heretofore. The writer, as far as he could recollect, said that when a battery commander gave the word "Trot," he looked down with dismay upon the anxious faces of his infantry escort. In reading this, he could not but be struck with the applicability of this situation to the commander of an English field battery, should he find himself in action called upon to trot, when he looked down upon the faces of his gun detachments. (Laughter and applause.) He remarked that the distinguishing feature of field artillery upon which the German author insisted should be its mobility. Doubtless our horse artillery was the finest in the world; but, after all, the field batteries formed our artillery of the line. The Prussian field artillery, he was informed, carried gunners on the axletree boxes, as well as on the limbers—a plan we had found to work well for so many years in India, and which system many of his brother officers agreed with him, he believed, in considering might well be adopted in our field batteries at the present time. He could not help feeling that to lecture to field artillery officers on tactics, so long as they did not possess the means of moving with their gun detachments beyond a walk, though interesting and improving to their minds, was likely to be practically as futile as teaching a bear to dance with his hind legs tied together. (Loud applause.)

Captain STRANGE said he was astonished to see at Chalons last year that the French artillery had no means of carrying its gunners except on the wagons. It was to such mistakes, combined with their imperfect tactics, such as advancing their artillery with or before skirmishers, and (to enable them to bring up gunners) getting their wagons into impossible positions, that the disastrous results of the campaign to the French were in some measure to be attributed. Besides this, the men were handicapped, so to speak, by having to carry their packs and carbines, and hampered to such a degree that he had seen them fall off the wagons. In reference to the study of tactics in the British army, he should like to ask Colonel Chesney whether he thought it was practicable to learn it until a law was passed permitting troops to go across country?

Colonel CHESNEY said other nations had the same difficulty to contend with; and for want of all the opportunities they would like for practice, they must be content to use discussions such as this, and instruct one another and the public mind, which was generally perfectly indifferent about such things until a time came when the subject was forced upon it by the course of events. Those who had studied the matter should strive to teach the country what was needed, and he would encourage them by referring to Belgium, where, chiefly by the efforts of one able and energetic man, the army of the country had been put upon an excellent footing. (Applause.)

Major-General SIR LINTORN SIMMONS said he had hesitated to speak on the subject of the very able lecture they had heard; but, encouraged by the discussion, and by the very favourable reception of his brother officer, Colonel Chesney, he would venture to say a few words. The term "column," unless explained, was, he thought, liable to be misunderstood. In the French and most other armies, a column, as generally formed, consisted of several lines of men behind each other, in all twenty or more deep; but the Prussian company column was a different thing altogether, more approximating to a line, and one, moreover, of extreme flexibility. The Prussian formation is in three ranks; the company column, therefore, is either six or twelve deep—more generally the former, when, if the third rank is skirmishing, as is the custom with the troops in immediate contact with the enemy, the column is in reality only four deep. In this formation, if he understood the matter, they might either deliver their fire, the two front ranks kneeling, or they might deploy into line, the movement being so simple and rapid as to be capable of being executed in close proximity to the enemy. In the Russian war the enemy used columns so deep that the men could not make use of their arms. As an instance he would mention the attack on Kars, when the Russian columns were completely crushed by the fire of musketry, aided by a very feeble artillery; their loss in killed and wounded, as since given to him by the Chief of the Russian Staff, was equal to the whole force opposed to them. He regarded the advance of a line of Prussian company columns as that of a very powerful though flexible line, and reminded the meeting that our own troops fought in line against the first Napoleon with admirable success. Now, however, when it has become necessary to give up the deep column formation, and deploy out of the range of rifled artillery at some 1400 or 1500 yds. from the enemy, he feared that an advance in line as practiced by us—which is perhaps the most difficult movement an army can be called upon to perform—will be found almost impossible of execution; whereas the Prussian line was so broken up into a number of short lines that the advance was much less difficult, and therefore he thought these small pliable columns were better than any other formation for an advance. (Hear, hear.) There was one thing, however, above all others that the present war was teaching us, and that was the necessity of a thorough education of the officers of the army. (Applause.) The Prussians were educated to the fullest extent in the knowledge necessary for the duties they had to perform. This education not only favoured the column formation, but even that of the smallest columns ever known—sometimes no more than the two Uhlans with which the records of the war had made them so familiar. (A laugh.) The Prussians knew the roads and the formation of the country better than the natives, and everyone possessed a general knowledge of what he had to do that had been found of immense service in this campaign. And not only were the officers well educated, but the officers taught the men, and he attributed very much of their success in this war to cultivation of intellect and the high order of instruction that all had received. (Applause).

Captain W. S. M. Wolfe said they had just been shown how the tactics of the Prussian infantry answered when it was successful, but he should like to know how the system would stand a repulse. It appeared to him that either of the formations displayed in the diagrams would, if compelled to retire, get into such a state of confusion that they could never be sufficiently reorganised to effect a creditable retreat. One had always heard in lectures and read in books how the Prussian infantry was to be taken into action, but one was never told how it was to be brought out again. (A laugh.) He begged to differ from the opinions expressed by some of the previous speakers as to the cause of the Prussian successes in this campaign, as he believed that the victory was simply the result of superior brute force. (Hear, hear.) He considered that our system of small battalions would have achieved the same results, and believed that the Prussian infantry would have been, in the event of a repulse, as thoroughly disorganised as they were at Langensalza in 1866.

Colonel Chesney said he must admit that the Prussian troops did get a good deal mixed up at Langensalza, as one square was composed of portions of five regiments, but that he did not think it was a fair case from which to judge the efficacy of the Prussian system.

Major-General Wilmot said nothing remained for him, as president of the meeting, but to return thanks to the lecturer for his valuable and interesting lecture, and to those who had taken part in the discussion. He was sure that everyone would agree with the remarks which had fallen from General Simmons as to the necessity of educating the army, and they were heartily glad that so able an officer had charge of the instruction of their young men. (Applause.) With regard to the remarks of Colonel Domville upon the selection of skirmishers, he might offer an opinion that, with the enemy in front of them, men would be more likely to pay attention to their officers than in mere practice, whether the skirmishers were all of one company or detailed from several. As regards the important point mentioned by Captain Wolfe, the formation was scarcely so peculiar as to render retreat more dangerous than usual. Whatever formation they might have been in before, if thoroughly routed they generally did the movement in one way, and that was in the best way they could. (A laugh.) He assured Colonel Chesney that the officers of the Royal Artillery appreciated his kindness in finding an opportunity, amid his numerous avocations, to come and give them the advantage of his careful study; and if at any future time he could give them another lecture, they would heartily rejoice. (Much applause.)

The proceedings then terminated.

THE FUTURE
ARMAMENT OF OUR FIELD ARTILLERY.

A PAPER READ AT THE R.A. INSTITUTION, WOOLWICH, JANUARY 16, 1871,

BY

LIEUTENANT C. JONES, R.A.,

CAPTAIN INSTRUCTOR, ROYAL GUN FACTORIES.

Colonel Phillpotts, R.H.A., occupied the chair, and introduced the lecturer to the meeting, stating that if at the conclusion anyone present wished to offer any remarks, the meeting would be happy to hear him.

Lieut. Jones then read the following paper:—

That the equipment of our field artillery is not in a satisfactory condition is allowed on all sides. The subject has, for some years past, attracted considerable attention, and we have lately been awakened to its importance by the total overthrow of the French artillery in the earlier battles of the present war, which overthrow has been very generally attributed to the inferiority of their artillery. The steps which have lately been taken by our authorities have gone far towards improving our position in this respect, as I hope to shew in the course of this paper. I do not propose to go into the whole question of equipment: it is not one which can be fairly dealt with in the space of one short lecture, even if I were in a position to do it justice. I wish to speak more particularly of the gun, and the question which I propose for discussion is this; "What are the *best* guns with which we can arm our field artillery?" The subject would appear to be one suitable for discussion in this Institution, and I hope to be able to bring forward some FACTS which may materially assist us in fairly discussing the matter, and possibly in arriving at a just conclusion.

Now the first question which suggests itself in connection with the armament of field artillery, is one which, though of the greatest importance, has long since been worn threadbare, I mean the question of the relative advantages of a breech-loading and a muzzle-loading gun.

It would be waste of time to recapitulate the well known arguments on both sides, suffice it to say that the balance of opinions seems for some time past to have been on the side of the muzzle-loader; every committee of artillery officers that has gone into the subject having reported strongly in its favour, and a gun of this description having been lately adopted for the armament of our batteries in India, and our horse artillery at home. We may therefore assume for our present purpose that the future field gun will be a muzzle-loader, and any who are inclined to dissent from this assumption will, I hope, favour us with their opinions during the discussion which is invited at the conclusion of this paper.

It being assumed then, for the present, that our field guns should be muzzle-loaders, the next question which presents itself is, "What is the most suitable metal of which to construct them?" Now until the present year the whole of our rifled field guns, with the exception of a few mountain guns required on an emergency for Bhootan, were made of wrought-iron or steel, or of a combination of both, but the mountain 7-prs. for Bhootan were improvised by rifling bronze 3-prs., and, for obvious local reasons, the gun lately adopted for India was made of bronze.

We have then four metals, or combinations of metals, to choose from, viz.:—

1. Steel alone.
2. Wrought-iron alone.
3. Wrought-iron lined with steel.
4. Bronze.

A great deal may no doubt be said in favour of each of the four. The question is however not what will make a *good* gun, but what will give us the very best gun with which to arm our batteries for home service. Let us see then what are the merits and demerits of each.

And 1st, as regards *steel alone.*—The only gun in the service which is made of this material alone is the 7-pr. mountain gun of 150 lbs. weight, commonly known as the Abyssinian gun. The charge of this piece is so small that it can be fired with perfect safety, but steel has not been introduced for larger natures on account of the undoubted liability of guns made of that material, unstrengthened with iron coils, to burst explosively when firing our ordinary service charges. This is greatly due to the want of uniformity exhibited by masses of steel, a defect which has driven even the celebrated Krupp to give up attempting to make heavy guns homogeneous in structure, and to adopt a system of building up, similar to that which has been in use in this country for years, though he still adheres to this treacherous metal for every portion of his guns.

The bursting of steel guns, to which I have referred, has happened in a number of instances; one of the most notable being the destruction of six of the Prussian 9-prs. in the campaign of 1866.

As it is a first essential that our guns should be perfectly safe, this material by itself must be discarded.

2nd. *Wrought-iron.*—The original Armstrong 6-pr. gun had a steel tube with coiled iron exterior, but the quality of the steel could not at that time be depended on, and the guns which were introduced into the service in 1858–9, were therefore made entirely of coiled wrought-iron, this construction being adhered to for the greater number of our B.L. guns.

We have therefore had the experience of about twelve years in judging of the suitability of wrought-iron as a material for field guns, and, as far as safety from rupture is concerned, it may be stated to be absolutely perfect, for no gun of this nature has ever burst explosively on service, or from fair usage.

However, for some time past, the plan of making the whole gun of wrought-iron has to a great extent been abandoned, for, though perfectly safe from any danger of bursting, the imperfections inherent in this material, and the great difficulty experienced in making the inner barrel sufficiently sound, satisfactorily to resist the corrosive action of the powder gas, have led to the adoption of steel for the core, coils of iron being shrunk on the outside to strengthen and support it. We have thus, as far as the inner barrel is concerned, reverted to Sir W. Armstrong's original construction, as exemplified in his first experimental gun (the 6-pr.) and we are enabled to do so from the improvement in the manufacture of steel since 1858. The advantages of the change are obvious: defects in the material which are of no consequence whatever in the outer portions of a gun, are very detrimental in the surface of the bore, where the gas acts directly on them and eats them out rapidly, particularly if they occur in rear of the trunnions. Steel therefore, being entirely free from such defects, has been adopted for the tubes of guns in order to obtain a hard and sound *surface* capable of resisting the friction of the shot and the action of the gas, but it is found even then that the tube is the more perishable portion of our heavy guns, and that it sometimes fails while the iron exterior remains intact, thus affording conclusive evidence of the superiority of good wrought-iron in resisting the dynamical strains to which a gun is subjected on firing, and the danger of trusting too much to the results obtained when specimens of metals are tested by statical strains only.

Wrought-iron lined with steel having then been proved, by a series of costly experiments unequalled in the annals of artillery, to be the best construction for our so-called iron guns of the service, let us now see what advantages or disadvantages would result from the substitution of bronze in its place for field guns.

The following are the principal points of comparison between the two metals, iron and bronze, viz.:—

1. As regards security from bursting.
2. Qualifications for the inner barrel, *i.e.* (*a*) hardness, (*b*) soundness, and (*c*) capability of resisting expansion.
3. Deterioration from exposure.
4. Economy.
5. Facility of manufacture.
6. Facility for changing the system, *i.e.* facility of remanufacture and value of old metal.

1. *As regards security from bursting.*—Bronze (unalloyed) will not burst, and it has been stated in a lecture in this Institution * that "no known metal, or combination of metals, gives such absolute security from bursting as bronze." That "an individual steel gun, *with or without wrought-iron coils,* may be stronger perhaps than an individual bronze gun of the same size; but take 1000 bronze guns, and you may be perfectly certain that not one will burst. It remains to be seen if the same is the case with steel guns, *with or without wrought-iron coils.*"

I beg leave to take exception to this statement, and more particularly that part of it which includes steel *tubes* covered with iron coils, and steel *guns* without iron coils, in one sweeping condemnation; for it cannot but be a condemnation of a gun to say that it is liable to burst on service.

As I have already stated, steel by itself is untrustworthy, we have ample evidence of the fact; but as regards wrought-iron coils the case is very different, and I maintain that, with the evidence of the last twelve years before us, there is not the shadow of reason for the slightest mistrust, either of guns built up entirely of iron coils, or of those constructed of this material over a lining of steel.

I am not now speaking of our heavy guns which are (as is well known) built up upon the last-mentioned method, and the wonderful endurance of which under enormous strains has gained them a world-wide celebrity. (See Table I.) But I am referring solely to guns of comparatively small calibre such as are used for field and siege purposes, and of which we have, during the last twelve years, introduced into the service nearly 4000; and I confidently affirm that it does not remain to be proved that guns built up on this system afford "*absolute security from bursting,*" as it has been amply proved already. This confidence is founded on the *fact* that no single instance can be referred to in which one of these guns has burst with fair usage, while numbers of them have fired thousands of rounds, and some are still, as far as the body of the gun is concerned, in a serviceable, or at worst, repairable condition, as the guns have not burst, but only the tube or some portion of them failed.

Table I.

Table of Endurance of Heavy Muzzle-Loading Rifled Guns.

12-inch	25 tons	1 gun fired	262 rounds.	9-inch	12 tons	1 gun fired	500 rounds.
		1 〃 〃	200 〃			1 〃 〃	402 〃
11 〃	25 〃	1 〃 〃	119 〃			1 〃 〃	307 〃
10 〃	18 〃	1 〃 〃	514 〃	8. 〃	9 〃	1 〃 〃	433 〃
		1 〃 〃	163 〃			1 〃 〃	408 〃
9 〃	12 〃	1 〃 〃	1107 〃	7 〃	6·5 〃	1 〃 〃	1729 〃
		1 〃 〃	1070 〃			1 〃 〃	1061 〃
		1 〃 〃	1049 〃			1 〃 〃	1009 〃
		1 〃 〃	945 〃			1 〃 〃	986 〃
		1 〃 〃	600 〃			1 〃 〃	908 〃
		1 〃 〃	500 〃			1 〃 〃	637 〃
		1 〃 〃	500 〃			1 〃 〃	636 〃

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* "Proceedings R.A. Institution," Vol. VI., p. 482.

TABLE II.

List of Built-up Guns which have fired a large number of Rounds.

		No.		No. of rounds.	
12-pr. guns, 8 cwt.	M.L.	52		2955	
		10	about	2000	
	B.L.	38		2864	
		337	With iron tube	1067	3264
			With steel tube	2197	
		7		4417	
		8		1085	
		18		1515	
		243		2629	
		125		2695	
		610		1038	
		631		2353	
		98	With coiled tube	1276	3237
			With forged tube	1961	
40-pr. guns, B.L., 32 and 35 cwt.		206		1615	
		54		5615	
		114		2512	
		174		1754	
		237		2461	
		363		1998	
		446		1176	
		459		3605	
		532		1116	
		585		2960	
		123		2059	

Moreover the Report of the Armstrong and Whitworth Committee is most conclusive on this point:—After the three 12-pr. (8 cwt.) guns, viz., the Armstrong M.L. and B.L. and the Whitworth M.L. guns, had each fired about 2800 rounds, the M.L.'s with 1 lb. 12 ozs. powder and 12 lb. shot, attempts were made to destroy them by firing greatly increased charges of both powder and shot, with the following result:—At the 42nd round the B.L. Armstrong gun split open, but did not burst; at the 92nd round the Whitworth steel gun *burst violently* into eleven pieces; while the M.L. Armstrong gun failed at the 60th round, one of the outer coils having cracked and fallen off *without flying into pieces.*

The Committee consequently reported "that guns fully satisfying all conditions of safety can be made with steel barrels strengthened with superimposed hoops of coiled wrought-iron, and that such guns give *premonitory signs of approaching rupture;* whereas guns composed entirely of steel are liable to *burst explosively* without giving the slightest warning to the gun detachment."

They also reported that all the guns exhibited a degree of "strength far surpassing the possible requirements of the service." It would be difficult to express in stronger terms confidence in our present service construction of guns.

I have laid great stress upon this point, not only because it is of vital importance that our gunners should have the most perfect confidence in their weapons, but also because of the statements which have been made, which, without drawing any distinction whatever between steel alone and coiled iron lined with steel, have tended to depreciate the safety of every rifled gun we have in the service, be it big or little; for, assuredly, a construction which is not capable of firing with safety charges of *two or three* pounds of powder, cannot for one moment be trusted to fire charges of 100 and 120 lbs.

2. The next point to be considered is the relative merit of steel and bronze as materials for the inner barrel of a gun, *i.e.* the capabilities of each to resist the wear caused by continued firing. It is not necessary to enter at length into this question. The staunchest advocates of bronze allow that it is deficient in hardness, the first quality which is required to resist the scoring action, due partly to the friction of the shot when passing through the bore, and still more to the heat of the combustion of the charge, and the rush of the gas over the shot.

Again, it is found practically impossible to produce wholesale perfectly homogeneous bronze castings, that is castings in which the quality of the metal is the same throughout, and which are quite free from tin-spots and porous patches. Mr. Abel, the Chemist to the War Department, in a minute dated August 28, 1869, accounts for this in the following way. He says :—

> "The difficulty attending the production of thoroughly sound and sufficiently uniform bronze castings arises out of the circumstance that a mixture of copper and tin, which is sufficiently soft to constitute a material for ordnance, does not consist simply of one definite alloy of copper and tin; and that, when these metals are melted together, there exists a great tendency to the formation of alloys of definite composition in which the proportion of *tin* is comparatively high, and which, from their tendency to separate from the liquid mixture in a crystalline form, give rise to the production of cavities or porous patches in the castings, on the one hand, and of spots or veins of comparatively hard metal on the other." . . . .

Now these porous patches may occur in the interior of the mass where they are of little consequence, or they may occur in the surface of the bore, in which case they are even more important than those defects which, as already stated, have led to the abandonment of wrought-iron for the inner barrel of guns, inasmuch as tin is much more fusible than iron, and is consequently more rapidly acted on by the heated gases. None of us, I think, have the slightest conception of the enormous heat generated by the combustion of even comparatively small charges of powder, but some idea can be formed of it from consideration of the following fact. If a 12-pr. B.L. gun be fired for fifty rounds very rapidly, say in ten minutes, it will be so much heated that the hand cannot be placed on the outside. Now the total time that the heated gas has been in contact with the bore of the gun amounts in fifty rounds to only $\frac{1}{4}$ of a second, as the time for each round is $\frac{1}{200}$th of a second. Therefore the gun has been cooling in the intervals between the rounds for 9 minutes 59$\frac{3}{4}$ seconds and heating for $\frac{1}{4}$ second, and still at the end of the series water will almost boil in it; it is needless to remark that the heat even of an oxyhydrogen blowpipe would be quite incapable of producing this result. Now the local heating at the seat of the shot is far greater in a rifled than in a S.B.

gun, on account of the greater weight of shot in proportion to the area acted on, and also the reduced windage. In fact the rush of gas over the shot may be said to approximate somewhat to the conditions of a blow-pipe flame, a large quantity of heat being concentrated on a small surface.

It can therefore be readily imagined that spots of such a fusible metal as tin will be at once eaten away when separated from the copper; this occurs even at proof, and holes are developed which rapidly increase with repeated firing and render the gun unserviceable. Out of the three guns used in the late trial at Aldershot two have been condemned from this cause, having only fired 242 rounds each, while another bronze gun has become unserviceable at Shoeburyness from a like reason, having fired about 700 rounds. I have gutta-percha impressions of these guns on the table and also those of iron and steel guns which have fired various numbers of rounds with which to compare them.

There can be no doubt then that steel is superior to bronze in hardness and soundness, and the advantages of these qualities for the inner barrel of a gun are obvious. We are not driven to resort to "an artifice" so as to "isolate" the cast-iron of the projectile from the bore, and we are not limited as regards the hardness of the studs; in fact ribbed shells can be fired without material injury, such shells being stronger, less liable to injury, and, I believe, more economical and simpler to manufacture than those having soft studs. Moreover double shell can be fired without any danger of injuring the gun, and the case shot is not so liable to damage the bore and grooves.

Again the soundness of the material, offering as it does no cavity or defect upon which the powder gas can lay hold, causes the erosion to be more uniform and gradual, while the higher melting point of the material has probably a tendency in the same direction.

But there is a third point in which steel is superior to bronze for the barrel of a gun, viz., in its greater power to resist expansion. In our service iron guns the weight of shot and charge of powder are only limited by their capability of consuming the powder effectively. But in guns made of a soft metal, like bronze, the expansion of the bore at the seat of the shot is so considerable that, however secure from bursting the gun may be, the charge (including shot) must be restricted within comparatively narrow limits, otherwise the efficiency of the gun becomes rapidly reduced by loss of velocity, and there is a tendency for the studs to override the grooves. The bronze gun referred to before which became unserviceable after about 700 rounds, had actually lost 100 ft. velocity in that number of rounds, fired with 9 lb. projectiles only, while the iron gun of the same weight was designed for, and is capable of, firing a 12 lb. projectile with a sufficient charge to give it an efficient velocity, and such a gun has actually fired nearly 3000 rounds, with a comparatively small loss of velocity, in the Armstrong and Whitworth experiments.

There are several other instances of the failure of bronze guns on account of the softness and expansibility of that material. In 1867 a

5-inch gun was rifled for some valuable experiments regarding the resistance of the air by Professor Bashforth, but was found to be totally unserviceable after a few rounds of $\frac{1}{8}$th charges, the studs on the projectiles having preferred to cut channels for themselves through the metal of the gun rather than follow the grooves prepared for them. Thus the gun was rapidly converted from a three groove into a multi-groove piece, and an iron gun had to be substituted in its place. It is worthy of remark that this same iron M.L. gun made the most accurate shooting of any gun ever fired at Shoeburyness, due probably to some fortunate suitability of the twist of rifling to the length and calibre of the projectiles.

Again the 20-pr. bronze howitzers lately under trial were assigned a charge of 2 lbs. or $\frac{1}{10}$th (that of our iron guns being $\frac{1}{6}$th) and one of them when fired with 2·5 lbs. or $\frac{1}{8}$th expanded in the chamber over $\frac{1}{20}$th of an inch, and the studs have consequently left the grooves and cut their way through the soft metal. Looking then at all these causes of failure, bronze, in its present state, cannot be considered suitable for the inner barrel of a rifled gun, and the only method of adapting it for this use appears to be by alloying it with some foreign matter, or by devising some means for procuring a sounder, harder and more homogeneous structure throughout the casting; at present we are unable to do so, and experiments carried out for this purpose in France, Belgium and America have I understand resulted only in failure, though the results obtained are not conclusive.

3. *Deterioration from exposure.*—Bronze is undoubtedly a less oxidizable metal than iron, and will consequently deteriorate less from exposure to the weather *uncared for.* However the care required to prevent any deterioration whatever of an iron gun from this cause is so very slight that it practically amounts to keeping the gun clean; and, so far from neglecting to clean the material in their charge, the only accusation on this score that is ever brought against our field artillerymen is that they are, if anything, inclined to polish too much. Be that as it may, the fact remains that iron is the material of which both our small-arms and our heavy guns are made, and they appear quite capable of sustaining, without perceptible deterioration, even greater rough usage and exposure than our field guns are likely to be called upon to endure.

4. *Economy.*—This is an argument which at the present time carries great weight, and there can be no question that bronze is cheaper than iron for guns, simply because it is worth more when old. But to what does this economy amount? It has been carefully ascertained how much it would cost, taking into consideration the value of the store of old bronze guns, to re-arm the whole of our field artillery, navy, reserve forces and reserves in store with iron and bronze guns respectively, and the saving in adopting bronze amounts to just £30,000, being considerably less than the cost of maintaining one battery on a war footing for one year. Is such an amount worthy of consideration in a question like this upon which the efficiency of our artillery in a great measure depends, and which, as we have seen lately, may greatly influence the fate of an army?

5. *Facility of manufacture.*—Considerable stress has been laid upon the greater simplicity of manufacturing bronze guns, and undoubtedly the operation of casting is simpler than that of coiling and forging. In practice however the casting of bronze is not found to be such a simple matter as it at first sight appears. On reference to the records of the Royal Gun Factories we find that even in its best days, the casting of sound bronze guns was accomplished with considerable difficulty, as, on an average, nearly *one* out of every *three* blocks had to be condemned even for smooth-bored pieces; while the fact that at the present time the rough casting for an 8 cwt. gun requires 24 cwt. of metal in order even to approximate to soundness, indicates that the process is not an extremely easy one, nor can it be said to have been brought to perfection. Moreover the difficulties which have always attended the casting of bronze guns even when new metal was used are greatly increased when it is attempted to utilise old gun-metal. Mr. Mallet points this out at page 86 of his work on the "Construction of Artillery," and, arguing from experiments, attributes the uncertainty of the result to the unequal oxidation of the two metals copper and tin, which leads to a change in the proportions of the metals present after each re-melting. This necessitates the addition of from 10 to 15 per cent. of new gun-metal to the old guns when being re-cast, as well as additional tin to compensate for the greater oxidation of that metal. So that before we can practically utilise the existing stock of old guns a considerable outlay has to be made for new metal to mix with them, and even then the result is not satisfactory.

On the other hand the whole of the difficulties which have at any time interfered with the rapid and certain production of good iron guns have, thanks to the genius and perseverance of our Civil Engineers and mechanicians, been entirely overcome, and we would appear to be throwing away the whole of the advantages we possess in this respect over other countries should we adopt an inferior metal for our guns on the ground that the manufacture is less complicated. We are now in possession of the whole of the appliances necessary for the manufacture of thoroughly sound and trustworthy iron guns from *two cwt.* up to *thirty-five tons*, and, with our existing plant and machinery we are in a position to turn out field guns of this material quite as rapidly as, if not more so than, those of bronze. Is there then any sufficient reason why we should fall back for home service upon a system which, though apparently simple, has never been really satisfactory, and which must consequently require experiments and time to bring it to perfection.

These remarks do not of course apply to India, where the method of building up iron guns is quite unknown, while that of casting in bronze, such as it is, has been familiar for ages to the Hindoos; neither are the materials for iron and steel guns obtainable in the country. As therefore it has been decided that India should make her own field guns and thus be independent of this country (and this can only be done by making them of bronze), it would appear advisable to try if it be possible to make good and trustworthy guns of this material, and to experiment with this view. For home service, on the other hand, we have guns which, however perfect bronze may become, cannot with our present knowledge be improved upon, and which would consequently appear to answer the question, "What are the best guns with which we can arm our field artillery?" The gun they have now is a very good one, but it is not the best we can give them, and the same argument applies in this case as that which has led to the decision to re-arm our infantry with the Martini-Henry rifle, although we are well aware that the Snider-Enfield is superior to every rifle in use on the continent. When this re-armament is carried out the infantry will possess the best weapon the country can produce; whilst our ships and garrison artillery are already furnished with the best heavy guns in existence. Should not then our superb field artillery be armed with a weapon worthy of them?

6. *Facility for changing the system of armament, &c.*—This, the last point of comparison between the two metals, is altogether in favour of bronze. That material is always worth as much in the form of old metal as it cost when new, and can, with the addition of a proportion of fresh metal, be re-cast. Consequently, if it should appear desirable at any future time again to re-model our field guns, we could do so with greater facility and less cost in the case of bronze than in the case of iron. It is only reasonable to suppose that, had our present B.L. guns been bronze, the change to muzzle-loaders would have been carried out much more rapidly, as, no doubt, the heavy sacrifice entailed by the supersession of our present guns has delayed a step which the majority of us have been anxiously looking for. But after all it is only a matter of money, and the question still stands, whether the wealthiest nation in Europe is prepared to sacrifice one iota of efficiency for the sake of a few thousand pounds—a trifle compared to the total cost of her army and navy?

We have now discussed the various points of comparison between bronze and iron combined with steel as materials for field guns, let us recapitulate the results arrived at.

(1) As regards security from bursting, both are perfectly trustworthy, and there is nothing to choose between them.

(2) As regards qualifications for an inner barrel, steel is undoubtedly greatly superior to sound bronze, if we could get it,—much more therefore to the unsound stuff that is now produced.

(3) A bronze gun will deteriorate less from exposure *uncared for*, but the iron M.L. gun requires simply to be kept clean.

(4) Bronze is cheaper than iron, taking into consideration the value of the old metal.

(5) Bronze guns, if we could make them sound and serviceable, would be simpler to manufacture than the compound guns.

(6) Bronze affords greater facilities for a change of armament if deemed advisable.

Balancing all the points which bear on the one side or the other it is evident that the decision to stop the further manufacture of bronze guns is necessitated by the results arrived at up to the present time, while in the meantime experiments are carried out with a view to perfect the manufacture of bronze by alloying it with phosphorus or iron, or by casting it after some new method, so as to meet the question of the supply of guns for India.

For the present however the best guns we can make are muzzle-loaders built up of wrought-iron and steel, and, assuming that this is to be the construction of our future field guns, what data have we for determining the weight of projectile to be thrown, the consequent weight and calibre of the gun, and the weight of draught and total equipment, having due regard to that first essential "*mobility*." And first, as regards the weight of the projectile; this, it would appear, taken together with the number of rounds which it is considered necessary to carry, should regulate the whole equipment. Now it will probably be allowed that the heavier the projectile the better, provided it can be thrown with a sufficient velocity without injury to the gun and carriage, and also, that a sufficient number of them can be carried in the limber and wagon to prevent the possibility of the supply failing in action. This statement scarcely admits of question, but, in case any person should entertain doubts on the subject, it is only necessary to point out that the advantages of weight of metal have been so apparent that, in every war which has taken place during this century, and which has lasted a sufficient time to enable a new gun to be introduced, the calibre of the guns in use at the termination of hostilities has been greater than that of the guns taken into the field at the commencement. For instance; the artillery at the beginning of the Peninsular War were armed with 6-pr. guns of 6 cwt. and 5½-inch howitzers of 4¾ cwt., while at the end they had 9-pr. guns of 13½ cwt., and a few years afterwards, acting on the experience of this campaign, the 12-pr. and 24-pr. howitzers, of 6 and 12½ cwt., were introduced; the latter, with the 9-pr. of 13½ cwt., being the heaviest pieces with which our field batteries have ever been armed.

Again in the Crimea the siege train consisted at first of 24-prs., 32-prs., and 8-inch guns, which were gradually reinforced with 10-inch guns and 68-prs., as the value of the heavier natures became more and more apparent. The important part played by the two 18-prs. in the defeat of the Russians at Inkermann is matter of history, and, if Dr. Russell's report is to be believed, the fallen Emperor himself attributed the overthrow of his artillery at the battle of Sedan to the greater "range, precision, and *weight*" of the Prussian guns, alluding no doubt to their field battery guns throwing 15 lb. projectiles. I think we may safely say then that the heavier the projectile we can throw the better, with the provisos before stated.

Now what limits this weight? It is limited;

1st. By the weight of the gun necessary to fire with perfect safety a charge sufficient to give the shot the required velocity.

2nd. By the total weight which can be allowed to the equipment.

And 3rdly. By the number of rounds considered absolutely necessary to be taken into action with the gun.

These limitations are so intimately connected with and dependent upon one another that it is almost impossible to discuss one of them without introducing the others. I have therefore compiled a table (see Table III.) shewing the weight, and some other particulars, of the equipment of horse artillery and field battery guns which are (or have been) in use in this, and some continental armies; and, taking this table as our basis, I shall endeavour to show what are the most efficient guns we can now produce.

TABLE III.

Table of Field Battery and Horse Artillery Equipment.

Nature of Gun.	Charge.	Weight of shot.	Initial velocity.	Weight of gun.	Weight of gun carriage.	Weight of limber, complete.	Weight of draught.	Weight of wagon, complete.	Number of rounds with gun.	Number of rounds in wagon.	Total number of rounds.	Remarks.
	lbs.	lbs.	ft. per sec.	cwt.	cwt.	cwt.	cwt.	cwt.				
6-pr. M.L. smooth-bore (bronze)	1·5	6	1485	6	10·5	14	30·5	37	46	148	194	
9-pr. M.L. smooth-bore (bronze)	2·5	9	1614	13·5	12	14·5	40	38	32	96	128	
12-pr. howitzer (bronze) ...	1·25	9	1145	6·5	11·25	14·25	31·5	35·5	36	100	136	
24-pr. howitzer (bronze) ...	2·5	17·5	1222	12·5	14	14·75	41·75	39·25	24	60	84	
9-pr. B.L. rifled gun (iron and steel)	1·125	9	1058	6·5	10·5	14·5	31·5	40·25	30	90	120	
12-pr. B.L. rifled gun (iron and steel)	1·5	12	1239	8	12·25	16·25	37	43	32	90	122	
4-pr. Prussian B.L.R. (steel)	1·1	8·96	1184	5·4	9·35	16·75	30·5	43	49	108	157	
6-pr. Prussian B.L.R. (steel)	1·8	14·8	—	8·37	11·12	16·25	35·64	43·75	30	93	123	
4-pr. French M.L.R. (bronze)	1·21	9	1066	6·5	8·42	10·1	25·76	26·7	44	112	156	
9-pr. Indian M.L.R. (bronze)	1·75	9	1400	8	11	14·5	33·5	33·5	34	90	124	
12-pr. M.L. rifled gun (iron and steel)	2	12	1300	8	11	14·5	33·5	33·5	28	72	100	Proposed equipment.
16-pr. M.L. rifled gun (iron and steel)	3	16	1350	12	11·25	16·75	40	40	28	84	112	

[This table has been compiled from Lieut.-Colonel Millar's Equipment of Artillery, the Report of the Committee on the Bronze Gun for India, Colonel Maxwell's article on the same, and other sources.]

And first as regards the horse artillery. The bronze gun lately adopted for both horse artillery and field batteries in India has a calibre of 3 ins. and fires a projectile 9 lbs. in weight, while the iron gun of the same weight and calibre (as previously stated) will fire efficiently a 12-pr. shell, having been designed in 1867 as a 12-pr. It has been decided to give the horse artillery an 8 cwt. gun of 3 in. calibre: let us see then whether it be possible also to give them 12-pr. ammunition, and what advantages would be gained thereby. Of course we must not increase the weight of the equipment above what it is at present, viz., 33½ cwt., neither must we put too much strain upon our carriage.

124 rounds of 9-pr. ammunition are now carried in the limber and wagon, and we can only carry about 100 of 12-pr. without raising the weight. Taking into consideration the advantages of the increased weight of projectile, can this number of rounds (100) be considered sufficient for the expenditure in modern warfare?

Unfortunately we have no reliable information of the expenditure of ammunition, or of any artillery details, in the campaign now going on, as until lately we have had no artillery officers attached to either army, as was the case in 1866 in Bohemia, and now that we have sent some able men, their hands seem tied, and those who are not made prisoners tell us little or nothing of scientific interest. We can therefore only take the war of 1866 as our guide, and extract the information required for our purpose from Colonel Reilly's valuable report.

Now this report shews that on one occasion only, at the battle of Pressburg, did a battery expend more than 100 rounds per gun, viz., 110 rounds; and in the same action two other batteries fired 100 each per gun.

At the four engagements of Nachod, Skalitz, Schweinschädel and Gradlitz, which preceded the decisive battle of Kœniggratz, no single gun of the artillery of the Prussian 5th Corps fired more than 89 rounds altogether, that is, an average of about 22 rounds per action. Having been thus engaged four times, this corps was, as might be expected, put into the reserves at Kœniggratz and did not, I believe, fire a shot.

Again, in the last-mentioned general action of about ten hours' duration, Colonel Reilly states that the greater number of rounds fired by any individual battery was about 81 per gun; the next greatest expenditure of a battery was 37 rounds per gun, while the rest of the artillery engaged fired considerably less. He also informs us that the average expenditure of the whole of the artillery engaged throughout the campaign was only 11 rounds per gun per action!

Remembering then that we would be able, in the interval between one action and another, to refill our limber and wagon from the spare wagons of the second line and the reserves, 100 rounds appear sufficient to be carried with the gun, as they would more than cover the average expenditure in a general action such as that of Kœniggratz. As then we can only carry 100 rounds of 12-pr. ammunition as compared with 124 rounds of 9-pr., and keep the weight of our equipment within the required limits, what advantages would we gain, by the substitution of the heavier shell, to compensate for the reduction in number?

Firstly the heavy projectile, when moving even with a much lower velocity than the light one, will have more work stored up in it and will consequently have greater penetration and destructive effect when fired against houses, field works, or artillery carriages, for, firing against troops, though the principal work of field guns, is not all that they may be required to perform.

Again the segment and shrapnel shell will contain a larger number of pieces or bullets, in the proportion of 56 to 42 or $\frac{1}{3}$rd more, not taking into consideration the greater number of fragments from the body of the shell.

But the most important point is that the projectile retains its velocity for a longer time. The 9-pr. projectile, fired with special powder, has an initial velocity of rather over 1400 ft., and the 12-pr. fired with the same charge of 1 lb. 12 ozs. would start with a velocity of about 1250 ft. a second; if the charge be increased to $\frac{1}{6}$th, or 2 lbs., the velocity would then be about 1300 ft. a second. Now the diameter of both being the same, the lighter shot will lose its velocity, from the resistance of the air, much more rapidly than the heavy one, so that the respective velocities at 1000 and 2000 yds. would be in round numbers those shewn in the following table :—

TABLE IV.

Table shewing the Velocities of 9-pr. and 12-pr. Projectiles.

Charge.	Weight of shell.	Velocity at		
		Muzzle.	1000 yds.	2000 yds.
lbs. 1·75	lbs. 9	1400	1000	840
1·75	12	1250	980	860
2	12	1300	1010	880

This shews that, supposing the two projectiles to be fired with the same charge $1\frac{3}{4}$ lbs., the 9 lb. one will start with a much higher velocity (150 ft. more) than the 12 lb. one, but that its velocity falls off much more rapidly, so that at 1000 yds. range the difference is only 20 ft. and at 2000 the tables are turned and the 12 lb. projectile will be moving faster than the 9 lb. one.

Practically both shot will have sufficient velocity to be effective at short ranges, but the 12-pr. will actually surpass the 9-pr. at between 1400 and 1500 yds., and will consequently be far superior to it at all ranges above that, and, the longer the range, the more will this superiority tell. If the charge with which the 12 lb. projectile is fired be increased to 2 lbs. or $\frac{1}{6}$th, you see that it will actually have a higher velocity than the 9 lb. one even at 1000 yds., and therefore be very much more effective at all ranges above that distance.

Now, in these days of accurate B.L. small-arms, will it be advisable, not to say possible, to maintain artillery in action at ranges much under 1000 yds., with any probability of being able to bring it out again? I think we may safely say that the ordinary fighting ranges of artillery commence at about 1000 yds., and it appears that at these ranges the larger projectile will not only have the advantage of a larger number of bullets and splinters, but that this larger number will be moving at a higher velocity, so that the probability of striking the object aimed at will be greatly increased. This is when used as a shell. If used as a shot against guns, houses, &c. &c., the superiority is even more marked, as the energy or work stored up in a shot is represented by the mass multiplied by the *square* of the velocity. In fact all the advantages claimed, and established, for the M.L. 9-pr. gun over our present service 9-pr. and 12-pr. B.L. guns, apply with equal force to this same gun used as a 12-pr. instead of a 9-pr.

The drift of the whole argument is this. A 3 in. calibre cannot be equally suitable for firing a 9 lb. and a 12 lb. shot, and, as it appears that better results can be obtained from this calibre with the heavier projectile, it follows that to fire the lighter one with perfect efficiency its diameter should be reduced. I am now only speaking of the advantage gained in velocity. There are undoubtedly practical advantages to be gained by having one gun for both horse artillery and light field batteries, but it does not necessarily follow that the same ammunition should be fired, as, on an emergency, the different ammunitions would be interchangeable.

I may mention here that it is very doubtful whether the *bronze* 3-inch gun can be made into an efficient 12-pr., on account of the expansion of the bore with the heavy charge, and the consequent danger of the studs leaving the grooves. This is an argument which applies as much to sound as to unsound pure bronze, and bears against the introduction of that material, for home service, and in favour of the compound iron and steel gun.

It may be objected that the carriage adopted for the 9-pr. gun will not be strong enough to stand the additional strain thrown on it by the extra charge, and that the recoil will be excessive. Now the endurance of the carriage can only be determined by actual experiment, but, considering the test to which it was subjected by Major-General Eardley-Wilmot's Committee, I cannot think that there need be any fear of its failing. The Committee report that 3026 rounds were fired from one carriage, and 3746 from another, and that "during the firing of 500 rounds with $\frac{1}{5}$th and $\frac{1}{6}$th charges, the (latter) carriage was lashed to posts in front of the platform, so as entirely to stop recoil. The only injuries caused were—one spoke cracked, and the right axle-tree band broken through at angle."

This brings us to the question of recoil, which would undoubtedly be considerable if unrestrained. As however we have not been deterred from introducing into the service our enormous heavy guns by the difficulty of restraining their recoil, but have worked out the problem so satisfactorily that we can now safely bring up a 25-ton gun firing 70 lbs. of powder in the space of two or three feet, surely, if it be an object to do so, some simple means can be devised whereby the recoil of a field gun may be checked without damage to the carriage! Whether this be possible or not, a matter of two or three feet more recoil would scarcely seem a sufficient argument against our increasing the power of our guns in the manner proposed, for the arguments in favour of a 12 lb. projectile would appear to be irresistible, provided that it be allowed that 100 rounds are sufficient for horse artillery to carry in their limber and wagon. If, on the other hand, it be considered that the evidence of the one campaign in Bohemia is not sufficient to justify us in reducing the number of rounds below what it at present is, it would seem from the foregoing table of velocities that the 9-pr. gun should have a calibre of less than 3 ins.

The field battery gun next claims our attention.

As it has been considered advisable to give the horse artillery an 8 cwt. gun, and the advantages of increased calibre and weight of projectile being well recognised, we should undoubtedly give our ordinary batteries as heavy a piece as is consistent with celerity of movement. And here I would point out that the weight of the equipment of our present B.L. rifled 12-pr. is considerably less than that of the smoothbore gun and howitzer which it was intended to replace, viz., the 9-pr. gun and 24-pr. howitzer, though I am unable to discover any complaints of the weight of these guns and their equipments being excessive. Moreover by the introduction of rifled guns we have up to the present time lost entirely one important projectile, viz., an efficient *common shell;* in fact we have nothing to take the place of the old 24-pr. howitzer in this respect. Seeing then this want, can we now give our batteries a rifled gun of sufficient calibre to fire an efficient common shell, and still keep the weight of draught within that which has previously been allowed to our field battery carriages?

A gun has lately been made, weighing 12 cwt., which will fire a 16 lb. shell with a charge of 3 lbs. of powder, the calibre of the gun being 3·6 ins. A common shell of this calibre and weight, and of the proper length for good shooting, will contain a bursting charge of over 1¼ lb., that of the 24-pr. common shell being only 13 ozs. The shrapnel shell will contain 134 bullets, that for the B.L. 12-pr. containing 56. Both these projectiles, moving with the high velocity which it is proposed to give them (1350 ft.), will be much more efficient and destructive than any missiles taken into the field by any artillery at the present time. The question is can we carry a sufficient number of them? Now the average weight of one round will be 19 lbs., so that six rounds will weigh about 1 cwt. The iron carriages now used can be made much lighter than the former pattern made of wood, which has the double advantage of both causing the carriage to be less injured by the shock of discharge, and also of enabling us to carry the reduced weight in the shape of more ammunition.

Now the carriage designed for the 16-pr. gun is very little heavier than that for the 9-pr. of 8 cwt., and will probably be about 11¼ cwt. The limber is the same weight 10¼ cwt., and, assuming that we can allow the same weight to our equipment as that of the old 9-pr. S.B. gun, viz. 40 cwt., we have 6½ cwt. to devote to stores and ammunition.

The stores for the 9-pr. M.L. weigh about 1 cwt., and therefore 1¾ cwt. would appear to be sufficient to allow for the 16-pr. This leaves 4¾ cwt., which represents 28 rounds of ammunition, 12 in each limber box and 2 in each axle-tree box. Similarly, the wagon body and limber when empty weigh 23¼ cwt.: the stores probably not more than 2½ cwt., giving 14¼ cwt. for ammunition, which represents 84 rounds, or 14 rounds in each box. We should thus carry with the gun and wagon 112 rounds while the draught of each would be about 40 cwt., or 3 cwt. less than that of the present 12-pr. B.L. wagon: this of course only includes the stores which are allowed for in the statement of the weights of the 9-pr. M.L.R. equipment.

The recoil of this 16-pr. gun will probably be as great, if not greater, than that of an 8 cwt. 12-pr. fired with a charge of 2 lbs., and any objection which applies to one, will apply with equal force to the other. But, as has been before stated, the question of recoil appears to be one which ought to be readily overcome by the mechanical skill of the present age.

And now, gentlemen, I have reached the limit of what I proposed to say, and also, I greatly fear, of your patience. I have endeavoured, as stated at the outset, to bring before you some facts bearing upon the question under discussion, and also to draw from them only such conclusions as they would appear undoubtedly to warrant, avoiding, as far as possible, the introduction of any new theories or hobbies of my own.

The armament of our field artillery is a question which admits of such diversity of opinion, and is moreover one of such importance, that it should be approached with an unbiassed mind, and be discussed without "fear, favour, or affection." If to-day I have been fortunate enough to bring forward even one piece of information which was not previously known to all of you, and which may in any way assist in the solution of the question, I shall feel amply rewarded for my labour.

At the conclusion of the reading, which was warmly applauded,

Colonel Phillpotts again invited discussion.

Lieut.-Colonel Miller, V.C., R.A., asked the lecturer if the size as well as the weight of the projectiles for the 16-pr. shell gun had been considered in estimating the number of rounds to be carried?

Lieut. Jones replied that this had been considered. The ammunition boxes for the 16-pr. gun are, he understood, the same size as those for the 9-pr.

Major-General Lefroy, C.B., R.A., asked whether the statement made by the lecturer as to one in every three bronze guns being spoiled in the casting was borne out by the books of the Department of a date prior to 1815? There were comparatively few guns cast after that for many years, and the art seems to have been in some measure lost, for there were many failures when casting was resumed at the time of the Russian war, as there was said to be now.

Lieut. Jones.—I cannot fix the date, but it was at the end of last century.

Colonel **Phillpotts**.—And also in the days of Mr. Schalch and Mr. King.

Major-General **Lefroy** said it seemed remarkable, considering the tenor of the lecture they had heard, that in the present war nearly all the field guns in use, both by the French and the Prussians, were of bronze, and also that the Admiralty are constantly making very large bronze castings for ships' screws, without failure. When he was at Spandau, in 1869, the Prussians were re-casting their old smooth-bore bronze guns into new rifled guns, being dissatisfied with steel. He should not like to have it said that other nations could make bronze guns, and that we could not.

Captain **Strange**, R.A., said, with regard to the Prussian use of bronze, their guns being breech-loaders, they got over the difficulty as to the rush of the gas over the shot, by covering the projectile with a lead coating which fitted the grooves and allowed no space for the escape of gas. He had noticed, however, in the section of the horse artillery gun, that the guttering was not so much in the grooves as in the lands, and it surprised one to hear that in other cases the failure had been in the grooves, because the stud resting in the grooves prevents a rush of gas between them and the surface of the groove. Then as to equipment. In the short campaign which the lecturer had quoted on the subject of proportions of ammunition, the artillery arm of the service had been terribly abused, but the fact was that it had not been brought sufficiently into action. So the Prussian "Retrospect" stated; and this ought to be taken into consideration before the experience gained in that war was taken as a datum to show the number of rounds it was necessary to take into action. And while on the subject of equipment, he submitted for consideration whether we do not now carry with our field guns a good deal of useless rubbish on the gun and its limber which ought to be left behind with the wagons—(laughter)—soldiers' valises, knapsacks, camp-kettles, and twenty-four carbines—he need not go on. (Laughter and applause.) Bell tents might be exchanged for "*tente d'abri*." He might answer the question of Colonel Miller as to the packing of the limber boxes, by saying that the 12-pr. shell for the 9-pr. gun occupied no more space on the bottom of the box, being longer, but of the same diameter as the 9-pr. projectile. They only formed a higher wall round their cartouch-box. (Applause.) Captain Strange also asked the lecturer whether it had ever been thought desirable to line bronze guns with steel or wrought-iron, on the Palliser principle?

Captain C. **Orde Browne**, R.A., wished to remind the lecturer that the number of rounds each gun might be expected to have *available for firing in action* bore only a certain proportion to the number of shot or shell it was necessary to carry; because while it was desirable to be prepared for every emergency with case shot, common shell, and shrapnel, the particular circumstances in which the gun is placed probably render one description only suitable. Thus it is not to be expected (unless under exceptional circumstances) that a gun would be called upon to expend the whole of its ammunition of all kinds. For instance, case shot cannot be used at long ranges, and even before the supply of ammunition is reduced to this the gun would have been firing common shell, which he would remind his hearers would form a very poor substitute for shrapnel for use against troops. (Hear, hear.)

Lieut. Jones, in reply, said that Captain Strange's observations as to the deterioration of the bronze guns having, according to his experience, been caused by scoring in the *lands* rather than in the *grooves*, was due to the fact that the windage over the body of the projectile is much greater than that over the studs. Therefore the gas, rushing over the shot, eats out the defective spots in the lands, while the studs prevent this occurring to the same extent in the grooves. This difficulty would be avoided if the metal could be cast sound, but, even if sound, the defect of expansion remained, causing a tendency of the studs to leave the grooves, as happened in the 20-pr. howitzer, a plaster cast of which he exhibited. The wear of the driving side of the grooves near the seat of the charge is also shewn to be considerable by the gutta-percha impressions of sound bronze guns laid on the table. On this account he considered that bronze, however sound, was inferior to steel for an inner barrel. Then, as to lining bronze with iron or steel; the subject had certainly been considered, but the proposition was really impracticable, owing to the variation in the expansion of the different metals when subjected to heat, which would soon render the tube loose and the gun unserviceable. (Hear, hear.) With regard to the proportion of ammunition to be carried, he must not be understood as attempting to lay down any law respecting the number of rounds necessary to be carried. He submitted the statements in his paper in order that those who were better capable of judging might recognise the advantages of the heavy projectile.

Colonel Milward, C.B., R.A., said a good reason why the guttering was more over the lands than in the grooves was that the windage was much greater over the lands than over the studs. The practice now going on proved more clearly every day that the windage allowed over the studs of the 9-pr. muzzle-loading ammunition was too small, as the tendency of the projectile to jam was constantly experienced.

Colonel Phillpotts.—This applies equally to the iron gun.

Colonel Milward.—I spoke of either the steel or bronze.

Lieut. Jones.—But was not the windage fixed in order to save the bronze gun?

Colonel Milward.—Certainly; that was so.

Colonel Phillpotts said he differed from Captain Strange in one remark, and that was his proposed abolition of bell tents and camp-kettles. (Laughter.) He quite agreed with him as to the inutility of carrying twenty-four carbines, and the desirability of reducing the soldiers' kit, but rather than discontinue the use of bell tents and have recourse to *tente d'abri*, he would do even more if necessary to save the men from exposure on service. (Hear, hear.) It would take rather a large *tente d'abri* to cover a tall soldier like Captain Strange. (Laughter and applause.)

Major-General Lefroy said, as a reduction of the equipment had been referred to, he would call attention to one way of getting rid of some of the surplus weight. They now carried their spare wheels on the wagon, which was about as reasonable as carrying their spare horses. (Laughter.) Each of these wheels represented nearly 2 cwt., which they had to carry because no one had been ingenious enough to make them run after the guns, with the spare horses to drag them. (Hear, hear, and a laugh.) There was no reason why this should not be done, and the best means of effecting it was very well worthy of the attention of officers.

Lieut. LOGAN, R.A., said another plan, not of reducing weight, but of saving the shaft horse by the introduction of some kind of break, was desirable. The shaft horse at present was unduly worked in comparison with the rest of the team, and now that axle-tree seats were likely to be allowed, the break could be easily worked, which would not only save the shaft horse in halting and going down hill, but would avoid frequent damage to the harness, as also the delay caused by having to apply the drag-shoe.

Colonel PHILLPOTTS said that about twelve months ago a self-acting break was proposed by a Plymouth man, but he supposed it was thought too complicated for gun-carriages.

Lieut. H. B. R. HARVEY, R.A., asked if General Lefroy could give them any information as to the proportion of failures in the manufacture of bronze guns for the Prussian army, and also the failures in the bronze castings of screws for vessels for the Admiralty, to which he had referred.

Major-General LEFROY replied that he was unable to give any facts on the subject, except that when he was in the arsenal at Spandau he had a great deal of conversation on the subject of bronze guns, and heard nothing of failures or difficulties of manufacture.

Lieut. HARVEY.—And were there no cases of failure in the bronze castings for the Admiralty ?

Major-General LEFROY.—I cannot say.

Colonel YOUNGHUSBAND, R.A., said he thought it was a mistake to say that the service guns in the Prussian army were of bronze. He should say, on the contrary, that all the field guns now in use by the Prussians were of steel. He believed that they had certainly decided upon adopting bronze, but the whole of their field batteries were still composed of steel guns.

Major-General LEFROY said, if that were so, what had the Prussians done with the bronze guns which they were casting in large numbers in 1869, for the gun department of the arsenal at Spandau was full of them ?*

Colonel YOUNGHUSBAND said his belief was that the Prussians had

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* Extract from a letter of Major-General Beauchamp Walker, dated 28th January, 1871. Communicated by Major-General Lefroy :—"I saw a battery of bronze 6-pr. guns (14 lb. shot) yesterday parked near Viroflag. I think that there were 600 new bronze field guns ready before the campaign. The number is just as likely to have been 900. If I see anybody who can tell me how many batteries were brought with the army, I will write again. The one I saw yesterday belongs to the 11th Army Corps." In a subsequent letter, dated 20th February, General Walker said :—"One bronze field battery has been with the 3rd Army from the commencement of the war, and four or five more have come at different times, so that there are now 30 or 40 of these guns with this army." See also the "Times" military correspondence, February 20, 1871, for evidence to the same effect.

made no bronze field guns except for the purposes of experiment. When he was at Spandau, in 1869, he saw none but those made for experimental purposes.

Colonel Domville, R.A., asked whether this apparent discrepancy of evidence did not arise from a difference of date; one officer speaking of 1869 and the other of 1870. (Hear, hear.)

The discussion being ended—

Colonel Phillpotts, in the name of the meeting, returned thanks to Lieut. Jones for his lecture, the meeting endorsing the sentiment by loud applause.

THE MERITS OF A

LARGE BORE AND SMALL BORE CONTRASTED,

WITH REFERENCE TO

RIFLED ARTILLERY AND SMALL-ARMS.

A LECTURE DELIVERED AT THE R.A. INSTITUTION, WOOLWICH, FEB. 17, 1871,

BY

LIEUTENANT J. SLADEN, R.A.,

ASSISTANT INSTRUCTOR, ROYAL LABORATORY.

MAJOR-GENERAL J. H. LEFROY, C.B., R.A. IN THE CHAIR.

MR. CHAIRMAN AND GENTLEMEN :—The subject which it is proposed to consider to-day is one which is calculated to provoke a good deal of discussion; and the opinions of individual officers on these controverted points are so many and so numerous, that I cannot hope that everything I bring forward for your consideration will meet with the approbation of all parties; but I do hope that the discussion of these matters by officers who are most concerned in them, will have practically the good effect of merging our different notions into one harmonious whole, which is, I believe intended by us *all;* viz., the good of the service.

In order to obtain the best results with any gun or rifle, the *diameter* of the bore must bear a certain proportion to the *weight* of the projectile intended to be carried on service, due regard being paid to the mobility and efficiency of the various parts of the equipment; and the power of the gun depends considerably upon the selection of the *best* proportions.

It is necessary to fix upon one of these elements as a standard to judge by, *e.g.*, either the diameter or weight. The weight of the projectile seems to be the most practical standard to start from, since upon that, mainly depends the number of rounds that can be carried into action.

This will then be considered first with regard to small-arms. For range, penetration and accuracy the heaviest bullet should be used consistent with the requisite number of rounds of ammunition which the soldier can carry into action. The weight of the bullet in the Martini-Henry, Snider, and the needle gun is about 480 grs.; and this is about the heaviest that can be carried with efficiency. Sixty rounds of Boxer ammunition Pattern VIII, for the Snider-Enfield packed as for service weigh 6 lbs. 4 ozs. 7 drs., while sixty rounds of the Boxer Henry cartridge for the Martini-Henry rifle weigh 6 lbs. 10 ozs. 10 drs. Any increase of weight beyond this, would be likely seriously to affect the carrying of a sufficient number of rounds into action.

The question now becomes; what diameter of bore should be given to a rifle, so as to produce the greatest effect with this 480 gr. bullet? The Committee on Small-arms, from experiments extending over some considerable period of time have answered the question practically and conclusively—viz., ·45 in. for the Martini-Henry, rather than ·5 or ·577 in., which latter is the diameter of the bore of the Snider-Enfield.

What has been the result? Simply this; increased range, greater accuracy, flatter trajectory, and greater penetration, besides other improvements not connected with the subject matter in hand. Thus, the Martini-Henry is a much more powerful rifle than the Snider although firing the *same weight* of bullet. In the Snider, we have an instance of adapting a certain weight of bullet to suit a rifle already made; while in the Martini-Henry the rifle was made to suit the weight of bullet. It is evident in the case of the Snider, that power is sacrificed, on account of having such a large bore.

The same principle applies to guns—a gun may be made with too large a bore to project effectively a certain weight of projectile.

Now let us consider a method of determining the comparative "*power*" of different guns with reference to the weight of projectile and diameter of bore. This "power" means (other things being equal), greater accuracy, flatter trajectory, greater penetration and greater range,—or it may be stated in other words to be the power which a gun has of hurling a projectile through the air, so as to lose the least velocity over a given range.

This must not be confounded with the "energy" of the projectile, *i.e.*, the work stored up in it at any given time.

In Table I. a comparison is made of the power of different rifles and guns (supposing them to have the same muzzle velocity) *i.e.*, the power which the projectiles they throw have to overcome the resistance of the air.

I need hardly remind you that the velocity of a projectile is continually being reduced by the resistance which the air opposes to its motion—whence it follows that the *less* resistance which the air opposes to a projectile, the *greater* will be its remaining velocity, and consequently it will travel faster and range farther. Just on the same principle if two trains of the same weight are travelling at the same rate, and steam is shut off both at the same instant, and to one the break is applied, so as to cause resistance to motion, this one comes to rest sooner than the other, and travels over a shorter distance. This by the way, serves to illustrate the *importance* of determining experimentally the actual resistance of the air to projectiles in motion.

There are two mechanical reasons which affect this question of velocity, which should be kept distinct from one another.

(1) The resistance of the air; which to similarly shaped projectiles varies as *the square of the diameter*, thereby tending to reduce the velocity in that ratio.

(2) The weight of the projectile; in proportion to which it is enabled to overcome the resistance opposed to it, so that the greater the weight the more power the projectile has of overcoming the resistance. For instance, a heavy train requires more resistance to bring it up than a light one, supposing both to be travelling at the same rate.

Combining these two reasons into one statement, we say that the power of overcoming the resistance of the air for any gun varies directly as the *weight* of the projectile it throws, and inversely as the square of the diameter of the bore.

Thus,

$$\text{Power of gun} \propto \frac{\text{weight of projectile in lbs.}}{\text{square of the diameter in inches}}$$

supposing the projectiles to have the same muzzle velocity. (See Table I.)

Table I.

Table showing the relative Power of Guns in the Service.

Nature of gun.	Weight of shot.	Diameter of bore.	Weight in lbs. Square of diameter in inches.
		ins.	
Snider-Enfield	480 grs.	0·577	206
Martini-Henry	480 〃	0·45	339
9-pr. M.L.	9 lbs.	3·0	1000
12-pr. M.L.	12 〃	3·0	1333
16-pr. M.L.	16 〃	3·6	1234
20-pr. B.L.	20 〃	3·75	1422
64-pr. M.L.	64 〃	6·3	1613
7-inch M.L.	115 〃	7·0	2347
9-inch M.L.	250 〃	9·0	3083
10-inch M.L.	400 〃	10·0	4000
16-pr. M.L.	16	3·4	1384
16-pr. M.L.	16	3·3	1469

I know that *practical* men place very little faith in mathematical formulæ, and I believe they are right to a certain extent, for the basis of many mathematical formulæ is only a hypothetical condition not precisely true in actual practice; but *this* does not belong to that category, for it is the expression of an actual experimental fact, verified by Professor Bashforth in his experiments at Shoeburyness on this particular subject.

Now let us compare by this method the "power" of the Martini-Henry and Snider rifles, both of which throw a 480 gr. bullet.

$$\text{Martini-Henry } \frac{w}{d^2} = \frac{\cdot 06857}{(\cdot 45)^2} = \cdot 0339$$

$$\text{Snider } \ldots\ldots\ldots \frac{w}{d^2} = \frac{\cdot 06857}{(\cdot 577)^2} = \cdot 0206$$

Thus the Martini-Henry bullet has more than half as much power again to overcome the resistance of the air than that of the Snider-Enfield, and consequently does not lose its velocity so quickly; whereas, the weight of bullet to be carried is the same.

One of the chief reasons of the superiority of the French musketry over that of the Prussians in the present war has been their quickness to discover the advantages possessed by a small bore over a large bore for small-arms; although unhappily for them their foresight did not extend to their field artillery. The Chassepot has a bore of about ·44 in. in diameter and fires a 380 gr. bullet. Comparing this with the Martini-Henry, we have

$$\frac{w}{d^2} = \frac{\cdot 05428}{(\cdot 44)^2} = \cdot 0280$$

i.e., the power of the Martini-Henry is to that of the Chassepot as 339 to 280.

Here, it may be said is an instance of a larger bore ·45 in. beating a smaller one ·44 in., in power &c. To which I reply, it is not small bores as small bores that I advocate, but the proper relation of the weight of the projectile to the square of its diameter. Much controversy has arisen between the advocates of large bores and small bores, as well as between the advocates of breech-loading and muzzle-loading, from not distinguishing between things that differ, and not considering that these questions are only *means to an end*, but are not *the end itself*, which of course is the greatest efficiency possible under existing circumstances. For instance, the "Times" correspondent writes "those miserable French muzzle-loaders," and is ready to indulge in an invective at what he is pleased to call "Woolwich-ism"—apparently not knowing that *at present* we have muzzle-loading guns at least equal to any breech-loader that could be brought against us.

But to return, it has been suggested that a 380 gr. bullet would be heavy enough to fire from the Martini-Henry rifle, *i.e.*, a bullet 100 grs. lighter than the present one. No doubt the soldier would be able to carry a few more rounds into action; but firing that weight of bullet out of the same bore as the Martini-Henry would make the rifle inferior in power to the Chassepot; so that now is the time before the rifle is definitely introduced into the service to settle absolutely the weight of the bullet that should be carried, taking all things into consideration; for any decrease from the present weight will decrease the power of the rifle. To make it of corresponding power with the reduced weight of the bullet, the diameter of the bore must be reduced proportionally.

The grand maxim to remember is this; that the weight of the projectile must be absolutely fixed upon, before a sound basis of construction can be found in order to obtain the greatest power out of any gun or rifle. Any deviation from this rule, *i.e.*, any attempt to make a gun shoot a particular projectile must always be attended with loss of power. The mistake of adopting a rifled small-arm of comparatively large bore has already necessitated the introduction of a new arm.

Table II. shows the comparative velocities of the Martini-Henry, Chassepot, Snider and needle gun, from which it may be seen how the ratio of the diameter of the bore to the weight of the bullet affects the velocities of the various rifles.

TABLE II.

Comparative Table of Velocities of Rifles used by the English, French, and German Infantry.

Distance.	Chassepot.	Martini-Henry.	Snider-Enfield.	Needle gun.
yds.	f.s.	f.s.	f.s.	f.s.
0	1391	1334	1262	991
50	1288	1254	1147	951
100	1199	1182	1054	914
150	1120	1119	992	882
200	1054	1064	946	—
250	1009	1021	905	—
300	971	988	868	—
350	938	958	—	—
400	908	932	—	—
450	880	908	—	—
500	855	885	—	—

The Snider has a muzzle velocity of 1262 f.s., but owing to its large bore, the resistance of the air reduces the velocity to 1147 f.s. in the first 50 yds., thus losing 115 f.s. in 50 yds.; while the Martini-Henry starts with a muzzle velocity of 1334 f.s. and only loses 80 f.s. in 50 yds.

The distances at which the velocities of the respective bullets would be reduced to about 880 f.s. are for

	yds.
Martini-Henry	500
Chassepot	450
Snider-Enfield	284
Needle gun	150

This will give some idea of their respective ranges. The Martini-Henry and Chassepot rifles fire the same weight of charge (85 grs.), but different weights of bullets (the Chassepot bullet being about 100 grs. lighter)—consequently it is projected with a greater velocity, viz., 1391 f.s. as against 1334 f.s. in the Martini-Henry: but the bore being larger proportionally to the weight in the Chassepot than in the Martini-Henry, that velocity is more quickly reduced; so that at 150 yds. from their muzzles, they have the same velocity (1120 f.s.), and at about 350 yds. the Martini-Henry bullet catches up that of the Chassepot, and goes ahead of it increasingly; and so ranges farther.

The same state of things takes place when two projectiles of different weights are fired with the same charge of powder out of the same gun. For instance, the 3-inch wrought-iron and steel muzzle-loading gun of $8\frac{1}{4}$ cwt. if fired with a charge of 1 lb. 12 ozs. and a 9 lb. shell, has a higher muzzle velocity than when fired with the same charge and a 12 lb. shell; but in the former case the velocity is more quickly reduced by the resistance of the air on account of the greater sectional area it opposes to it in proportion to the weight of the shell—so that for an extended range the 12 lb. shell has the greatest advantage even in *flatness* of trajectory, while at *all ranges* it has the advantage both for shrapnel (in having a larger number of bullets) and for common shell (in having a larger bursting charge), besides having greater "energy."

This brings us to the consideration of the second branch of the subject with reference to field artillery. The same principle, which I have before stated with regard to small-arms, holds for field guns. The first thing to be determined is the weight of the projectile which can be conveniently carried in the limbers of a battery,—and the *heavier* the better consistent with the mobility both of gun and carriage.

This is a question which I think should be decided absolutely before the gun is constructed by the general consent of officers who have had practical experience in actual campaigning, and should have the greatest possible ventilation, so as to collect the opinion of all who are capable of giving one: always remembering this, that (*cæteris paribus*) the heavier the projectile the greater the power of the gun; so that it is very important to carry the maximum weight of projectile consistent with the mobility both of gun and carriage.

This being done, the calibre of the gun should be determined so as to give on the whole the best practical results; and this is a point which requires the closest consideration before the matter is definitely settled. The tendency of all improvements in rifled arms is to increase the ratio of the weight to the diameter of the projectile.

Table I. shows the comparative power of many of the service rifled guns, from which it appears that the power of the gun generally increases as the projectile increases in weight.

Comparing field guns and small-arms, it is evident that the latter can never compete in power and range with field artillery; hence mitrailleuses although useful in their way up to 1200 or 1400 yds. can never compete with field guns when properly constructed; but it becomes imperative on us to get the greatest mechanical advantage out of the guns that we possibly can. To neglect this is to throw away an advantage which a heavy projectile puts us into the possession of.

But it may be said, if this is the case, where will you draw the line in reducing the diameter of the bore? It is only reviving Sir J. Whitworth's notion. He tried it and failed?

Perhaps it is not very generally known that we have in the service a Whitworth rifle of ·45 in. in diameter introduced in the year 1863—in fact, so far as bore and twist is concerned, much the same as the Martini-Henry, so that to Sir J. Whitworth is mainly due the credit of first pointing out the advantage of small bores.

But then what about his guns? Well, he carried his notions beyond practical limits.: being a good mechanician he saw the advantage to be obtained, but being an indifferent artillerist he overlooked the practical difficulties—one of the principal of which is the burning of the powder in the bore—he could not burn enough powder to project his shot with as much velocity as his rival, and so for comparatively short ranges failed in the competition. Hence we arrive at a practical limit to the reduction of the bore, it must not be so much reduced as to fail in burning the greatest charge with which the projectile is to be fired—but it *should be reduced to* that limit; and no doubt as there is considerable surplus strength in the field guns, a quicker burning powder might be made if necessary. Sir J. Whitworth seems to have corrected his mistake in the 12-prs. he has recently supplied to the French Government. He fires a 12 lb. shell with 2 lbs. of powder out of a 2·75 in. bore with a twist of about 1 turn in 18·2 calibres. Another practical difficulty in the reduction of the bore is the consequent decrease in the capacity of the shell for bursting charge—no doubt we can go too far in that direction, but the *juste milieu* in this, and other matters is the great thing to be obtained. On the other hand, it is easy to have a shell with a large bursting charge, by sacrificing the range accuracy and penetration of the gun—and a great deal has been said about the advisability of introducing howitzer batteries, as in the old smooth-bore equipment.

It was necessary in those days to have howitzers to throw a shell with large bursting charge, because there was no means of increasing the internal capacity of shell, otherwise than by increasing the diameter of the bore—but now when by increasing the length of the shell, the bursting charge can be increased proportionately, there seems to be only the necessity of having two shells of different lengths, with different capacities for bursting charge, to perform all the functions of the old howitzer and gun batteries, without the disadvantages consequent thereon. In fact, with a properly constructed rifled gun, *i.e.*, one with sufficient twist to spin a long projectile, the specialities of the old howitzer and field gun would be imitated in *one* gun by a variation in the length and weight of the projectiles, thus having a common shell for use as a gun battery, and a double shell for use as a howitzer battery. It does not seem advisable to make a compromise between the two, *i.e.*, between a gun and a howitzer; which would in *reality* effect neither purpose to the greatest advantage.

Now comes the question of mobility; (1) for horse artillery acting with cavalry, (2) for field batteries and horse artillery of the reserve, (3) for heavy field batteries or field batteries of reserve.

The weight of the projectile being fixed upon in each case; what is the maximum weight of gun and carriage that can be allowed so as to keep within the bounds of efficient mobility?

This point was I think well and ably determined by a "Committee of Superior Officers of the Royal Artillery appointed to consider whether the rifled field guns to be hereafter constructed should be on a breech-loading or a muzzle-loading system, and to report what calibres are desirable to be introduced for the various branches of field service."

Sir Richard Dacres was President, and Colonel Miller Secretary to the Committee. Their report was published on the 4th of December, 1866—an extract from it is as follows:—

"For Horse Artillery.—The Committee recommend a gun of not less than 3 ins. calibre, length of bore not to exceed 60 ins., and weight not to *exceed* 6 *cwt.*; weight of projectile to be 9 lbs., or thereabouts.

"For Field Batteries.—A gun of not less than 3 ins. in calibre, length of bore not to exceed 72 ins., and weight *not to exceed* 8 *cwt.*, weight of projectile to be 12 lbs. or thereabouts."

All the above guns to be of one uniform calibre.

"Heavy Field Batteries, or Field Batteries of Reserve.—The Committee unanimously agreed that it is necessary to have in the field some batteries of more powerful guns than the rifled 9 or 12-prs., not because they would command a greater range, or possess superior accuracy to those pieces, but on account of their throwing larger common shells, more formidable shrapnel (or segment) shells, and more destructive case shot. Such guns would be certainly more effective for the attack or defence of entrenched positions, and frequently for covering important movements, or for co-operating with reserves at the critical moment of a general action."

They also reported "that the balance of advantages is in favour of muzzle-loading field guns, and that they should be manufactured hereafter."

I will next quote an extract from a letter written to me on the subject by Major W. Stirling, R.A., with regard to mobility:—

"I expect officers differ very largely on the point of weights for field artillery, but the way I look at it is this—six horses are as many as can work together in a team over broken ground without great loss of power, and therefore in calculating weights I think they should be what six horses can manage.

"In the 'Handbook of Field Service' I see 5 cwt. per horse is the maximum weight allowed for a team, and consequently this would fix the weight for the team of six at 30 cwt. This however I would hardly call the maximum weight for this reason, that I see the present horse artillery gun moving with cavalry (*i.e.*, the 9-pr. Armstrong breech-loader), and over rough ground, *tolerably easily*, with six horses; and its weight is according to the Report of the Indian Committee in the autumn of 1869—36 cwt. 2 qrs. 3 lbs. or over 6 cwt. per horse.

"In the same way our field battery gun weighs behind the team 41 cwt. 0 qrs. 14 lbs., or nearly 7 cwt. per horse of team of six; and I think it is a fair specimen of the *maximum weight* for our field batteries.

"I think 36 cwt. quite the maximum for horse artillery; I do not mean that necessarily all the horse artillery should be armed with this gun; but all that part which has to work with cavalry should not exceed, and if possible should be 3 or 4 cwt. under 36 cwt.

"The horse artillery in the reserve might have a gun the same weight as that of field batteries with advantage, on the same principle, and with the same object, that we had 9-pr. troops of horse artillery at the close of the Crimean war.

"Eight horses are allowed to the 12-pr. on service, and properly so; when the draught is straight, and the ground fairly even, the extra pair may be worked with advantage; and where circumstances do not favour the four pair being worked, they may relieve the weaker horses of the team here and there, and so enable you to carry on farther. I think however that our horses *could not manage a heavier load,* nor do I think our *gunners could handle* a heavier gun than this 12-pr. Armstrong in the field; consequently I say 41 cwt. is the *maximum* for field batteries. There is one special point I think should be brought to the front just now in discussing these points, and it is the great difference in the weight of gun and wagon, both in the horse artillery and field batteries. In both of these I think the wagons are *too heavy*.

	Guns.			Wagons.		
	cwt.	qr.	lb.	cwt.	qr.	lb.
9-pr. B.L., R.H.A.	36	2	3	48	0	16
12-pr. B.L., Field Batteries	41	0	4	54	3	15

"Wagons have to go where guns go; they get the worst drivers, the worst horses, and are allowed a smaller number of them, and yet their weights are in each case $\frac{1}{3}$rd more. It will be objected that this is including the men (mounted); so it is, but removing the men's weight throughout, we still find that the horse artillery wagon exceeds the weight of gun by $\frac{1}{4}$th of the gun's weight.

"The battery wagon exceeds the weight of its gun by $\frac{1}{5}$th the gun's weight.

"At present the gunners in a field battery must be carried on the wagon, when moving at any pace exceeding a walk from one position to another; and 9 cwt. per horse is more than we find they can manage. In China the wagons of Armstrong batteries stuck in the mud, and the wagon bodies had to be detached from the limbers, and left till next day; fortunately the limbers carried all the ammunition that was required at "Sinho;" but this was a terrible mess for a field battery to be in, and we should have heard more of it, if enterprising Uhlans or Cossacks had been hovering on our wake. I think the weight of the wagons, either in horse artillery or field batteries should not exceed the weight of the gun (in neither case including the weight of men.)"

The weights behind gun team given by Major Stirling for the 9-pr. and 12-pr. Armstrong include the weight of two men mounted and their kits: but in Table III. which I have prepared from various sources (principally from the Report of the Indian Gun Committee, and Captain Majendie's Report on his official visit to Belgium), the weights behind gun team in no case include the weight of the men. The table shows at a glance, the nature and weights of guns used by various continental powers in comparison with our own.

Thus, the weight of the 9-pr. muzzle-loading gun for the R.H.A. behind team is 35 cwt., *i.e.*, nearly $3\frac{1}{4}$ cwt. heavier than the 9-pr. Armstrong and $4\frac{1}{2}$ cwt. heavier than the Prussian horse artillery gun; and the gun itself (8 cwt.) more nearly coincides in weight with the present 12-pr. breech-loader and with the Prussian 15-pr. (canon de 6 rayé); so that it is nearly the same in weight as the heaviest field battery gun in the Prussian service, and therefore more adapted, so far as weight is concerned, for field batteries than for horse artillery generally.

And here I would notice briefly that the capabilities of different guns should be measured by their weights, or rather by the weights of the gun and carriage, than by the weight of the projectile they throw. It is all the same, so far as the weight of the gun is concerned, whether a heavy projectile is fired with a low charge, or a light projectile with a heavy charge. It is no great wonder for an 8 cwt. gun to shoot better than a $6\frac{1}{2}$ cwt. gun; therefore it is not fair to compare the 9-pr. muzzle-loader with the 9-pr. breech-loader, but it should be compared with the 8 cwt. 12-pr. breech-loader, which has been done by a Special Committee on Muzzle-loading and Breech-loading Field Guns who reported on the 25th of last November "that judging from the results of practice in the hands of the troops at Aldershot, the 9-pr. muzzle-loading and the 12-pr. breech-loading guns appear in respect to shooting to be much on a par. In conclusion the Committee cannot refrain from expressing their opinion that the present 9-pr. breech-loading gun of 6 cwt. is not an efficient weapon for horse artillery."

Now it is a question I believe with officers whether the present weight

TABLE III.

Table showing the Comparative Weights of Guns and Number of Rounds carried by the Horse and Field Artillery of various Armies.

	Horse Artillery.								Field Artillery.							
	French canon de 4, M.L.	Prussian canon de 4, B.L.	Austrian canon de 4, M.L.	Belgian canon de 4, B.L.	English 9-pr., M.L.	English 9-pr., B.L.	English 6-pr. smooth-bore.	English 12-pr. howitzer.‡	Prussian canon de 6, B.L.	Belgian canon de 6, B.L.	English 12-pr. M.L.*	English 12-pr. B.L.	French canon de 12, M.L.	English 16-pr. M.L.†	English 9-pr. smooth-bore.	English 24-pr. howitzer.‡
Calibre ....ins.	3·40	3·10	3·08	3·08	3·00	3·00	3·66	4·58	3·60	3·60	3·00	3·00	4·77	3·60	4·2	5·72
Weight of projectile ....lbs.	8·90	9·36	8·00	9·43	9·00	9·30	5·00	10·2	14·80	15·02	12·00	11·50	25·00	16·00	8·00	21·00
Weight of charge.......... "	1·21	1·10	1·10	1·167	1·75	1·125	1·5	1·25	1·80	1·54	2·00	1·50	2·19	3·00	2·5	2·5
Ratio of weight of projectile to weight of charge..........	$\frac{1}{7\cdot3}$	$\frac{1}{8\cdot5}$	$\frac{1}{7\cdot3}$	$\frac{1}{8\cdot1}$	$\frac{1}{5\cdot1}$	$\frac{1}{8\cdot3}$	$\frac{1}{3\cdot3}$	$\frac{1}{8\cdot1}$	$\frac{1}{8\cdot2}$	$\frac{1}{9\cdot7}$	$\frac{1}{6\cdot0}$	$\frac{1}{7\cdot7}$	$\frac{1}{11\cdot4}$	$\frac{1}{5\cdot3}$	$\frac{1}{3\cdot3}$	$\frac{1}{8\cdot4}$
Weight of gun..........cwt.	6·50	5·41	5·18	5·78	8·25	6·50	6·00	6·50	8·37	8·50	8·25	8·00	12·00	12·00	13·50	13·00
Weight of gun carriage.......... "	8·42	9·35	8·60	—	11·00	10·25	10·25	11·25	11·12	—	11·00	12·00	—	—	12·00	14·00
Total weight of gun and carriage... "	14·92	14·76	13·78	—	19·25	16·75	16·25	17·75	19·49	—	19·25	20·00	—	—	25·50	27·00
Weight of limber, with ammunition, &c "	10·12	15·75	9·86	—	15·75	15·00	13·25	13·95	16·15	—	16·75	17·00	—	—	14·60	14·80
Total weight behind team§ .... "	25·04	30·51	23·64	29·40	35·00	31·75	30·50	31·70	35·64	34·40	36·00	37·00	38·12	40·00	40·10	41·80
Number of horses	4	6	4	6	6	6	6	6	6	6	6	6	6	6	6	6
Weight per horse ....cwt.	6·26	5·08	5·91	4·90	5·83	5·29	5·08	5·28	5·94	5·73	6·00	6·16	6·35	6·66	6·68	6·96
Number of rounds carried on limber and on gun carriage	36	49	40	50	34	34	46	36	30	38	34	34	18	28	32	24
Number of rounds carried in the ammunition wagon	96	108	116	108	90	90	148	100	90	100	90	90	54	84	96	60
Total number of rounds	132	157	156	158	124	124	194	136	120	138	124	124	72	112	128	84
Total weight of wagon, with ammunition, &c..........cwt.	26·37	43·16	27·95	—	33·20	40·25	37·20	35·60	43·70	—	36·00	43·25	—	—	38·50	39·30
Bursting charge ....ozs.	7·0	5·9	7·0	5·8	7·5	6·5	—	7·0	8·5	8·8	11·00	9·5	—	16	—	16

* A wrought-iron and steel gun adapted to throw a 12 lb. shell.

† Experimental, the weights as estimated by Lieut. Jones, R.A.

‡ The howitzers are added to the table at the request of Major-General Eardley-Wilmot, R.A.

§ Exclusive of limber gunners and their kits.

N.B.—Mobility is not a question of *what can be carried*, as in the days of smooth-bores; but of what can be carried with efficiency in the exigencies of modern warfare.

of the 9-pr. breech-loading gun and carriage, viz. 31·75 cwt. behind team, is not the *maximum* weight for horse artillery when acting with cavalry; in fact it is thought by some that the weight should be reduced to 30 cwt., *i.e.*, about the weight of the light 6-pr. smooth-bore, the former equipment of the horse artillery. This would more nearly correspond in weight with the horse artillery equipment of continental powers. The Belgian horse artillery gun (canon de 4) weighs about 29½ cwt. behind team. The gun throws a 9·4 lb. shell, with a charge of 1·16 lbs. of powder with a muzzle velocity* of 1221 f.s.; the gun itself being under 6 cwt. This gun is almost identical with the Prussian horse artillery gun (canon de 4). Colonel Maxwell, R.A., in his "Report on Experiments carried on in Belgium with Phosphoric Bronze as applied to Field Artillery," compares this gun with the 9-pr. muzzle-loader (page 19) thus:—

> "Both these guns (*i.e.*, the canon de 4 and the canon de 6) appear to be inferior to the British 9-pr. muzzle-loading bronze gun.
>
> "(1) In flatness of trajectory.
> "(2) In the necessary complication of breech-loaders.
> "(3) In accuracy of practice and efficiency of two projectiles (shrapnel and case shot).
> "(4) In a detonating fuze.
> "(5) In the necessity of lead-coated projectiles.
> "(6) Lesser height of wheels.
>
> "The canon de 4 (*i.e.*, the Belgian horse artillery gun of less than 6 cwt.) is on the other hand, *superior* to the 9-pr. muzzle-loading bronze gun.
>
> "(1) In the larger provision of ammunition especially in the limber (viz., 50 against 34 in limber, 108 against 90 in wagon.)
> "(2) In the smaller load for the gun team (nearly 6 cwt.)
> "(3) In a common shell which bursts into a large number of pieces.
>
> "The rapidity of fire is the same in both cases."

With regard to the *inferiority* stated by Colonel Maxwell, if we introduced a *muzzle-loading* gun of 6 cwt. to fire a 9 lb. projectile with a charge of about 1 lb. 6 ozs., the only objection of any moment would be the flatness of trajectory due to about 109 f.s. more muzzle velocity (and remember the Belgian gun is only 5·78 cwt. and the 9-pr. muzzle-loader 8 cwt.); and with regard to the *superiority*, they seem to be precisely the points which of all others are necessary for an efficient horse artillery gun, viz., greater number of rounds in limber, much greater mobility and a common shell bursting into a large number of pieces.

Surely with the mechanical knowledge we possess in this country we should at least be able to build a gun to rival the Belgians, *i.e.*, a muzzle-loading steel, or steel and wrought-iron gun, weighing about 6 cwt. (according to the recommendation of the Committee of Superior Officers of Royal Artillery in 1866), of 3 ins. in calibre to throw a 9 lb.

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* See "L'Artillerie de Campagne," by Captain Nicaise, of the Belgian War Office.

projectile with a muzzle velocity of at least 1221 f.s. (the same as the Belgian gun).

Such a gun would be much superior to the present 9-pr. breech-loader in every way; it would have 151 f.s. more muzzle velocity; also a greater number of rounds of ammunition in the limber and wagon: while the inferiority to the 9-pr. muzzle-loader would be about the same as you would get by firing that gun with a charge of 1 lb. 6 ozs. instead of 1 lb. 12 ozs., with a clear gain of 3 or 4 cwt. in mobility. If it were found advisable to reduce the bore to 2·8 ins., the gun would range nearly, if not quite equal to the 9-pr. muzzle-loading Indian gun.

For field batteries the Committee of Superior Officers recommended that the weight of the gun should not exceed 8 cwt., and that the weight of projectile should be about 12 lbs. This is exactly the weight of the muzzle-loading wrought-iron and steel gun; only it throws a 9 lb. shell instead of 12 lb.

This gun would perhaps bear a 2 lb. charge (if we may judge by the Prussian canon de 6, which throws about a 15 lb. projectile with a charge of 1 lb. 13 ozs., the gun only weighing 8·37 cwt.), and in Table III. I have estimated the weight behind team owing to the additional weight of ammunition to be about 36 cwt., *i.e.*, about 1 cwt. less than the weight of our present 12-pr. breech-loader. This gun (so far as weights are concerned) would then closely correspond with the Prussian and Belgian canon de 6, with this exception that they throw a 15 lb. projectile with a smaller charge of powder, but it would be superior in range to both of them. It may be noticed that at present we throw a 9 lb. shell out of an 8 cwt. gun with a *large* charge, while the Prussians throw a 15 lb. shell out of the same weight of gun with a *small* charge; illustrating extremes on both sides: I venture to submit that the golden mean viz. a 12 lb. shell out of an 8 cwt. gun would be found the best for practical purposes.*

We next come to heavy field batteries or batteries of reserve which the Committee of Superior Officers unanimously recommended should fire a heavier projectile than 12 lbs. This recommendation is being practically carried out by a committee, who have already experimented on a gun weighing about 12 cwt., and firing a 16 lb. shell with 3 lbs. of powder. The calibre of this gun is 3·6 ins., and projects a shell with a bursting charge of about 16 ozs., *i.e.*, 3 ozs. more than the bursting charge of the old 24-pr. howitzer.

Now on comparing the power of this gun in table with the 12-pr. muzzle-loading gun, it will be seen that if projected with the same velocity, it would not range so far (the power of overcoming the resistance of the air being only 1234 to 1333 for the 12-pr.); when it ought to be more powerful on account of the heavier shell. This is owing to its relatively large bore to the weight of the shell.

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* The only advantage of a 9 lb. shell would be a slightly flatter trajectory for short ranges; but as it seems likely that mitrailleuses will be more than a match for artillery at short ranges, it is not of much importance. The disadvantages are less effective shrapnel in having a smaller number of bullets, less effective common shell, only having 7 ozs. bursting charge instead of 11 ozs.; besides having less "energy" or power of penetration at *any distance.*

In fact having so large a calibre is a retrograde step even with reference to the present service breech-loading guns, as you will see by comparing it with the 20-pr. breech-loader of 3·75 ins. in calibre, and the 12-pr. breech-loader of 3 ins. in calibre; and it is the very reverse of the plan we are about to adopt in small-arms, and is not adapted for getting the greatest mechanical power out of a gun designed to throw a 16 lb. shell, taking all practical considerations into account. These considerations are the burning of 3 lbs. of powder in a smaller bore; the slight corresponding decrease in shell capacity, and the avoidance of undue lengthening of the shell.

If it were found advisable to reduce the calibre to 3·3 ins., the "power" of the gun would be increased from 1333 to 1469, as compared with 1000 in the Indian gun; the bursting charge would still be about the same, and the length of the shell would be increased about an inch. Experimental shell for the 3·3 in. have been recently made in the Royal Laboratory, which are compared with the 3·6 in. thus:—

Shrapnel.				Common shell.			
Calibre.	Length.	Weight.	No. of bullets.	Calibre.	Length.	Weight.	Bursting charge.
ins.	ins.	lbs. ozs.		ins.	ins.	lbs. ozs.	ozs.
3·6	9·35	16 $7\frac{1}{4}$	63 at 18 per lb. and 56 at 84 per lb.	3·6	10·30	16 0	15
3·3	11·55*	16 $7\frac{1}{2}$	72 at 18 per lb.	3·3	11·55*	16 5	$15\frac{1}{2}$

The shrapnel and common shell for the 3·3 in. bore would be thus the same length—and the shrapnel would contain a greater number of larger bullets, and therefore be more effective, against carriages, *matériel*, &c.

The increased length of projectile could be met by slightly increasing the length of the gun, and diminishing the length and thickness of the iron jacket at the breech, so as to keep the gun the same weight; and also by increasing the twist of the gun, making it 1 turn in 90 ins., instead of 1 turn in 108 ins. At any rate it might be easily tried, by boring out a new gun first for 3·3 in. calibre, and then if found unsatisfactory to go to 3·6 ins.

A double shell, weighing about 22 lbs., fired from this gun would perhaps answer all the purposes of a howitzer battery. The tendency also of reducing the bore would be towards the prevention of excessive recoil.

The French have a 12 cwt. gun for their heavy field batteries with a bore of 4·77 ins., throwing a 25 lb. shell with a charge of $2\frac{1}{5}$ lbs. of powder—with its low relative charge of powder and its large calibre, the gun can only be effective at very moderate ranges, and would hardly be able effectively to return the fire of the Prussian canon de 6 at 3000 yds., besides labouring under the great disadvantage of greater weight for the gun team. Indeed, Captain Nicaise,† of the Belgian War

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* Both these shell, *i.e.* shrapnel and common for 3·3 in., might be reduced ·25 in. in length, bringing their weights to about 16 lbs.

† See "L'Artillerie de Campagne." Nicaise.

Office, states that the *want of mobility* of this gun has prompted the French to adopt a lighter gun for their field batteries.

Now this French gun is 2 cwt. *lighter* than the weight which Lieut. Jones, R.A., estimated in his recent lecture for the 16-pr. when carrying 28 rounds in the limber (and this is a very moderate estimate); it is also rumoured that the gun is to be increased in weight to 12½ cwt., so that it seems likely it will be found necessary to limit its employment to the field batteries of reserve.

In conclusion, it seems advisable in the selection of a new gun to consider first the weight of the projectile to be used, and the number of rounds requisite to be carried into action, due regard being had to efficiency and mobility. *That* being decided upon, the next step is to determine what calibre is best adapted to throw that shell with the greatest practical advantage, balancing the merits of long range, superior accuracy and flatness of trajectory against that of large shell capacity. With regard to the trial of new guns before introduction into the service, it has been the custom for some years past to determine the muzzle velocity of the projectile. This was all that could be done with accuracy* till the invention of Professor Bashforth's chronograph in 1865, to whom we are indebted for having determined with great precision the law of the resistance of the air to the motion of spherical and elongated projectiles; in fact all these tables of remaining velocities before you, have been calculated from his experiments carried on at Shoeburyness from October 1867 to May 1868. This chronograph has been reported upon by a Committee of Reference, consisting of Professors Stokes and Adams of Cambridge, and Captain Andrew Noble of Elswick, who state "that the instrument is simple in principle, easy to work with, and not readily liable to get out of order, and we think it well adapted for general employment at schools of instruction in gunnery."

This instrument measures the velocity at ten or more different intervals—so that it not only determines muzzle velocity, but also the loss of velocity over successive equal distances. This loss of velocity is due to the resistance of the air (which of course will increase with the *unsteadiness* of the shell), and affords a true criterion whereby the shooting powers of the gun (so far as range, accuracy and flatness of trajectory is concerned) may be estimated, which the determination of a single muzzle velocity *does not.*

I may add that I have used an instrument designed by Mr. Bashforth similar in principle to the above at the rifle range in the Marshes to determine the velocity of the Martini-Henry, Chassepot, Snider and needle gun for the Small-Arms Committee, the results of which are embodied in Table II.

But to return to the construction of guns: there are two methods of obtaining a powerful shooting gun to fire a shell of given weight:—

(1) By getting a great muzzle velocity, *i.e.*, by using a high charge of powder and comparatively light shell.

(2) By lessening the resistance of the air, *i.e.*, by using a smaller bore.

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* *Vide* p. 161 Reports on Experiments with Bashforth's Chronograph.

The first method necessitates a heavy gun in proportion to projectile in order to prevent excessive recoil, thus sacrificing mobility to a great extent.

The second method necessitates a slightly diminished bursting charge in common shell, but enables us to obtain the same practical range out of a *lighter* gun by projecting it with less muzzle velocity; so that with *greater mobility* the same effect can be produced with the gun. The proper combination of these two principles will give the best gun for a given weight of shell. Our artillerists at present are very strong on the first method—as you will see by the relative charges of powder to weight of projectile in the table.

The charge of powder in the Indian 9-pr. muzzle-loader, and the proposed 16-pr. is nearly $\frac{1}{5}$th the weight of shell, while all continental guns, and our own breech-loaders have a charge from $\frac{1}{7}$th to $\frac{1}{11}$th weight of shell.

The penalty is increased weight of gun in proportion to shell, and consequent loss of mobility: it is a method of obtaining range by a "*force brutale*," just as we have been using till lately a "*poudre brisante*" for obtaining velocity from our heavy guns, and exhibits more of the character of the national bulldog than the wisdom of the serpent.

The light 6-pr. smooth-bore bronze gun, formerly used by the horse artillery had a greater muzzle velocity than our present 9-pr. muzzle-loader, but owing to its large calibre (3·66 ins.), and light shell (5 lbs.) the resistance it met with was so great that it would not range farther than the Martini-Henry rifle. The great advantage in rifled guns is caused by increasing the ratio of the weight of the shell to the diameter of the bore, and by the use of pointed projectiles, *i.e.*, by diminishing the resistance of the air for a given weight of shell; and all further improvements in artillery practice will be made on the same principle when the practical objections, which I have briefly touched upon, are overcome.

TABLE IV.

Table showing the relative Velocity of our Service Rifled Guns.

Distance in feet.	Indian 9-pr.	M.L. 12-pr.	B.L. 12-pr.	M.L. 16-pr.	M.L. 64-pr.	M.L. 7-inch.	M.L. 8-inch.	M.L. 9-inch.	M.L. 10-inch.	M.L. 35 ton.	Martini-Henry.	Chassepot.
	f.s.	f.s.	f.s.	f.s.	f.s.	f.s.	f.s.	f.s.	f.s.	f.s.	f.s.	f.s.
0	1700	1700	1700	1700	1700	1700	1700	1700	1700	1700	—	—
1000	1483	1537	1527	1522	1561	1603	1618	1625	1642	1648	—	—
2000	1290	1386	1369	1360	1430	1510	1539	1553	1586	1597	—	—
3000	1138	1253	1233	1221	1311	1421	1463	1483	1531	1547	—	—
4000	1027	1143	1120	1108	1207	1338	1390	1416	1477	1498	—	—
5000	957	1055	1034	1024	1119	1262	1323	1352	1424	1450	—	—
6000	903	994	976	968	1047	1194	1260	1292	1374	1404	1400	1400
7000	855	947	930	922	996	1133	1202	1237	1327	1360	990	949
8000	—	907	890	881	955	1079	1150	1186	1282	1317	—	—
9000	—	871	853	844	920	1035	1103	1139	1239	1277	—	—
10000	—	—	—	—	888	1001	1061	1097	1199	1239	—	—
11000	—	—	—	—	—	971	1026	1059	1162	1203	—	—
12000	—	—	—	—	—	945	999	1027	1127	1169	—	—
13000	—	—	—	—	—	921	974	1002	1095	1138	—	—
14000	—	—	—	—	—	899	952	979	1066	1108	—	—

At the close of the lecture—

Major-General Lefroy, C.B., R.A., said the meeting would be very happy to hear any gentleman who wished to make observations on the subject of the paper, and he hoped that the gallant officer on his right (Major-General Sir Edward Warde, K.C.B.), who had been, as they had been already informed, a member of the "Committee of Superior Officers" by whom this subject was considered in 1866, and was so highly qualified to advise on all subjects connected with the movement of field artillery, would favour them with some remarks.

Major-General Sir Edward Warde said the subject which they had met to consider was one of great importance, although to his mind it was a very simple one, and he thought the lecturer had shewn an accurate appreciation of the requirements of the service in submitting three different natures of field gun for their consideration, which in his opinion would always in future be required to form an efficient artillery with an army in the field. He would say nothing with regard to the able manner in which his young friend Lieut. Sladen had placed this subject before them, because he felt satisfied that the Chairman would, when he addressed the meeting, fully express the feelings of all those who were present, with his usual ability; but he must express the pleasure that he had himself personally derived in seeing an officer who had joined the service under the shadow of his own wing when he commanded the 6th Brigade, entering on a course which was so eminently calculated to reflect credit on himself and on the corps to which he belonged. Mobility, as regarded field artillery, was in his opinion the paramount consideration. It was of course most important that our field guns should be as hard hitting, as far ranging, and should carry as large and damaging a shell as was consistent with facility of transport, and the certainty of being enabled to place them in the positions indicated at the exact moment when they would be there required. We required a gun for the horse artillery sufficiently light to ensure great rapidity of movement, and the certainty of being enabled to overcome all difficulties and inequalities of ground, however great; a rather heavier and more damaging gun for our field batteries, but still not so heavy as to cause doubt or uneasiness as to being enabled to ensure its being in its proper place at the proper time; and we also required as heavy a gun as could with safety be taken into the field, and accompany the movements of the force, of which it would form a component part, for special purposes—such, for instance, as destroying any temporary cover with which the enemy might have provided himself, or for silencing the fire of his artillery. The 16-pr. gun now submitted for consideration appears well calculated to meet these requirements. There must be many present who remembered the effect that was produced by the two 18-pr. guns at Inkermann, which were brought into action at a critical moment, and by subduing the heavy fire of the Russian artillery, contributed *very largely* to the glorious success of the day. He would only detain them further to say that, in his opinion, mobility with regard to field artillery was the first consideration, as it would be far better to have a light gun that could always be put into the right place at the right time with certainty, than a heavier and more damaging one about which there would be doubt and uneasiness as to its being at all times available when required.

Lieut.-Colonel F. Miller, VC, R.A., who was next called upon by the Chairman to address the meeting, said he would make a few remarks upon the quantity of ammunition likely to be required in action. Since it had been proposed to have a 16-pr. gun for field batteries, he had had much conversation with officers on the subject, and had found that opinions varied considerably with respect to the number of rounds which were practically requisite to be carried with each gun, and that there was a difficulty in finding good data to furnish as safe basis. If they adopted the 16-pr. he had understood that they could only carry into action 104 rounds against the 124 rounds which the 12-pr. carried, and this diminution was to his mind a serious consideration. On the table before them the 16-pr. was shown as carrying with it 112 rounds, which would be a loss of only 8 rounds as compared with the 12-pr., but he believed that 112 was rather an excessive estimate. He saw the Secretary of the Shell Gun Committee present; perhaps he could inform the meeting on the point.

Captain W. R. Lluellyn, R.A., said the subject had not yet been worked out.

Lieut.-Colonel Miller.—May I assume the number of rounds to be 104?

Captain Lluellyn.—My impression is that the number of rounds will be 112, but the Committee have not yet decided.

Lieut.-Colonel Miller said he would assume, for the sake of argument, that the number of rounds would be 104, which he thought more probable. That would involve a loss of 20 rounds, and the question was, would there be sufficient for a long day's work? He might take it for granted that the amount of ammunition available was only that carried by the gun and one wagon; for the second line of wagons must be regarded as a reserve which could not be brought near the enemy, or at all events there would be such an uncertainty about its being at hand when wanted that it could not always be depended upon. Then came the question as to how many rounds were fired in one day's engagement. The experience of the Prussians in 1866 had been often quoted on this point, but the evidence about its expenditure was very incomplete. They had a valuable report from Colonel Reilly, R.A., who was sent out on that occasion by the Government, but the only absolute information he could give on this point related to the 2nd Prussian army, under the Crown Prince; whereas it was the 1st Army, under Prince Frederick Charles, that had had its artillery most severely engaged. At Kœniggrätz it carried on a regular fire from seven in the morning until three in the afternoon. He could give them no detailed facts as to the expenditure of ammunition on that occasion; but a German writer, Colonel Rüstow, who received a great deal of credit on the continent as a military historian, said that during the day the field batteries had twice to be replenished from the reserves; and Captain Brackenbury, who was with the Austrians, and who attended to give evidence before the Committee of Superior Officers of which Sir Richard Dacres was President, when questioned as to the amount of ammunition expended, was unable to give tables or statistics, but stated that some of the guns fired away all their ammunition, and that he knew as a fact that some had fired about 157 rounds by twelve o'clock in the day. Colonel Reilly's report contained a table showing that the highest expenditure in the 2nd Prussian Army under the Crown Prince at Kœniggrätz, was by a battery of the Guard Artillery, which fired 81 rounds per gun; on which occasion, judging from the report of the Guards' movements, they probably opened fire about noon and ceased at about four o'clock, giving an average of 20 rounds per hour. At the battle of Blumenau they were informed that one battery fired 113 rounds per gun, but that was neither an action of any serious importance, nor one upon which they could base any reliable calculation as to the total amount required; for though it began early in the morning, it was interrupted by the truce at mid-day. The number of rounds fired, however, was as great as that proposed for the 16-pr., even if they accepted the highest estimate for the equipment of that gun. Reverting to our own experience, before rifled artillery was introduced, he found again great difficulty in getting reliable statistics. He had referred to several accounts of Waterloo, but looked in vain for information as to the number of rounds fired per gun. It was true he had an extract from a note-book belonging to Sir Hew Ross, which stated that the total number of rounds fired at Waterloo was 9467, but then he did not know to how many guns that applied. He believed that there were about 78 British guns on the field, which would give an average of about 122 rounds each. In General Mercer's diary, recently published by his son, it was said that the number of rounds fired at Waterloo in his troop averaged 700 per gun; but that must be an error, for it was hardly possible that every gun should keep on firing at the rate of 90 rounds an hour for eight hours together. (A laugh.) Coming a little later, he found that at Inkermann "B" Field Battery fired an average of 84 rounds per gun, "G" Battery 82, and the two 18-pr. guns about 84 each. That battle began early in the morning, and the troops were out of fire by mid-day, so that the artillery combat lasted probably five or six hours. At Alma the expenditure was small. The total number of rounds fired was 880, to be divided among 54 guns, according to the number of batteries present, but six certainly of the guns—the battery to which he belonged—did not fire a shot, and he believed that there were two other batteries which fired very little, if at all. That battle lasted two and a half or three hours, and he should say the expenditure averaged about 24 rounds per gun for the guns actually engaged. Then at Balaclava he found that "I" Troop of Royal Horse Artillery fired 43 rounds, "E" Field Battery 33, "W" Battery 31, and "P" Battery 28. On the whole he thought that an estimate of 20 rounds per gun per hour would be a fair one for calculating the requisite equipment; for the greatest speed at which they were likely to fire would not exceed two rounds per minute, and that would be only kept up for a few minutes together, to check an advance of troops or before the assault of a position. The presumption was that in firing regularly "from right to left," and after making allowances for change of position, one round per gun every three minutes or thereabouts was a fair average for well-contested encounters, and that would give the 20 rounds per gun per hour which he took as his basis. Of course they had to consider how long an action was likely to last, and he thought that, considering past experience, they might fairly assume five hours as the likely duration of a regular battle. If so, he might be asked why 100 rounds would not be sufficient to take with the gun; and his answer was, that the gun might be in action for two or more successive days, and that they ought to consider the chance of the reserve wagons missing their intended direction, or being blocked up and detained in the road, or of their falling into the hands of the enemy, or, again, of arrangements being disorganised by a retreat; in any of which cases there was a great doubt as to their joining their guns in time. Therefore he regarded 120 rounds as the very lowest provision that could prudently be allowed for each gun; even that would only give them enough for five hours' engagement on one day and leave but 20 for the operations of the next. Some batteries in a division might fire more rounds, and some less, than others, in which case they could replace one another as they had opportunity; but he thought 120 rounds per gun was the very lowest supply which would give the artillery sufficient fighting power. If the question at issue was a choice between a 12-pr. (muzzle-loading) and the new 16-pr., supposing they had equal initial velocities, he should say that the 12-pr. was quite effective enough against such obstacles as are met with in ordinary field engagements. For his own part, he would rather go through a campaign with the 12-pr. and 124 rounds per gun than with the 16-pr. and any less number per gun. (Applause.)

Lieut.-Colonel R. Biddulph, R.A., observed that in discussing the number of rounds to be carried with a gun, the number in the limber should be borne in mind instead of in the wagons, for it was just as easy to bring up two wagons as one when a gun required more ammunition. Colonel Miller had referred to the fact that at Balaclava "I" Troop of Royal Horse Artillery fired only 43 rounds. That was true, but the explanation was that the guns had to cease firing for want of ammunition, having expended all that they carried in the limber boxes. It was the only case of the kind with which he was acquainted, and arose from the horse artillery having been improperly retained in action when the field batteries should have been engaged. He saw from the figures in the table before them that our horse artillery was, with respect to the number of rounds per gun, in a worse position than any on the continent, and he hoped that they might at least adopt some plan of carrying more rounds in the limbers; horse artillery being much more liable to get separated from its wagons than field batteries. Our old 9-pr. used to carry 32 rounds in the limber and 96 in the wagons, making 128 in all—only 2 rounds worse than the present 12-pr. For field batteries he thought 32 rounds in the limber would be sufficient. (Applause.)

Major-General Lefroy said that Colonel Miller, in his enquiry as to the number of rounds liable to be expended in a single engagement, had, he thought, overlooked one source of information—the Report of the Committee of Revision in 1819, which in calculating the ammunition "required to sustain an action of some duration," reckoned 166 rounds for the 9-pr. gun, 144 rounds for the 24-pr. howitzer, and a great deal more for the Royal Horse Artillery—namely, 223 per 6-pr. gun and 236 per 12-pr. howitzer. He wished also to point out what he considered a slight error in Colonel Miller's figures; for in taking the average expenditure of ammunition in certain cases, he appeared simply to have divided the total consumption per battery by six, the number of guns; whereas it should be remembered that the guns usually expended considerably more than the howitzers. Thus at Inkermann the expenditure of gun ammunition of "E" Battery was 369 rounds, or 92 per gun, and of howitzer ammunition 133 rounds, or only 67 per howitzer, and these quantities were not exceeded in any of the engagements of the Crimean war. The distinction of guns and howitzers no longer exists, and all future provision must be on the higher scale for guns.

Lieut.-Colonel Miller said he had a table in his hand which furnished the exact figures he had quoted, showing the total in the last column.

Major-General **Lefroy** said that was probably correct, but the figures led to an erroneous inference by reckoning guns and howitzers as all one. He agreed however with much that had fallen from Colonel Miller as to the importance of carrying enough ammunition into the field, but he thought his calculation of an expenditure at the rate of twenty rounds per hour an extravagant one. (Hear, hear.) Twenty rounds, or at the rate of twenty rounds per hour might doubtless be reached for a spurt, especially in firing case shot, but they could not take it as an average for continuous firing.

Major-General **Sir Edward Warde.**—It would never be realised.

Major-General **Lefroy** said, at all events he was not afraid of that of which their fathers in artillery were not afraid. (Applause.) The Committee of 1819 to which he had referred actually contemplated equipping 12-prs. of 18 cwt. as horse artillery of reserve. There is of course a line to be drawn somewhere, but nothing in his opinion would turn on a cwt. or two, more or less. But in discussing this question, there was one thing to be borne in mind. Were they talking of home defences? If so, they must remember that they had in every part of Great Britain excellent roads over which they could transport heavier *matériel* and move their guns in all directions more readily than in any former military experience, and much the same might be said of the roads all over Europe—the last few years had seen them greatly improved. This fact ought to have some bearing on the question as to the weight of their artillery equipment. (Hear, hear.) As to the general question of large bore and small bore, light guns or heavier guns, he supposed it was a point upon which they must agree to differ; and to show how impossible it was to reconcile all minds upon such matters, he referred to the committee which met to discuss the very question in 1866, where two officers stood out against all the rest of their colleagues in favour of having the same gun for horse artillery and field batteries, but when enquiry was pushed a little farther it was found that one wanted to have a gun of 6 cwt. and the other preferred one of 8 cwt. for both services. (A laugh.) However, he would not detain the meeting longer, but discharge the one remaining duty of returning thanks to Lieut. Sladen, in the name of the meeting, for the interesting information he had given them, remarking that the benefit of such papers was not confined to those who had the advantage of hearing them. Their chief value was in disseminating correct information through the service in print, thus helping to create a well-informed public opinion; and it was impossible not to contrast the advantages of officers at the present day in this respect with the state of things that prevailed at no remote period. Lieut. Sladen had delivered himself very clearly of his subject, and had elucidated the matter with a mass of figures the preparation of which must have involved considerable labour. (Applause.) He had pleasure in congratulating him on his success, and expressing the gratification of the meeting. (Applause).

Major-General F. M. **Eardley-Wilmot**, R.A., F.R.S., said it might be satisfactory to Lieut. Sladen to know that the Royal Laboratory had been called upon to make a shell such as he had described.

The Chairman then closed the meeting.

MOUNTING OF TWELVE 12-TON GUNS

AT MALTA, 1870,

BY 10TH BRIGADE, R.A.

THE work was begun on the 4th January, and completed on the 4th May following.

The guns parked in the Military Store Yard at the Right Marina Wharf, were conveyed to the following works:—

1 to St. Lazarus' Bastion, East Valetta.
1 to the English Curtain, West Valetta.
2 to Abercrombie's Bastion } Fort St. Elmo Valetta.
1 to Ball's Curtain } Fort St. Elmo Valetta.
2 to Fort Tigne, Valetta District.
2 to No. 3 Battery, Fort Ricasoli } Cottonera.
3 to No. 2 Battery, Fort St. Angelo } Cottonera.

Valetta.—The five guns for Valetta were conveyed singly by land, on a special drug, about 12 ft. long by 6 ft. 4½ ins. across the axle-trees, having rear trucks 3 ft. and front trucks 2 ft. in diameter, with tires 8 ins. wide; the weight of the drug being about 3½ tons. (*Vide* par. 1662, "Changes in Artillery Matériel," 1. 10. 68).

A gun was placed on the drug by means of an 18 ft. strengthened gyn, and then removed from the yard beyond the Right Marina Gate.

The following day 180 to 200 men, assisted by eight or ten mules, drew it to the battery for which it was intended—a distance of two or three miles—in about two hours.

The bridges on the road to St. Elmo were carefully shored up by the Royal Engineers, and gave no sign of yielding when this great weight—about 15 tons—passed over them.

The drug answered well, the roads being exceedingly firm, solid rock coming to within a few inches of the surface, which was macadamised; but dampness in the atmosphere, or a fall of rain, made a considerable difference in the draught.

The drug was taken through gateways and across bridges barely 8 ft. wide; through a cutting at the entrance of Fort Tigne only 7 ft. wide; ascents as much as one in fourteen, and descents as great as one in ten, were accomplished in safety, the drug having no break, by means of from 60 to 100 men holding on to check drag-ropes in rear.

On a dry day, a declivity of about one in thirty was sufficient to allow of the drug, when once started, keeping itself in motion; about twenty men were required in rear to keep it in check.

The drug turned with the greatest facility in streets running at right angles to each other, as well as in the most cramped places.

Owing to the badness of the road on the glacis at Fort Tigne, it was found necessary to raise the drug by means of hydraulic jacks and levers, and place planks under the wheels; and also at the bottom of Strada Forni Valetta, a street having a descent of one in ten, with the English Curtain rising from it at a slope of about one in three; in which case it was also necessary to use strong tackle to draw the drug up the short but steep ascent.

On two occasions the weight of the gun and drug broke in the top of a drain, and also a stone about 9 ins. thick, forming part of the covering of a tank; but no delay occurred on account of this.

The mules were taken out of the shafts and replaced by six men on entering the gate of the town, and in some places at Sleima; but on passing over rough ground, it was found necessary to assist them by four or five extra men holding on to steadying-ropes attached to the point of each of the outer shafts.

The washers of the drug were found to be too small for the hooks of the parbuckle-ropes used as drag-ropes; iron shackles were made and fitted for the purpose.

On arriving at the battery, the drug was run with the gun muzzle foremost into the embrasure. The gun was then lifted by an 18 ft. strengthened gyn, and the drug withdrawn. The platform was run under the gun by means of a common transporting axle and wheels, on which it was balanced so as to allow of the front trucks being dropped at once on the front racer. The weight of the rear end of the platform was taken by a lever and fulcrum, the wheels and axle withdrawn, and the rear trucks were then gradually dropped in their place.

The carriage, placed on a general service drug, was next run up and hauled on to the platform, and the gun dropped into its trunnion holes.

The operation of mounting the gun took three-quarters of an hour.

On one occasion an attempt was made to run the platform with its carriage on the racers by means of its own special transporting axle; but although carried out, the attempt, in point of time, proved a failure, owing to the cramped nature of the ground, the great weight to be moved—nearly 5 tons—and the width of the axle being too great to work easily under the gyn.

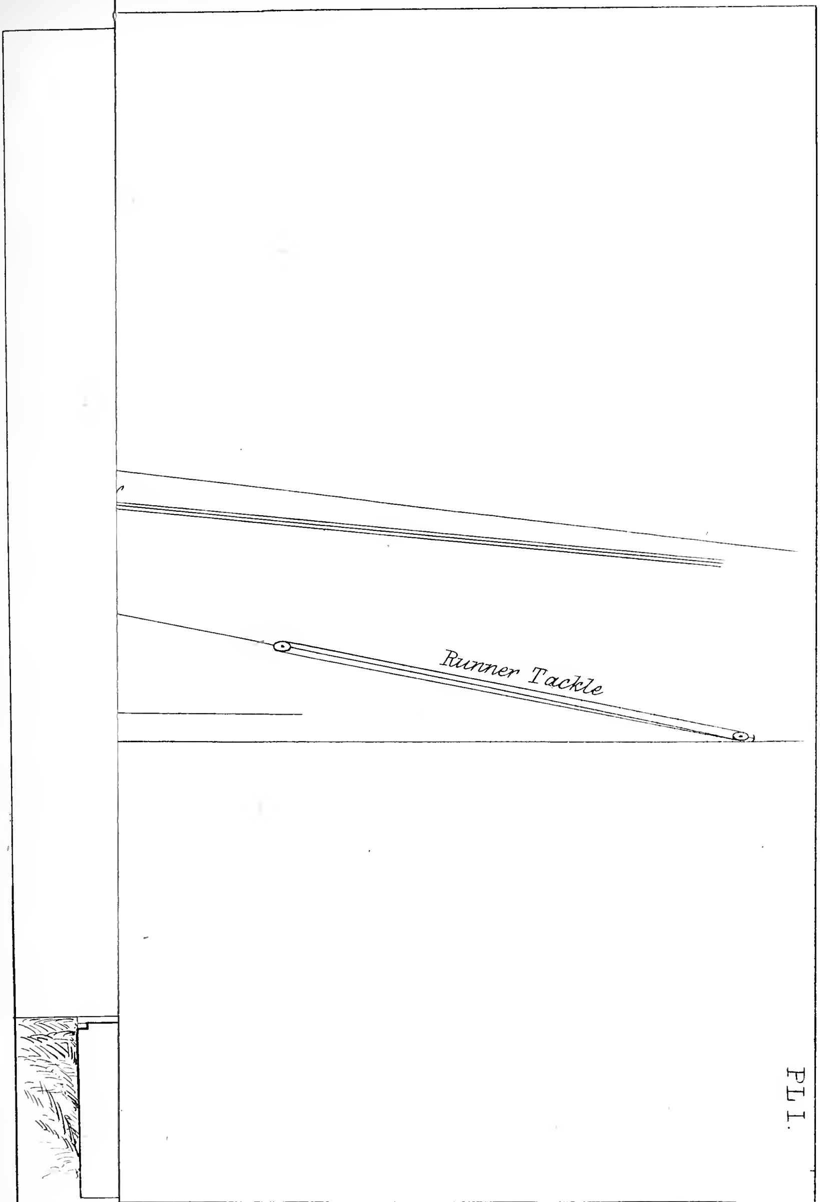
To facilitate the balancing of a platform on an axle and wheels, small movable iron bands might be attached to and under the side pieces of the platform, in such a way as to allow of their working on a hinge, and being easily opened or thrown back.

The gyn falls of 5-inch rope appear too weak for guns of this weight; 5½-inch rope would be better adapted.

The guns were slung by a chain in lieu of rope, as the 9-inch rope sling was found to stretch considerably.

Fort Tigne (Plate I.)—The two guns for Fort Tigne were brought

PL. I.



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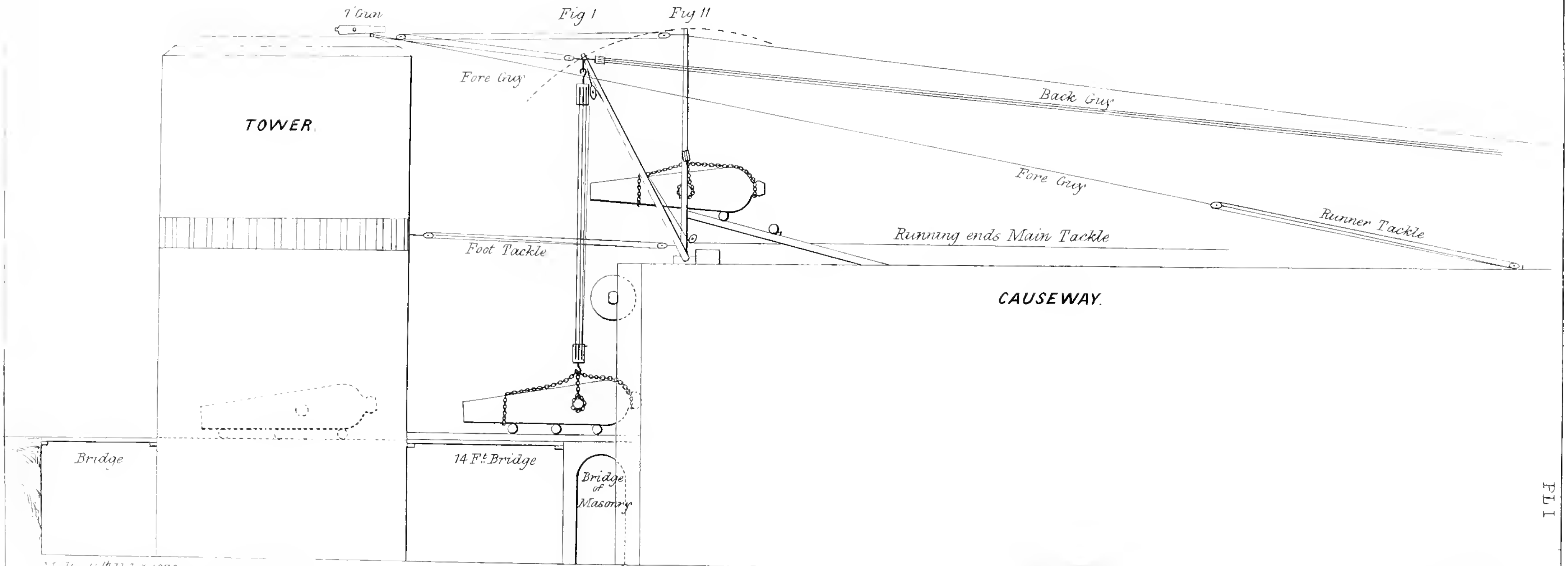
SECTION OF TOWER & SHEERS AT FORT TIGNE.



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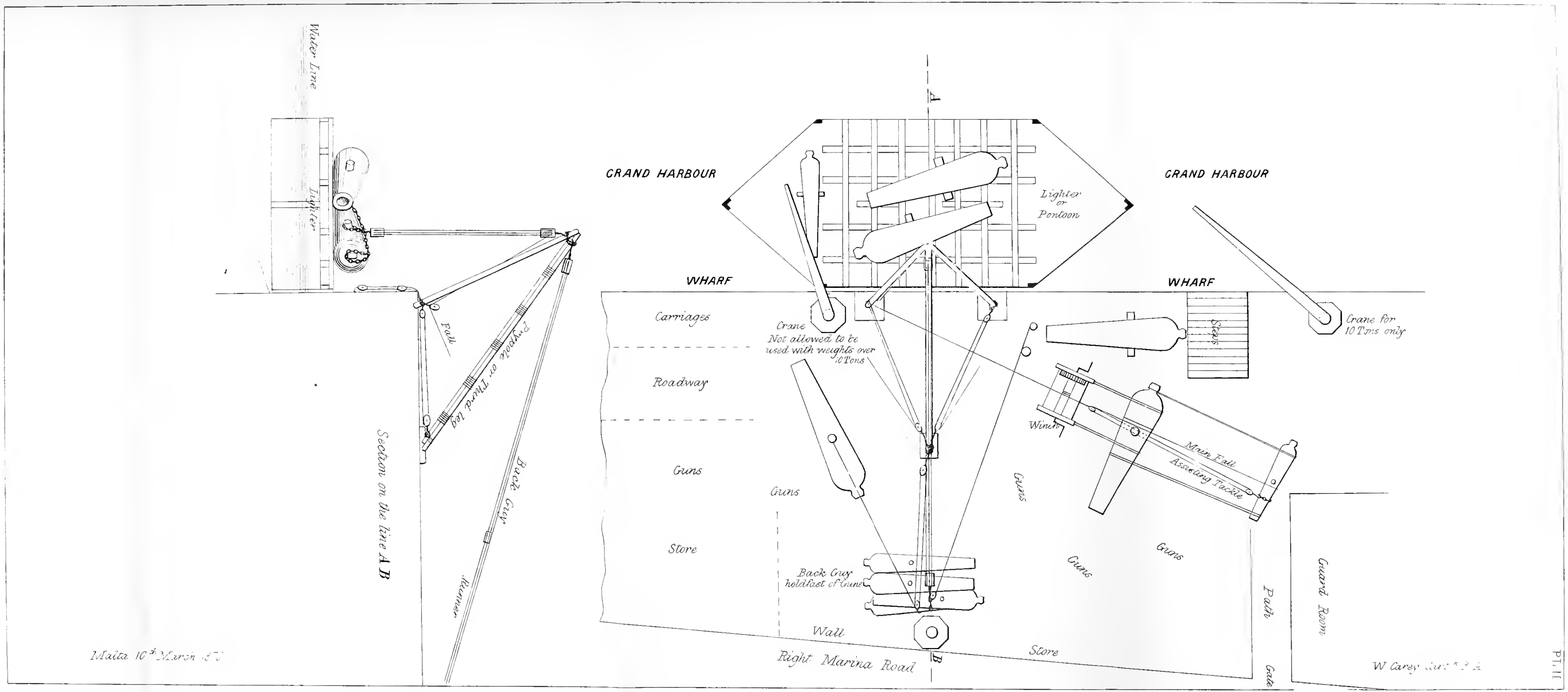
W. Carey Captn R A

Pl. I


Water Line
Lighter
Fall
Pryrole or Third leg
Back Guy
Runner
Section on the line A B
GRAND HARBOUR
GRAND HARBOUR
A
Lighter or Pontoon
WHARF
WHARF
Carriages
Roadway
Guns
Store
Crane
Not allowed to be used with weights over 10 Tons
Crane for 10 Tons only
Steps
Winch
Main Fall
Assisting Tackle
Guns
Guns
Guns
Guns
Back Guy holdfast of Guns
Wall
Store
Right Marina Road
B
Path
Gate
Guard Room
Malta 10th March 87
W Carey Lieut R.A
PL. II

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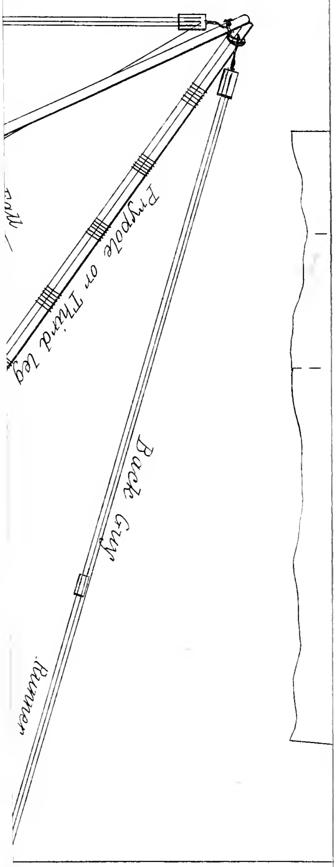

round by road on the drug, a distance of about four miles, and dropped on skidding at the entrance gate of the fort. Time occupied being about four and a half hours.

The guns were then taken across the drawbridge, through the tower, and on to the inner bridge by means of skidding and rollers.

They were then lifted about 16 ft. on to the causeway of the fort, by means of the cheeks of a strengthened gyn rigged as sheers.

The back guy, as well as the fore guy, consisted of 4½-inch tarred rope; the former rove through two double 15-inch blocks, the latter through two single 12-inch blocks.

The main tackle was a coil of 5½-inch rope, rove through a double 15-inch and two single 18-inch blocks at the head of the sheers, and through a treble 15-inch block at the gun; both ends of the fall being led to and worked by iron winches secured on the causeway.

The feet of the gyn pivoted in wooden shoes, specially made on the ball and socket principle. They were about 18 ins. square by 8 ins. deep, cupped out in the centre to a depth of 6 ins. by 10 ins. in diameter, to receive oak caps made to fit over the spike and on to the foot of the gyn. These shoes answered very well.

On taking the weight of the gun, the sheers were inclined outwards about 7 ft. (Plate I.)

A gun was raised and landed on the causeway in the course of an hour and a quarter.

Embarking (Plate II.)—The two guns for Fort Ricasoli, and the three for Fort St. Angelo, were embarked on a Government lighter lent from H.M. Dockyard. The lighter was 45 ft. long by 15 ft. 6 ins. beam, about 4 ft. 6 ins. deep, flat-bottomed, with a flush deck, and with two guns on board drew about 3 ft. of water.

The guns were embarked by means of a strengthened gyn, rigged as three-legged sheers; but owing to the dryness of the atmosphere and the heat of the sun, the shakes in the cheeks of the gyn had opened considerably, and it was considered advisable to strengthen each cheek by means of three iron bands 2½ ins. wide and ½ in. thick, which effectually answered the purpose.

The back guy was similar to that at Fort Tigne.

The main tackle (Plate II.) consisted of a coil of 5½-inch rope, rove through two treble 15-inch blocks, the running end of which was worked by an iron winch.

The plan of operation was to place a gun in position the previous day, with the muzzle projecting well over the wharf, and then erect the sheers over it with a heel outwards of about 18 ins.

On embarking, the weight of the gun was taken by the winch, and then by easing off the back guy and hauling on the foot tackles, the sheers received the necessary heel outwards—about 7 ft.—and the gun was lowered 8 ft. on board of the lighter. The operation took one hour.

The lighter was then trimmed by lowering a 68-pr. on board by means of a crane close to the sheers, but only available for weights of 10 tons and under.

On embarking a second gun the same day, the gun was brought up under the sheers and hauled out by the main tackle on rollers. In doing this, great care is necessary to adjust the rollers so that the weight of the gun should be taken before swinging it clear of the wharf; otherwise, on the front roller coming to the edge of the wharf, the gun would drop with it, and break or strain everything by the jerk which is sure to follow.

Two guns were embarked in four and a half hours.

When a day intervened, the sheers were struck, a gun placed in position, and the sheers erected over it.

Disembarking (Plate III.)—The guns were disembarked on the rocks below the forts by the same arrangement; but in this case the gyns were stepped on a lower level than the top of the rocks on which the guns were to be landed. This allowed of the lower bar of the gyn being conveniently used, and the guns were swung in over it. On embarking, the bars of the gyn were not used.

A messenger of 3½-inch rope, rove through a single 12-inch block, assisted the iron winch, and was worked by a capstan. The messenger was also useful when stoppering the fall.

No front foot ropes were used on disembarking the guns, but were employed on embarking them.

Two guns were landed in the course of three and a half hours, but one gun could be landed in an hour.

The height to the top of the rocks was 6 ft. to 10 ft.

Besides the above, one gun at the Marina was raised by the gyn used as three-legged sheers with its own windlass, over which it was brought in, and dropped on the drug for conveyance to St. Elmo.

This was done as it was considered probable that the guns might have to be landed in that way at the foot of the ramp at Fort Ricasoli, the landing place at that point being very small.

The gyns stood well, and were sometimes inclined outwards about 8 ft.

Fort Ricasoli (Plate IV.)—The two guns were raised from the rocks into Fort Ricasoli—a height of 36 ft.—by means of large sheers, the spars for which were obtained from the Dockyard, and were old jib-booms, about 16 ins. in diameter at the butts and 49 ft. long. Iron chain of $\frac{9}{16}$ in. link was used in lashing them.

The back guy consisted of two coils of 5½-inch white rope spliced together, and rove through two double 15-inch blocks.

The fore guy was one coil of 5-inch tarred rope, rove through two 15-inch double blocks.

The main tackles—of which there were two—consisted of a coil of 6-inch rope, rove through two double 18-inch blocks, and were hooked into an iron chain sling of 1-inch link at the head of the sheers.

The falls were led to iron winches, and were also assisted by a messenger of 3½-inch white rope, rove through 12-inch single blocks, and worked by capstans.

The two guns were raised in the course of three and a half hours. The actual time of raising the first gun was one hour; the second was

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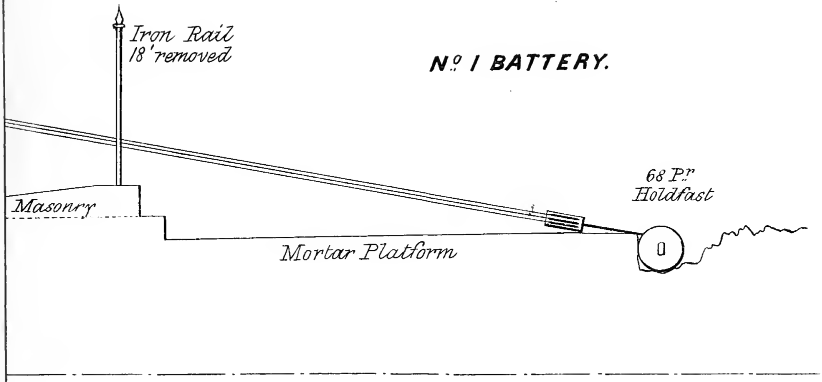
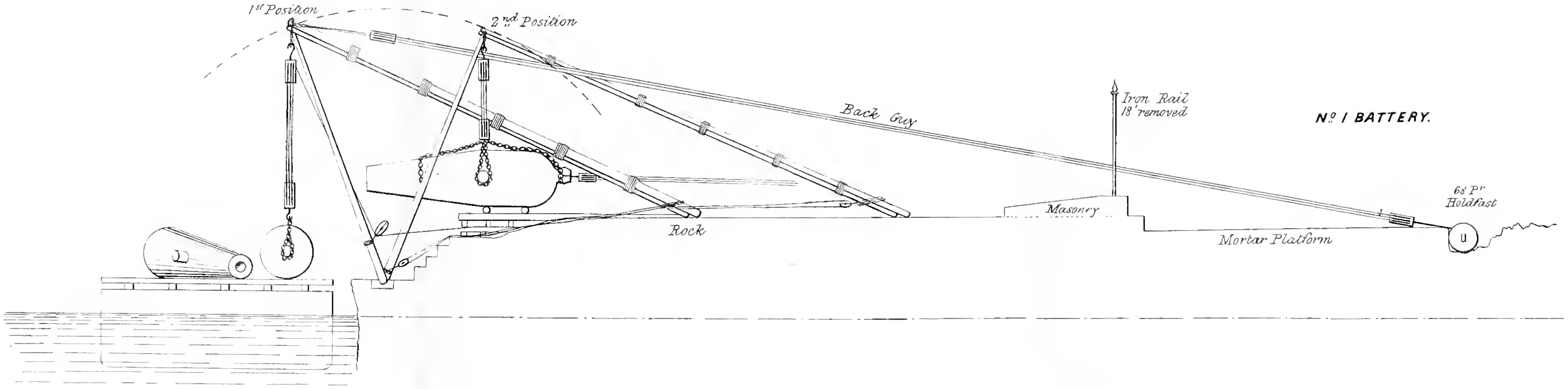


PL. III.

W. Carey. Captn. R.A.

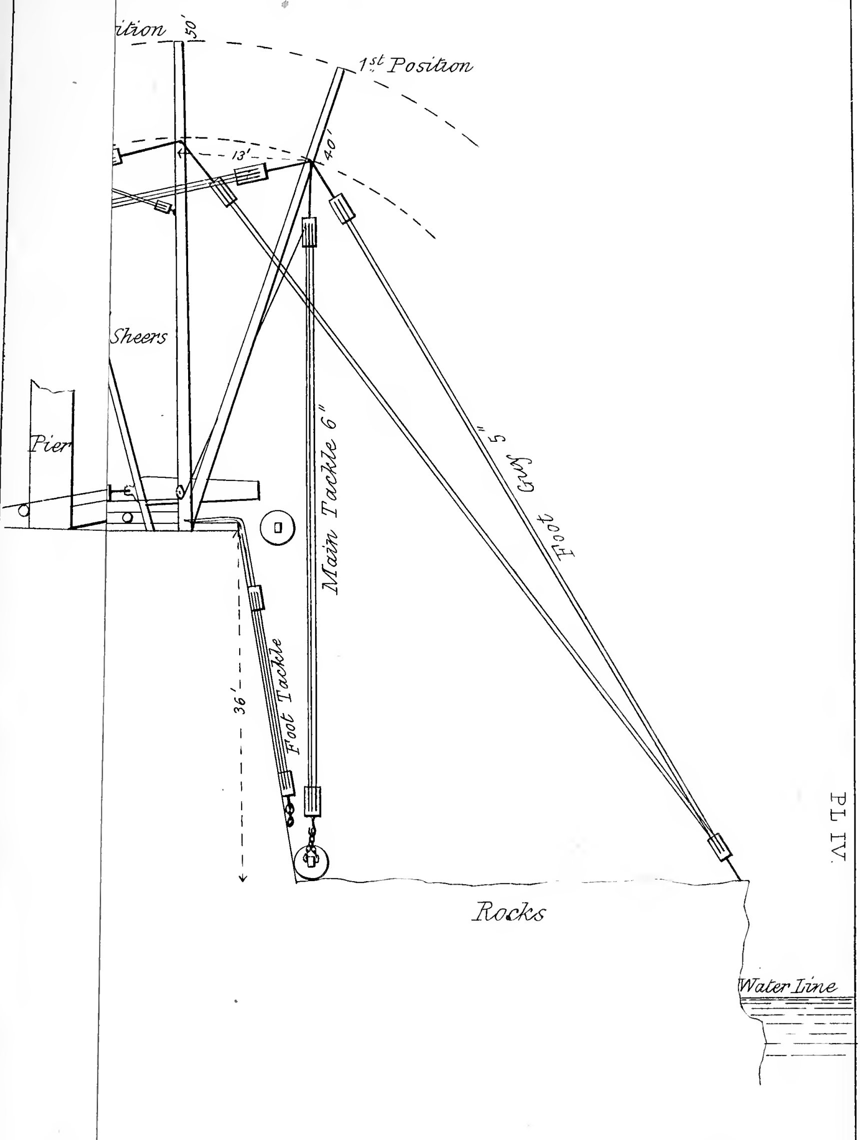
SECTION SHOWING THE LANDING OF GUNS AT FORT ST. ANGELO
ON THE ROCKS OPPOSITE THE MORTAR OR No. 1.B.



Malta 4th March 1870

W. Carey. Captn. R.A.

RT RICASOLI.

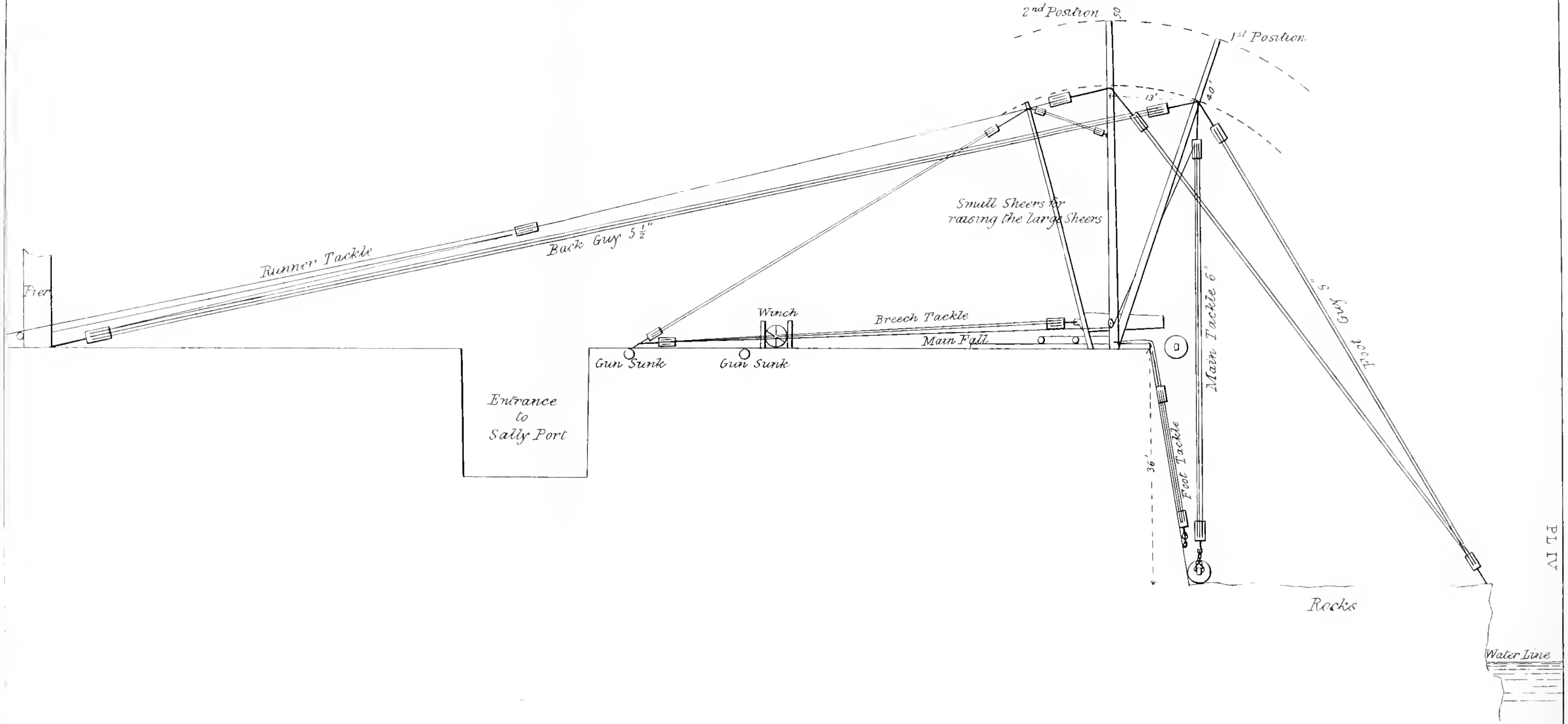


PL IV.

Malt

W. Carey Captn R.A.

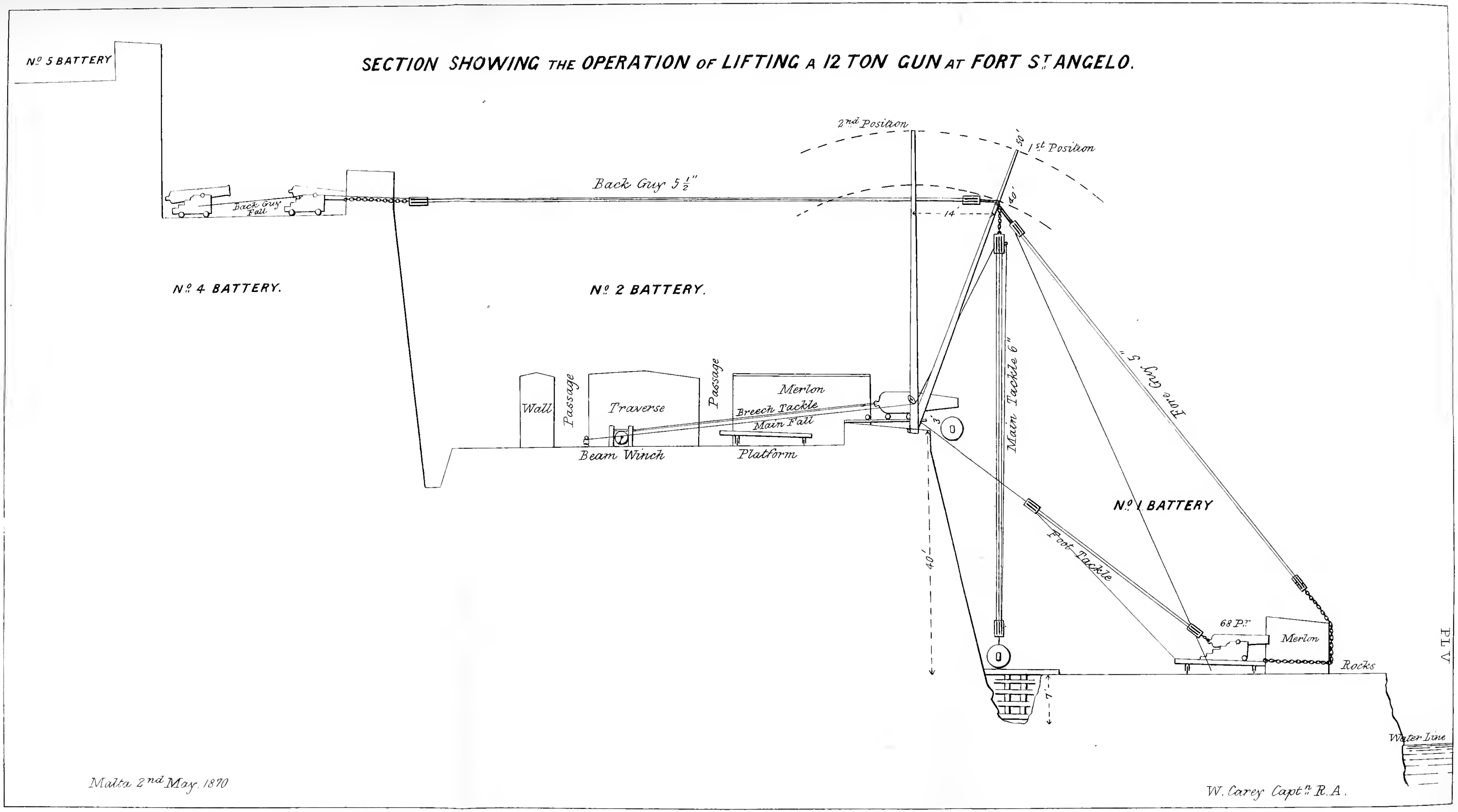
SECTION SHOWING THE OPERATION OF LIFTING A 12 TON GUN AT FORT RICASOLI.



PL IV

Malta 28th March 1870

J.W Carey Captn R.A.



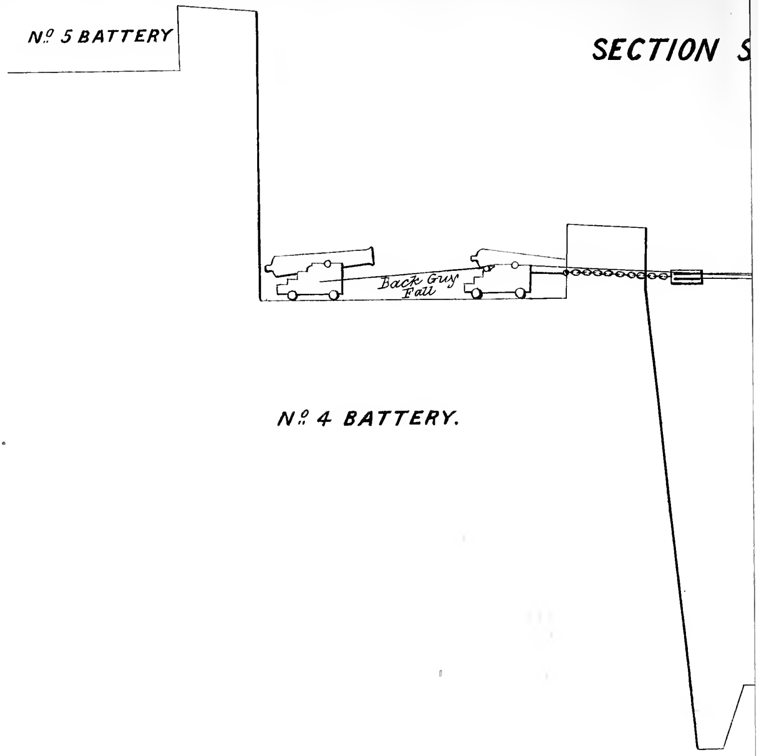
SECTION SHOWING THE OPERATION OF LIFTING A 12 TON GUN AT FORT ST. ANGELO.

Malta 2nd May. 1870

W. Carey Captn. R.A.

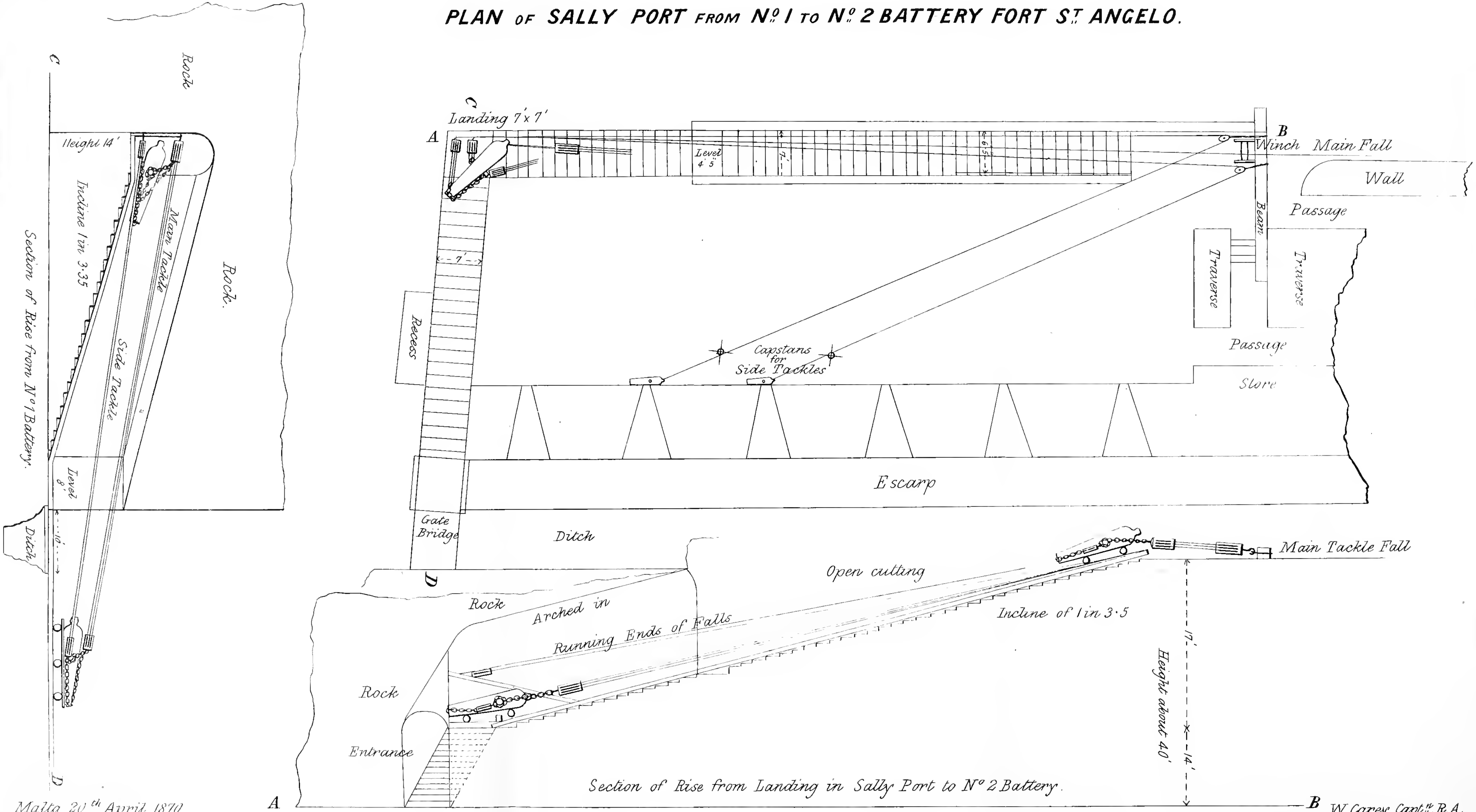
PL V

SECTION S



Malta. 2nd May, 1870.

PLAN OF SALLY PORT FROM No. 1 TO No. 2 BATTERY FORT St. ANGELO.

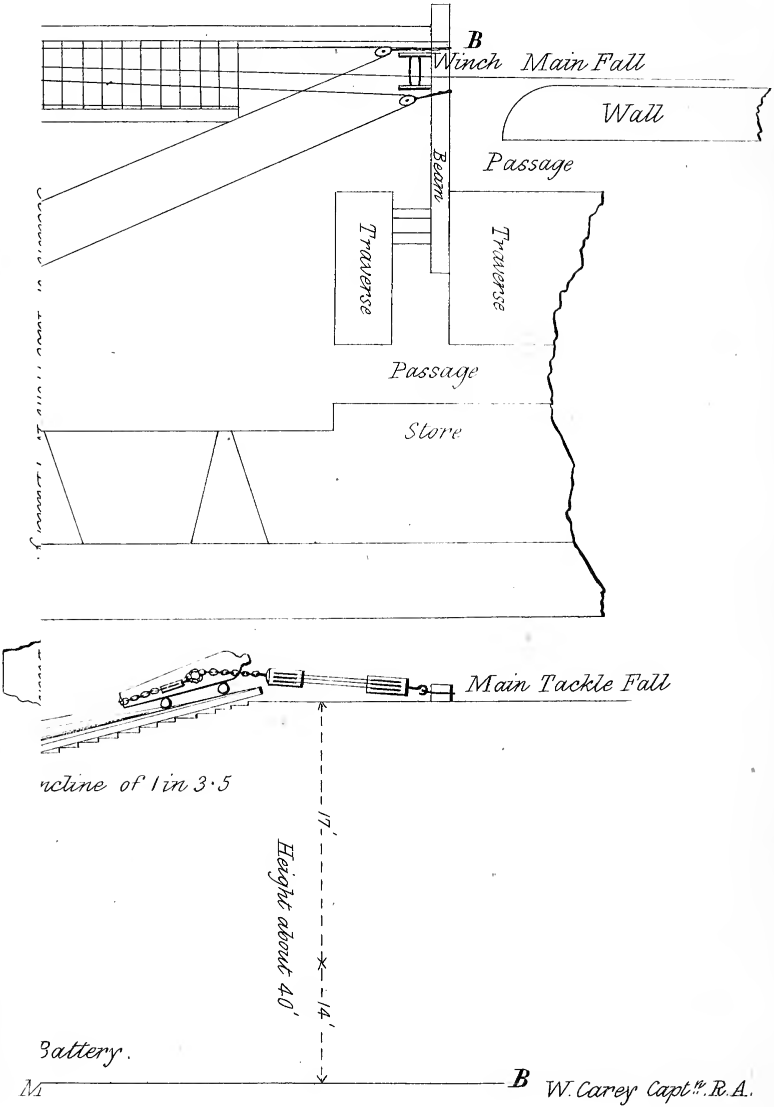


Malta 20th April 1870.

W Carey Captn. R.A.

PL.VI.

ORT S.T ANGELO.



W. Carey Capt.n R.A.

PL. VI.

raised the 36 ft. in 50 minutes. The inclination of the sheers at the time of taking the weight was 13 ft.

The guns were mounted in No. 3 Battery by means of the gyn, but were moved across the fort slung under two sling wagons, which travelled easily on firm ground, but owing to the narrowness of the wheels, sank at once in soft ground, when it was found necessary to lay down planks.

Fort St. Angelo (Plate V.)—Two of the three guns for this fort were raised from No. 1 into No. 2 Battery—a height of 43 ft.—by the same means as at Fort Ricasoli. One gun was raised in an hour and a quarter, the second in an hour.

As both guns were brought in at the same embrasure, the first had to be removed out of the way before the second was raised. In doing this, it had to be lowered about 2 ft. into the work. This was done by easing it down from the sill of the embrasure on an inclined plane of skids, by means of rollers and a 5-inch gyn tackle, which was secured to a 9-inch beam lashed across the sheers about 3 ft. above the feet.

The second gun was rolled back on to its platform, and both guns were then mounted by means of the gyn.

15-inch and 18-inch single blocks were very much required for leading off the falls of the tackles, and as only two 18-inch both-ways blocks had been received with the heavy gear, wire-strapped blocks were obtained from H.M. Dockyard.

The third gun for St. Angelo (Plate VI.) was taken up through the sallyport leading from No. 1 to No. 2 Battery.

The sallyport, for about two-thirds of its length, is tunnelled in the rock, and consists of two flights of steps from 6 ft. 6 ins. to 7 ft. wide, which meet about half way up, and are nearly at right angles to one another. A flag stone 7 ft. square in the angle forms a landing. The length of the lower portion was about 60 ft., the incline one in 3·35; the upper portion is 100 ft. long, with an inclination of one in 3·5.

The gun, placed on skids and rollers opposite the gate, was steadied by a temporary cradle, formed of two 14 ft. skids, bolted together in such a way that it might be taken to pieces as required.

An iron chain was used as a gun-sling, into which a main and two side or preventor tackles were hooked.

The main tackle consisted of a 6-inch coil of rope, rove through two double 18-inch blocks, the standing block being secured to a 20 ft. skid placed diagonally across the wall at the landing, one end resting in a recess, the other butting in a hole cut in the second flight of steps. This beam was also secured by a strut against the opposite wall.

A leading block led the running end of the tackle from the beam to a winch at the top of the sallyport.

The side tackles were 3½-inch rope, rove through double and treble blocks, the standing blocks of which were secured to a 13 ft. beam placed horizontally a little above the stone in the landing. The falls of these tackles were also led to the top of the sallyport, and thence to capstans. The rollers, 9 ins. in diameter, were 6 ft. long.

Skidding was laid down over the steps, and the gun was brought up from its position at the entrance of the sallyport to the landing—

a distance of about 80 ft.—in about two hours. When within 18 ins. of the landing, it was found that the blocks of the main tackle would not fleet, owing to the way in which the standing end was secured. Another tackle was applied from the top of the sallyport to the cascable, which was about 3 ft. beyond the corner, and the gun was landed and partly turned; but in doing this it was jammed on the cradle, and could not be extricated that day. It was afterwards cleared by means of hydraulic jacks, &c., and the gun was brought up the remaining 100 ft. of sallyport in two hours.

There was ample space for turning the gun in the angle; the failure originated in an oversight of not noticing the way in which the standing end of the tackle was secured, and then in allowing the gun to jam on the cradle in turning before it was safely landed.

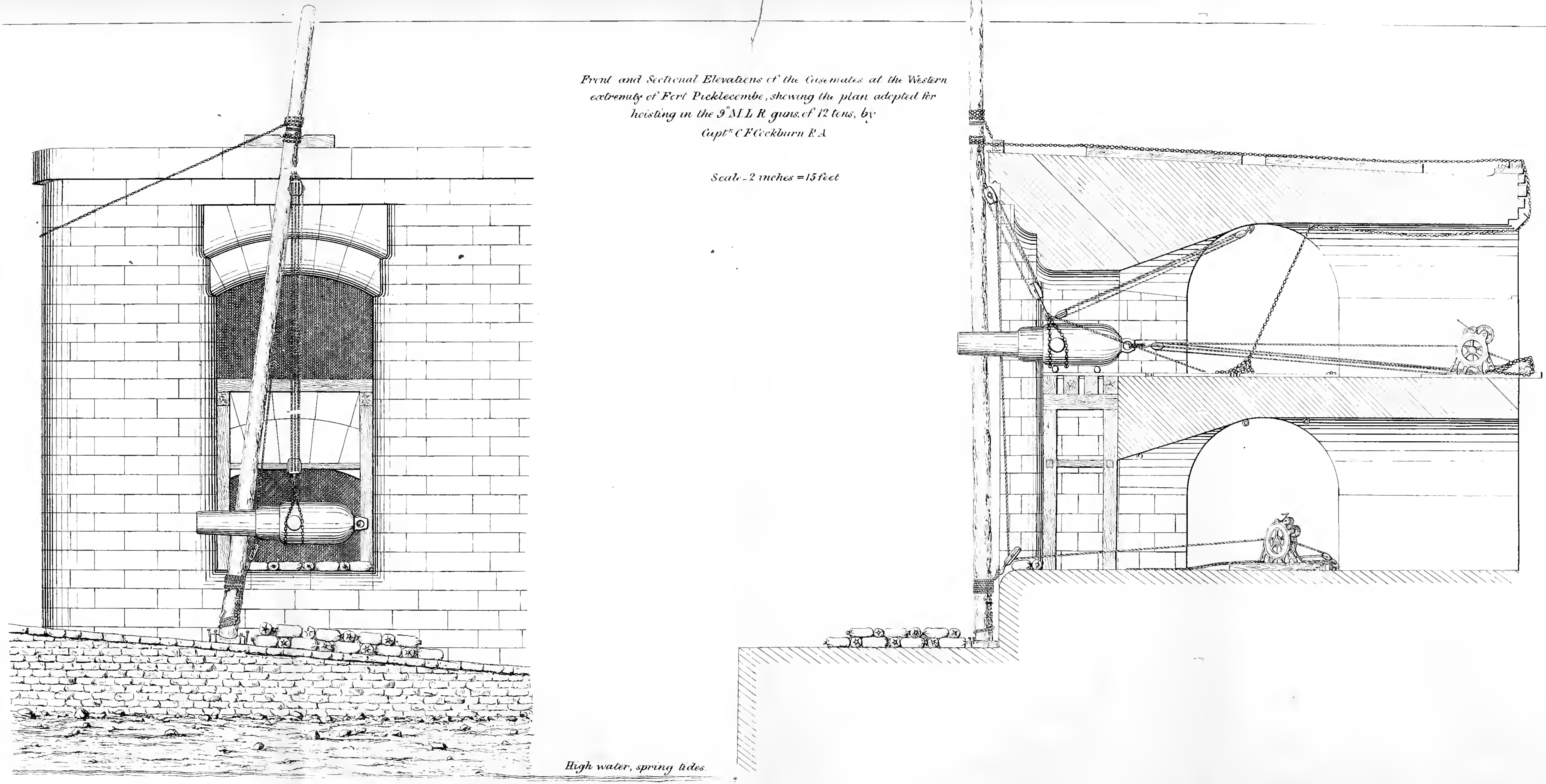
Had it not been for this, the gun would probably have been clear of the sallyport in five or six hours.

W. CAREY,

Captain, R.A.

Front and Sectional Elevations of the Casemates at the Western extremity of Fort Picklecombe, showing the plan adopted for hoisting in the 9" M.L R guns, of 12 tons, by
Capt^{n} C F Cockburn R A

Scale - 2 inches = 15 feet



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GENERAL ABSTRACT

OF THE

INCOME AND EXPENDITURE OF THE ROYAL ARTILLERY INSTITUTION,

From 1*st April*, 1870, *to* 31*st March*, 1871.

EXPENDITURE.

		£	s.	d.	£	s.	d.
Printing	Wages	144	7	5	671	15	1
	Type and Materials	148	0	0			
	Paper	205	17	5			
	Woodcuts	88	7	0			
	Lithography	85	3	3			
Chemistry					5	7	11
Photography	Attendance and Instruction	22	4	9	93	9	4½
	Chemicals and Apparatus	12	4	6			
	Printing and Mounting	59	0	1½			
Drawing	Instruction	105	0	0	106	9	7
	Materials	1	9	7			
Lectures					45	12	9
Taxidermy					16	11	6
Mathematical Instruction					25	4	0
Library, and Books for Sale					278	8	7½
Museum					100	16	0
Instruments					22	11	4
Carpenter	Wages	18	9	2	79	9	4½
	Materials	61	0	2½			
Furniture and Repairs					10	10	4
Subscriptions to Societies					4	4	0
Stationery					132	19	1
Postage and Parcels					54	16	8½
Incidental Expenses					55	11	9½
Wages to Clerks and Orderlies					131	12	8
War Office Photographs and Lithographs					44	6	1½
Paid for £325 4s. 1d. Consols					300	0	0
Premium for Fire Insurance of £5000					12	10	0
Cash in hand, 31st March, 1871,	Secretary	1	18	0½	2	12	1½
	Messrs. Cox & Co.	0	14	1			
					£2194	18	4½

INCOME.

		£	s.	d.	£	s.	d.
Cash in hand, 1st April, 1870					111	19	5
Printing					337	14	1
Chemistry					0	5	9
Photography	Chemicals	6	0	0	111	5	1
	Printing and Mounting	105	5	1			
Drawing	Instruction	68	2	9	70	1	0
	Materials	1	18	3			
Taxidermy					13	15	0
Mathematical Instruction					11	11	0
Books sold					96	12	11
Carpentry and Wood					19	3	1
Subscriptions	Entrance	62	0	0	1111	8	0
	Annual	1037	9	0			
	For 1871–2	11	19	0			
Stationery					181	3	7
Postage and Parcels					36	13	0½
War Office Photographs and Lithographs					48	6	9
Dividend on £1361 1s. 6d. Consols					20	2	3
Do. £1686 5s. 7d. do.					24	17	5
					£2194	18	4½

DR. DEBTOR AND CREDITOR ACCOUNT, 31st MARCH, 1871. CR.

	£	s.	d.
By Accounts with:—			
Mr. Gould, for "Birds of Australia"	110	15	0
Controller, Woolwich, for War Office Photographs and Lithographs	16	5	1
Messrs. Boddy and Co., for Stationery, Books, &c.	28	18	8
,, Tapling and Co., for Furniture	29	7	7
Balance Creditor	2208	4	7½
	£2393	10	11½

		£	s.	d.	£	s.	d.
Balance Cr.	Cash in hand	2	12	1½	1688	17	8½
	Consols Stock	1686	5	7			
Value of Stock.	Books for Sale	31	16	8	413	11	8
	Stationery	52	1	5			
	Printing Paper	48	13	6			
	"Handbooks" (unbound)	154	3	4			
	"Kane's Lists" do.	106	16	9			
	Chemicals in Laboratory	20	0	0			
Amount owing by Members and others for	"Kane's Lists"	14	17	0	291	1	7
	"Handbooks"	41	6	0			
	Printing	48	14	4			
	Chemistry	0	5	8			
	Photography	20	12	2			
	Drawing: Instruction	5	1	9			
	Drawing: Materials	0	9	11			
	Taxidermy	5	18	6			
	Mathematical Instruction	1	1	0			
	Books	29	7	8			
	Carpentry and Wood	3	16	10			
	Annual Subscription	26	14	0			
	Stationery	59	15	9			
	Postage	17	12	10½			
	War Office Photographs and Lithographs	15	8	1½			
					£2393	10	11½

Examined and found correct,

JOHN DESBOROUGH, Colonel R.A., President Sub-Committee.

WOOLWICH, 29th April, 1871.

A. D. BURNABY, Capt. R.A., Secretary and Treasurer.

ON,

£	s.	d.	£	s.	d.
			111	19	5
			337	14	1
			0	5	9
6	0	0	111	5	1
05	5	1			
8	2	9	70	1	0
1	18	3			
			13	15	0
			11	11	0
			96	12	11
			19	3	1
2	0	0	1111	8	0
7	9	0			
11	19	0			
			181	3	7
			36	13	0½
			48	6	9
			20	2	3
			24	17	5
			£2194	18	4½

Cr.

£	s.	d.	£	s.	d.
2	12	1½	1688	17	8½
86	5	7			
31	16	8	413	11	8
52	1	5			
48	13	6			
54	3	4			
06	16	9			
20	0	0			
14	17	0	291	1	7
41	6	0			
48	14	4			
0	5	8			
20	12	2			
5	1	9			
0	9	11			
5	18	6			
1	1	0			
29	7	8			
3	16	10			
26	14	0			
59	15	9			
17	12	10½			
15	8	1½			
			£2393	10	11½

nd Treasurer.

ANNUAL REPORT

AND

ABSTRACT OF PROCEEDINGS OF A GENERAL MEETING OF THE ROYAL ARTILLERY INSTITUTION, HELD ON MAY 23, 1871.

Colonel A. Benn in the Chair.

1. The Committee of the Royal Artillery Institution has the honor to present to the Annual General Meeting its Report and the Abstract of Accounts for the year ending 31st March, 1871.

It will be seen by the accompanying table that during the past year 51 officers have joined the Institution; and, after allowing for casualties caused by deaths, withdrawals, &c., there is a net increase of 19 members.

Rank.	April, 1870.	Additions during the year, due to					Total addition.	Deductions during the year, due to							Total deduction.	April, 1871.
		Promotion.	Retirement.	Re-election.	Removal from retired list.	New members.		Promotion.	Retirement.	Removal to effective list.	Resignation.	Withdrawal.	Names written off by Committee.	Deaths.		
EFFECTIVE LIST.																
General and Regimental Field Officers	190	11	—	—	—	1	12	—	6	—	—	1	—	2	9	193
Captains	461	6	—	1	1	9	17	11	2	—	2	1	2	5	23	455
Lieutenants	513	—	—	1	—	37	38	6	1	—	8	1	1	5	22	529
Paymasters	7	—	—	—	—	—	—	—	—	—	—	—	—	—	—	7
Quarter-Masters	10	—	—	—	—	1	1	—	2	—	—	—	—	1	3	8
Riding-Masters	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5
Surgeons-Major	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5
Surgeons	2	—	—	—	—	1	1	—	—	—	—	—	—	—	—	3
Assistant-Surgeons	16	—	—	—	—	—	—	—	—	—	1	—	—	—	1	15
Veterinary Surgeons	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5
RETIRED LIST.																
General and Regimental Field Officers	58	—	6	—	—	—	6	—	—	—	—	—	—	2	2	62
Captains	43	—	4	—	—	—	4	—	—	1	—	—	—	2	3	44
Lieutenants	4	—	1	1	—	—	2	—	—	—	—	—	—	—	—	6
Surgeons-Major	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2
Assistant-Surgeon	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
Chaplain	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
Quarter-Master	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
Honorary Members	42	—	—	—	—	2	2	—	—	—	—	—	—	1	1	43
Total	1366	17	11	3	1	51	83	17	11	1	11	3	3	18	64	1385

A list of members accompanies this Report.

2. With regard to the financial condition of the Institution, the Committee is glad to inform the meeting that it is in a sound and flourishing state, and that a further sum of £300 (realising £325 4*s.* 1*d.*) has been invested in Three per Cent. Consols Stock during the past year.

The general abstract shows the income and expenditure for the past year.

3. *Printing and Publication.*—Vol. VI. of the "Proceedings" has been completed, and four numbers of Vol. VII. have been issued, the papers enumerated in the annexed list having been published during the past year. Many of them are of great and permanent value.

List of "Proceedings" printed during the year.

The Mobility of Field Artillery; Past and Present. By Lieut. H. W. L. Hime, R.A. (No. I.)

On the Arrangement of Expense Magazines, Shell Rooms, Small Stores, and Side-Arm Sheds for Batteries of Heavy Rifled Guns. Communicated by the Director-General of Ordnance.

On the Construction of Batteries. By Major Griffith Williams, R.A. (*Circa* 1780). Communicated by Major-General Lefroy, C.B., R.A.

Heavy Rifled Guns. By Captain Haig, R.A., F.R.S.

The Field Gun for India. A paper read at the R.A. Institution, Woolwich, February 22, 1870, by Colonel H. H. Maxwell, R.A.

A Description of the "Scale of Shade," for representing Ground in Relief. By Captain G. A. Crawford, R.A.

Our Rifled Projectiles and Fuzes; Present Construction and Probable Efficiency on Service. A paper read at the R.A. Institution, Woolwich, March 8, 1870, by Captain C. Orde Browne, R.A., Captain Instructor, Royal Laboratory.

Remarks on Captain Nolan's Range-finding Apparatus. By Lieut. C. E. B. Leacock, R.A.

The Examination and Proof of Gunpowder, as carried on at the Royal Gunpowder Factory, Waltham Abbey. By Captain F. M. Smith, R.A., Assistant Superintendent.

English Guns and Foreign Critics. By Captain Vivian Dering Majendie, R.A., Assistant Superintendent, Royal Laboratory.

The Mobility of Field Artillery; Past and Present. By Lieut. H. W. L. Hime, R.A. (No. II.)

A Proposal for a Very Heavy Breech-Loading Gun of Novel Construction. A paper read at the R.A. Institution, Woolwich, April 12, 1870, by Captain J. P. Morgan, R.A.

Camel Guns. By Colonel H. H. Maxwell, R.A., Superintendent Cossipore Gun Foundry.

On Axle-tree Seats for Field Batteries. By Captain H. L. Balfour, R.A.

On the Re-Armament of Gibraltar. By Captain J. B. Richardson, R.A.

A Proposal for the Drill of Gunners of Field Batteries at other than Regimental Exercises. By Captain and Brevet-Major H. L. Geary, R.A., Adjt. 14th Brigade, R.A. (Field).

Some Observations amongst German Armies during 1870. By Colonel H. A. Smyth, R.A.

The Story of the 36-inch Mortars of 1855–58. By Major-General Lefroy, C.B., F.R.S., R.A.

The Reform of Prussian Tactics. A Lecture delivered at the R.A. Institution, Woolwich, December 13, 1870, by Lieut.-Colonel C. C. Chesney, R.E.

The Future Armament of our Field Artillery. A Paper read at the R.A. Institution, Woolwich, January 16, 1871, by Lieut. C. Jones, R.A., Captain Instructor, Royal Gun Factories.

The Merits of a Large Bore and Small Bore Contrasted, with reference to Rifled Artillery and Small-Arms. A Lecture delivered at the R.A. Institution, Woolwich, February 17, 1871, by Lieut. J. Sladen, R.A., Assistant Instructor, Royal Laboratory.

Mounting of Twelve 12-ton Guns at Malta, 1870, by 10th Brigade, R.A.

Short Notes on Professional Subjects, 1870.

Experiments with an 8¾-inch Krupp's Steel Gun at the Polygon of Brasschaet.

Experiments with a Krupp's Steel Gun at the Polygon of Brasschaet against iron-plated Targets of the "Warrior" and "Bellerophon" types.

Boxer Shrapnel Shells for Rifled Guns.

Table of Electro-Ballistic Experiments.

Account of Experiments with Gun-cotton and Nitro-glycerine.

Description of a Scale to be attached to instruments for finding the Distances of Ships at sea from elevated Coast Batteries.

Memorandum, dated July 12, 1870, relative to the progress of experiments by the Committee on Explosives since Preliminary Report.

The Line of Sight employed in laying Field Guns.

Abstract of a Report of an Experiment carried out at Colombo, by Colonel Cox, Commanding Royal Artillery, Ceylon, to determine the penetration of round shot.

Demolition of No. 37 Martello Tower by Gun-cotton, May 31, 1870.

Pocket Sextant.

Electro-Ballistic Experiments.

On the best means of ensuring Accurate Practice at Shipping from elevated Coast Batteries.

Piling of Shot and Shell—Elongated Projectiles.

Picric Powder.

Time and Percussion Fuzes for Field Artillery.

Directions for the use of Captain Tracey's Range Scale.

Method adopted for hoisting in the 9-inch M.L.R. Gun at Fort Picklecombe, Plymouth.

Captain J. P. Nolan's Range-finder.

Much interesting information has been published in the "Short Notes on Professional Subjects," which have accompanied each issue of the "Proceedings" since the last report, and it is hoped that an increasing number of members will aid in support of this means of imparting to their brother officers the observations and experience of individual members on subjects of professional and scientific interest.

A revised copy of "List of Service Ordnance and Ammunition," corrected to 31st March, has been issued to each member, and it is gratifying to know that this publication has proved eminently useful.

A copy of the monthly Regimental Lists is now circulated to members with each number of the "Proceedings."

A memoir of the late Field-Marshal Sir Hew Dalrymple Ross, G.C.B., compiled from original MSS. in possession of his family, is in course of publication. There are few chapters in the history of the regiment more interesting than the military biography of this distinguished officer, extending as it does over a period of 73 years, during which time the Royal Artillery took a prominent part in many important campaigns. The services of Sir Hew Ross in the Peninsula were the commencement of a career which was as distinguished as it was beneficial to his corps. The Committee rejoices that the Institution has been permitted to be the means of laying before the officers of the regiment a record of such honourable and brilliant service.

As this memoir extends over 100 pages, the Committee has decided on only printing off a limited number of copies. Any member can obtain a copy on application to the Secretary.

The constant demands upon the printing press for other work for members, show the general usefulness of this part of the establishment, and also the necessity of enlarging it. The Committee trusts that this want will be overcome by the additional accommodation about being given to the Department of Artillery Studies, and the space vacated being handed over to the Institution.

Since the last meeting, complete sets of the "Proceedings" have been presented to the Director of Naval Ordnance, the National Artillery Association, and the Secretary of State for India.

The Committee has great pleasure in informing the meeting that the sum of £10 10*s.* has been placed at its disposal yearly for five years by an officer of the regiment, for the purpose of founding a medal for the best essay on matters connected with artillery; and in the event of his proposal being successful in its results, this officer is further prepared to place in its hands £100, on the condition that £5 10*s.* be taken out of the funds of the Institution yearly to make up the amount necessary for the purchase of this medal.

This liberal offer was unanimously accepted by the Committee, and the following are the conditions of competition, which were drawn up and circulated to members in September last:—

(1) The candidates must be officers on full pay, and members of the R.A. Institution.

(2) The essays shall be in alternate years, on matters connected with (*a*) the duties and position of artillery, and (*b*) the manufacturing departments.

(3) The essays, which must not exceed 16 octavo printed pages, must be forwarded to the Secretary on or before the 1st of April in each year. The essays to be strictly anonymous, but each to have a motto, and be accompanied by a sealed envelope with the motto written on the outside, and the name of the candidate inside.

(4) The name of the successful candidate shall be announced at the Annual Meeting, and medallists shall be distinguished as such in all lists, &c., issued from the Institution; and in the event of a University man gaining the medal, a report of his success will be made to the University of which he may be a member.

(5) The essays will be submitted for decision to three Referees, chosen by the Committee.

(6) The successful essay will be printed and circulated to members by the Institution.

The subject for the essay to be rendered before 1st of April, 1871, shall be any point the candidate may select, connected with the duties and position of artillery.

Eight essays have been received, and submitted to the Referees—viz., Major-General Eardley-Wilmot, R.A., F.R.S., Colonel Hamley, R.A., C.B., and Major Geary, R.A.—who have decided in favour of the essay bearing the motto "Trunnion," which proves to be that selected by Lieut. H. W. L. Hime, 11th Bde. R.A.

4. *Library.*—"Gould's Birds of Australia," in eight volumes, has been purchased at a cost of £158 15s., and the Committee has arranged for this sum being paid off at the rate of £20 yearly. This work has been published in the same admirable style as the companion works already possessed by the Institution, and is a most valuable addition to the library. The balance of the debt of £63 for "Gould's Humming Birds," agreed on to be paid by instalments, has been paid in full.

The scrap book, containing extracts from the newspapers on professional subjects, is still kept up.

A list of the more important lithographs issued by the different departments, and arranged in sets, accompanies this report.

These, as well as others not included in the sets, and photographs of various drills and exercises, can be obtained singly as heretofore by members.

The "List of Changes in Artillery Matériel" can now be procured gratis by members, the Secretary of State for War having kindly placed at the disposal of the Committee a certain number of copies for distribution.

Among the works presented during the past year, one is specially worthy of mention—the "Official Record of the Abyssinian Expedition," presented by the Secretary of State for War; a handsome and valuable addition to the professional branch of the library.

In the following list of presentations it will be seen that very many maps have been received from the War Office, 17 of which illustrate the Peninsular battles from 1804 to 1810.

Books, &c., presented.

Journal of the Royal United Service Institution, Nos. 55 to 61, and Appendix Medical, Military, and Surgical Essays... Hinde's Discipline	10	The Council, Royal United Service Institution.
Proceedings of Institution of Mechanical Engineers, Nov. 1869, Jan., Apr., Aug., and Nov. 1870	5	The Council, Institution of Mechanical Engineers.
Lecture on the Construction and Maintenance of Telegraph Lines, by R. S. Culley, Esq.	1	The Commandant, School of Military Engineering.
Analytical Tables, &c., for use in the Laboratory, School of Military Engineering Lecture on "Building Materials," by W. D. Dent, Esq. Lecture on Railway Construction, by W. C. Unwin, Esq.	3	
Report on the present state and condition of Prehistoric Remains in the Channel Islands, by Lieut. S. P. Oliver, R.A.	1	The Author.

Megalithic Structures of the Channel Islands, by Lieut. S. P. Oliver, R.A., F.R.G.S.	1	The Author.
The Geology of St. Helena, by Capt. J. R. Oliver, R.A.	1	The Author.
Artillerie Practique employée sous les régnes et dans les Guerres de Louis XIV. et Louis XV., par le Baron Espiard de Cologne. With Plates	1	Lieut. H. W. L. Hime, R.A.
Notes on the Prospects of Lieutenants, Royal Artillery, by Lieut. H. W. L. Hime, R.A.	1	
Napier's History of the Peninsular War, in 6 Volumes	1	
Die Verwaltung des Norddeutschen Bundesheeres	1	
Hart's Army List, October, 1869, and January, April, and July, 1870	4	The Committee, R.A. Library.
Russian Artillery Journal, No. 12 of 1869, and 1 to 4 of 1870	5	Maj.-General N. de Novitzky.
Journal of the Royal Geographical Society, Vol. XXXIX.	1	The Council, Royal Geographical Society.
Proceedings of the Royal Geographical Society, Nos. 3, 4, and 5	1	
Journal of the East India Association, No. 1, Vol. II.	1	The Council, East India Association.
A Brief Account of some Travels in Hungaria, Servia, &c., by Edward Brown, M.D.	1	Gunner W. J. Pilley, R.A.
Proceedings of the Scientific Meetings of the Zoological Society of London, Parts 2 and 3	2	The Council, Zoological Society of London.
Smithsonian Report, 1868 " Contributions to Knowledge, Vol. XIV. " Miscellaneous Collections, Vols. VIII. and IX.	4	The Council, Smithsonian Institution.
Astronomical and Meteorological Observations made at the United States Naval Observatory during the year 1867	1	
Popular Science Review, Vols. I. to V. Wells on Dew	6	Lieut. N. S. Perceval, R.A.
Euvers du Marquis De Chambray. Three Vols. and Atlas Histoire de Napoleon et de la Grande Armée. Two Vols.	5	
Notes on the Great Pyramid of Egypt, by Colonel Sir H. James, R.E.	1	Lieut.-Colonel Milman, R.A.
Table showing the fall by Gravity in the Atmosphere, by Major-General P. Anstruther, C.B., R.A.	1	The Author.
Report on the Cartographic Application of Photography, by Lieut. J. Waterhouse, R.A.	1	The Author.

Maps of England, Wales, and Scotland, showing the Railways and Military Stations	2	Secretary of State for War.
Duplicate sets of 17 Plans, illustrating the Peninsular Battles from 1804 to 1810	17	
Record of the Expedition to Abyssinia. Two Vols. and Plates	1	
Copies of Maps of France, in 7 parts, viz., 9, 10, 14, 15, 17, 18, and 19 ...	2	
Copy of Map of France, in 3 sheets, and one copy of Map of Paris	1	
Sheet Maps of Paris, Berlin, Brussels, Basil, Hanover, and Munich	6	
Sheet Map of Mézières		
Carte Hydrographique du Départment de la Seine	1	
Photo-Lithographs, complete set of		
Treatise on Ammunition, Part 2	1	
Ideas on our Military Position in a war with Russia, by an Austrian Officer...	1	
Accounts of the Systems of Military Education in France, Prussia, Austria, Bavaria, and the United States	1	
Strength and Organisation of a North German Army Corps	1	
Report of a Special Committee on Ammunition for Martini-Henry Breech-Loading Rifles	1	
Handbook of the Manufacture and Proof of Gunpowder	2	
R.G.F. Lithographs	16	
R.L. Lithographs	3	
R.C.D. Lithographs	88	
War Office Photographs	64	
Description and use of Le Boulenge's Chronograph, by Lieut. C. Jones, R.A.	6	
Memorandum relative to the progress of Experiments by the Committee on Explosives since Preliminary Report of February, 1870	1	
Report of Special Committee on Field Artillery Equipment for India, 1869	1	
Experiments made with the Bashforth Chronograph, 1865 to 1867	1	
Captain Majendie's Report on an Official Visit to Belgium	1	
Ten Months in the Fiji Islands, by Mrs. W. J. Smythe	1	The Author.
Eclipses of the Sun, by Lieut. Collins, R.E.	1	The Author.
Our Effective Artillery; a Pamphlet, by Mr. Bashley Britten	1	The Author.
The last Campaign of Hanover, by Capt. H. Brackenbury, R.A.	1	The Author.

The British Army and Reserves	1	Anonymously.
Examination Papers, Royal Military Academy, June and December, 1870	...	The Governor, Royal Military Academy.
Report of the Central Committee on the Soldiers' Industrial Exhibition, 1870	1	
Institution of Civil Engineers. Minutes of Proceedings, Catalogue of Library	1	The Council, Institution of Civil Engineers.
Metals: their Properties and Treatment, by Professor Bloxam	1	The Author.
"Canada;" a Lecture by Captain F. Duncan, R.A., M.A., &c., &c., &c.	1	The Author.
History of Alsace and Lorraine, in German, by Gustave Gotting	1	The Author.
Imperial Strategy, by Captain J. C. R. Colomb, Adjutant Limerick Artillery Militia	1	The Author.
Reorganisation of our Military Forces, by Capt. J. C. R. Colomb	1	
Cours D'Administration Militaire, par. Vauchelle. Three Vols.	3	Mrs. H. F. Strange.
La Guerre de Sept ans Atlas		
Plates—Macaulay's Field Fortification...		
Netherlands Artillery Atlas	1	Netherlands Government.
Sheet Drawings of the Netherlands Artillery Material	6	
Tide Observations at Otaheite or Taheti, by Capt. Sir E. Belcher, R.N.	1	The Author.
A National Army; or, How to Solve the Problem of the Day, by Major J. Bevan-Edwards, R.E.	1	The Author.
Jackson's Woolwich Journal, from 1857 to 1862. Bound..................	2	Major-General J. H. Lefroy, C.B., R.A.
Preliminary Experiments on the Mechanical and other Properties of Steel	1	The Committee of Civil Engineers.

Books purchased.

Minutes of Evidence taken before the Royal Commission appointed to enquire into the present state of Military Education, &c., with appendix.
Revue Militaire Francaise. April, June, July, and September, 1870.
Manual of Artillery Exercises. Parts I. & II., and III.
The Ibis. Nos. 22, 23, and 24, Vol. VI. No. 1, Vol. I., new series.
Military Forces of the Crown. Two Vols.
Monograph of the Barbets. Parts II., III., IV., V., and VI.
Monograph of the Kingfishers. Parts IX., X., XI., XII., XIII., and XIV.
Gould's Birds of Great Britain. Parts XVII. and XVIII.
Monograph of the Pheasants. Parts I. and II.
Gould's Birds of Australia, in 8 Vols.
Gould's Birds of Asia. Part XXIII.
Witney's Metallic Wealth of the United States.
Record of the Expedition to Abyssinia. Two Vols.
The Student's Text Book of Electricity.
Instruction in Military Engineering. Vol. I.
Field Exercises and Evolutions of Infantry for 1870, with key.
Notes on Electricity. Tyndall.

Report of the Committee on Promotion and Retirement of Officers of the Ordnance Corps. Two copies.
The Campaign of 1866; A Tactical Retrospect. Translated from the German, by Colonel H. A. Ouvry.
Regulations for the Great Manœuvres of the Prussian Army, 29th June, 1861.
Manual of Gunnery for Her Majesty's Fleet.
Colonel Frome, R.E., on Surveying.
Text Book of Science. Elements of Mechanism.
Nautical Almanac of 1871–72–73.
Prussian Work on Rifled Field Guns, by Major Roerdansz.
O'Byrne's Collection of Army Circulars and General Orders for 1867–68–69.
The British Army and its Reserves.
Prussian Infantry, 1869.
Lessons of War, as taught by the Great Masters. By Lt.-Col. J. F. Soady, R.A.
Publication of the Palæontographical Society for 1870.
Polygonal Fortification, and Atlas; treatise on.
The Imperial Calendar.
Owen's Modern Artillery. Two copies.
Manual of Electricity, by H. M. Noad.
Lavallie's Physical, Historical, and Military Geography.
Percy's Metallurgy of Lead.
The Military Resources of Prussia and France.
Researches on Diamagnetism and Magne-crystallic Action, by Tyndall.
A System for forming the Regular Troops, Militia, and Volunteers into an Army.
Taubert's Field Artillery. Translated by Lieut. H. H. Maxwell, Bengal Artillery.

Arundel Society Plates.

Jesus and His Disciples at Emaus.
Christ and Mary Magdalene in the Garden.
The Triune God, the Virgin Mary, and St. John the Baptist.

5. *Museum.*—A list of the various donations to the museum accompanies this report.

During the past year the following additions have been made to the natural history collection—viz., a white tiger skin, very valuable and rare (shot at Mowlee, Jynteeah Hills, India) by Capt. C. W. Wilson, R.A.; head and horns of Thibetan and Indian antelopes, by Lieut. J. Biddulph, 19th Hussars; a very interesting collection of animals and birds, with a few shells, from Madagascar, by Lieut. J. C. Robinson, R.A.; a pair of Bengal florikens, by Brig.-General Bourchier, C.B., R.A.; insects and eggs from Australia, by Capt. Sandilands, R.A.; some birds from Canada and India, by Lieut. A. G. Yeatman, R.A., and Lieut. Beadnell, R.A., respectively; a few fine specimens of birds from Australia, by Asst.-Surgeon Fiddes, M.B., R.A.; 16 birds from China and 41 humming birds, by Mr. H. Whitely; 7 birds from Alderney, by Lieut. G. Montgomery, R.A. For all these the best thanks of the Institution are due to the donors.

Of British birds only one new specimen has been presented—viz., a male capercaillzie, by Capt. J. S. Stirling, R.A. The Committee has been enabled to obtain, by purchase, 23 choice specimens, it being most desirable that the collection of birds of the British Isles be made as complete as possible. As a guide to those members willing to assist, by sending skins or complete specimens, a list is given of the desiderata in this part of the museum.

More than 100 typical specimens of birds have been added to the mounted collection, the whole of which have been named and labelled. A catalogue of all the mounted specimens has been completed.

The antelope heads, horns, as also the reptiles arranged round the museum, have been labelled, and the donors' names attached.

Twelve officers have received instruction in Taxidermy during the year.

Consequent on the long connection with, and valuable services rendered to the Institution by Mr. Whitely, the Curator of the Museum, and also in consideration of the many donations given to it, the Committee has granted him, subject to the approval of the general meeting, an increase of £10 yearly, commencing on the 1st January, 1871.

Presentations to Museum.

Frogs	2	Rev. A. C. Fraser.
Chinese Summer Shirt and Slippers	...	Vice-Admiral Goldsmith, C.B.
Large Chinese Drawings in Water Colours, mounted on rollers	4	Capt. J. R. Dyce, R.A.
Mineralogical Specimens, consisting of Gold, Silver, Copper, and Lead Ores	14	Lieut. A. B. Brown, R.A.
Japanese Fishing Rod	1	Maj.-General Buchanan, R.A.
Skin of White Tiger	1	Capt. W. Wilson, R.A.
Antelopes' Heads and Skins	2	Lieut. J. Biddulph, 19th Hussars.
Collection of Birds and Minerals, 4 Horn Spoons, Horn Drinking Utensil and Dish, and Bamboo Snuff-box, from Madagascar	...	Lieut. J. R. Robinson, R.A.
29 Birds and 1 Fish from Canada	30	Lieut. A. G. Yeatman, R.A.
Type Specimens of rare China Birds	16	Mr. Whitely.
Humming Birds	41	
Birds from India	2	Lieut. Beadnell, R.A.
Birds from Scotland	2	Capt. J. S. Stirling, R.A.
Birds shot at Alderney	7	Lieut. Montgomerie, R.A.
Birds from India	2	Brig.-General G. Bourchier, C.B., R.A.
Australian Birds	10	Asst.-Surg. Fiddes, M.B., R.A.
Armstrong E Time Fuze, whole section	...	Mrs. H. F. Strange.
„ B „ „		
„ Concussion „ A „		
„ Percussion „ C „		
„ Pillar „ „		
„ Percussion „ Plug & thimble, Naval Service.		
Moorsom's Fuze, whole and section		
Boxer's Time Fuze, section only		
Pettman's Land Service, „		
(The whole in a mahogany case.)		
Obsolete Copper Coins from Gibraltar	75	Capt. J. B. Richardson, R.A.
Regulation Helmet for Officers, R.A., in India, from 1864 to 1870	1	Lieut. T. H. Lloyd, R.A.

1 Converted Enfield Rifle and Bayonet, 1 United States Cavalry Sword, and 1 Coat and Cap of a Fenian taken in a skirmish at Eccles Hill, Missisquoi, Canada, 25th May, 1870	...	H.R.H. Prince Arthur.
Insects (various) from Australia	99	Capt. Sandilands, R.A.
Eggs 〃	2	
Glass Case containing Eighty Medallion Casts, illustrating various victories during the Peninsular Campaign	80	Colonel Lewes.
Snouts of Saw Fish	3	Mr. Whitely.

Birds from India, presented by Lieut.-Colonel Bourchier, C.B., R.A.

Sypheotides bengalensis. ♂[*] ♀[†]

Birds from America, presented by Lieut. A. G. Yeatman, R.A.

Picus villosus. ♀
Melanerpes erythrocephalus.
Colaptes auratus.
Ceryle alcyon. ♀
Tyrannus carolinensis.
〃 〃
Myiarchus crinitus.
Turdus solitarius. ♂
〃 〃 ♂
〃 〃 ♀
〃 migratorius.
Mimus polyglottus.
〃 carolinensis.
Silia sialis.
Setophaga ruticilla. ♂

Dolichonyx oryzivorus. ♂
Quiscalus major.
Cyanocitta californica.
〃 〃
Demiegretta ludoviciana.
Garzetta candidissima.
Tringa alpina.
〃 wilsonii.
〃 〃
〃 〃
〃 〃
〃 bonapartii.
〃 〃
Limosa fedoa.

Birds from India, presented by Lieut. Beadnell, R.A.

Hydrophasianus sinensis.
Hydrophasianus sinensis, young.

Birds from Scotland, presented by Capt. J. S. Stirling, R.A.

Tinnunculus alaudarius. ♂
Tetrao urogallus. ♀

Birds from China, presented by H. Whitely.

Megalæma nuchalis.
Lanius shach.
〃 lucionensis.
Anthus agilus.
Corydalla richardi.
Calliope camschatkensis.
Dicrurus macrocercus.
Leucodioptron sinensis.

Pomatorhinus musicus.
Spizixos semitorques.
Pericrocotus griseigularis.
Oriolus chinensis.
Gracupica nigricollis.
Dendrocitta sinensis.
Treron formosæ.
Turtur humilis.

Humming birds, 41.

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[*] ♂ Male.

[†] ♀ Female,

Birds and Animals from Madagascar, presented by Lieut. T. C. Robinson, R.A.

BIRDS.

Milvus parasiticus.
Eurystomus madagascariensis.
〃 〃
Centropus tolu.
Dicrurus forficatus.
Hypsipetes ourovang.
〃 〃
Hartlaubia madagascariensis.

Leptopterus viridis.
Vinago australis.
Ardea ruficrista.
Gallinago bernieri.
Dafila erythrorhyncha.
Phaeton phœnicurus.
〃 〃 young.

ANIMALS.

Propithece diadema.

Lemur niger.

Birds from Australia, presented by Asst.-Surg. T. M. Fiddes, M.B., R.A.

Pomatostomus superciliosus.
Meliornis sericea.
Grallina picata.
Todirhamphus sanctus.
Platycercus eximius.

Trichoglossus multicolor.
〃 〃
Calyptorhynchus xanthonotus.
Thalassoica glacialoides.
Daption capensis.

Birds from Alderney, presented by Lieut. G. Montgomery, R.A.

Upupa epops.
Charadrius hiaticula.
Hæmatopus ostralegus.
〃 〃

Alca torda.
Fratercula arctica.
Larus canus.

British Birds Purchased.

Archibuteo lagopus. ♂
Falco peregrinus. ♂
Circus æruginosus. ♂
Syrnium aluco. ♂
Otus brachyotus. ♂
Anser brachyrhynchus. ♂
Tadorna vulpanser. ♂
Casarca rutila. ♂ ♀
Mareca penelope. ♂ ♀
Dafila acuta. ♂
Querquedula crecca. ♂
Pterocyanea circia. ♂

Branta rufina. ♂
Fuligula cristata. ♂
Nyroca leucophthalmos. ♂ ♀
〃 ferina. ♀
Somateria mollissima. ♀
〃 spectabilis. ♂ ♀
Oidemia fusca. ♂
Mergus cucullatus. ♂
〃 albellus. ♀
Puffinus anglorum. ♂
Sula bassana. ♂

Presented by Captain C. W. Wilson, R.A., from India.

White tiger skin.

Presented by Lieut. J. Biddulph, 19th Hussars.

Head and horns of Thibetan and Indian antelopes.

Presented by Captain Sandilands, R.A., from Australia.

99 Insects, various.
Australian bustard egg.
Black swan egg.

Specimens required for the Collection of British Birds and Eggs.

Griffon vulture.
Egyptian 〃
Golden eagle.
Spotted 〃
Osprey.
Cinereous eagle.
Rough-legged buzzard. ♀
Honey 〃
Kite.
Swallow-tailed kite and egg.
Jerfalcon.
Peregrine falcon. ♀
Hobby.
Merlin.
Red-footed falcon.
Goshawk.
Hen harrier.
Ash-coloured harrier.
Marsh 〃 ♀
Great-eared owl.
Hawk 〃
Snowy 〃
Tengmalm's 〃
Short-eared 〃 ♀
Little 〃
Sparrow 〃
Long-eared 〃
Barn 〃
Nightjar.
Dartford warbler.
Blue-throated warbler.
Alpine accentor.
Crested titmouse and egg.
Bearded 〃 〃
White wagtail.
Grey 〃
Ray's 〃
Grey-headed wagtail and egg.
Richard's pipit and egg.
Tawny 〃 〃
Red lark and egg.
Rock thrush.
Ring ouzel.
Blackbird.
Golden oriole.
Pied flycatcher.
Great grey shrike and egg.
Nutcracker and egg.
Raven.
Jackdaw.
Mealy redpole and egg.
Siskin 〃
Serin finch 〃
Painted bunting 〃
Lapland 〃 〃
Ortolan 〃
Cirl 〃
Short-toed lark and egg.
Calandre 〃 〃
Crested 〃 〃
Wood 〃
Shore 〃
Pine grosbeak and egg.
White-winged crossbill and egg.
Parrot 〃 〃
Three-toed woodpecker 〃
Downy 〃 〃
Hairy 〃 〃
Great spotted 〃 〃
Lesser 〃 〃
Great black 〃
Green 〃
Yellow-billed cuckoo and egg.
Great spotted 〃 〃
Ring dove.
Rock 〃
Palla's sand grouse and egg.
Pheasant.
Quail.
Andalusian quail and egg.
Capercaillie. ♂
Ptarmigan.
Ruffed bustard and egg.
Little 〃 〃
Great 〃
Little ringed plover.
Kentish 〃
Golden 〃
Crane.
Buff-backed heron.
Great white 〃
Purple 〃
Squacco 〃
Common bittern.

Little bittern.
Night heron.
Spoonbill.
Black stork and egg.
White "
Glossy ibis.
Whimbrel.
Esquimaux curlew and egg.
Bartailed godwit.
Black-tailed "
Spotted redshank and egg.
Yellow-shanked sandpiper & egg.
Green " "
Green-shank " "
Buff-breasted " "
Bartram's " "
Wood "
Spotted "
Avocet.
Black-winged stilt and egg.
Knot and egg.
Bonaparte's sandpiper and egg.
Purple " "
Pectoral " "
Temminck's stint and egg.
Little " "
Broad-billed sandpiper and egg.
Sanderling and egg.
Brown snipe and egg.
Great snipe.
Woodcock.
Grey phalarope and egg.
Red-necked phalarope.
Little crake and egg.
Moor hen.
Coot.
Spurwinged goose.
Egyptian "
Bernicle "
Red-breasted "
Canada "
Grey lag "
Bean "
White-fronted "
Hooper.
Bewick's swan and egg.
Polish "
Shieldrake. ♀
Wild duck.
Bimaculated duck and egg.
Garganey. ♂
Gadwall and egg.
Shoveler.
Red-crested duck and egg. ♀
Tufted duck. ♀
Golden eye.
Buffle-headed duck and egg.
Harlequin " "
Western " "
Eider ♂ "
Velvet scoter and egg. ♀
Common " "
Surf " "
Goosander.
Hooded merganser and egg. ♀
Red-breasted "
Smew and egg. ♂
Great northern diver and egg.
Black-throated "
Red-throated "
Red-necked grebe.
Sclavonian " ♂
Great crested "
Eared "
Brunnich's guillemot.
Black "
Little auk and egg.
Dusky shearwater and egg.
Greater "
Forked-tailed petrel and egg.
Wilson's " "
Stormy "
Fulmar "
Bulwer's "
Pomarine skua and egg.
Common "
Arctic "
Buffon's "
Great black-backed gull.
Lesser " "
Black-headed "
Bonaparte's gull and egg.
Little " "
Sabine's " "
Ivory " "
Caspian tern and egg.
Gull-billed " "
Whiskered " "
Sooty " "
Sandwich "
Roseate "
Common "
Arctic "
Lesser "
Cormorant.
Green cormorant.

6. *Classes.*—The Classes for Drawing, Mathematics, French, and German have met as usual; the former has been very well attended, the instructor, Mr. Needham, giving every satisfaction.

7. *Observatory.*—The rotatory dome of the equatorial room, manufactured in 1852 by Messrs. Ransom & May, of Ipswich, had latterly become so stiff as to require several men with tackle to turn it. An application to the Secretary of State for War for funds to place it in a proper state of efficiency was liberally responded to, and the work has been most satisfactorily executed by Messrs. Troughton and Simms. In addition to the re-adjustment of the running gear of the dome, the shutter has been made to slide with ease and smoothness, and the interior of the room has been cleaned and painted.

Under these circumstances, and looking at the prosperous state of the funds, the Committee is of opinion that the time has arrived for carrying out the intention, so long entertained, of procuring a telescope adequate to the requirements of the Institution. The cost of such an instrument properly mounted would be about £500, and the Committee proposes to ask the sanction of the meeting to this outlay.

8. *Photography.*—The photographic department requires much alteration and improvement, and a Sub-Committee has been appointed to ensure this being done thoroughly and economically.

9. *Chemistry.*—The laboratory has been in constant use by the classes of officers under the Director of Artillery Studies, as also by officers working independently.

10. *Instruments.*—One of the principal objects for which the Institution was founded, was to place within reach of its members instruments of a character often too expensive for private purchase. The Committee, in keeping this object steadily in view, has recently added to the supply of instruments a Grove's battery of 40 cells, and has ordered an electric lantern and lamp* of the most recent construction, by Browning. The acquisition of this apparatus will admit of a great extension being given to the lectures, many interesting subjects having been omitted hitherto from the want of it.

11. *Model Room.*—A stand of arms with bayonets (consisting of "Brown Bess" and the different carbines and rifles that have been in the service down to the Martini-Henry), has been deposited in the model room; also several service projectiles and other stores, a catalogue of which has been carefully kept up, so that members can now without any difficulty make themselves acquainted with them.

The Committee has purchased a Chassepôt rifle; a needle gun also has been placed at its disposal.

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* Since received.

The arrangement by which all stores supplied by the War Department are on local charge only, is a most advantageous one, as the Committee is enabled to procure direct from the Royal Arsenal the latest projectiles and stores in the service, and so make the model room one of the most instructive features of the Institution.

12. *Workshop.*—This shop is in good working order, and has been much enlarged.

13. *Museum of Artillery.*—The Secretary of State for War, in concurrence with H.R.H. the Field Marshal Commanding-in-Chief, having approved of the Museum of Artillery at the Rotunda being entrusted to the Committee of the Royal Artillery Institution, the transfer took effect on the 17th May, 1870.

A Sub-Committee has been appointed to assist the Secretary in its management, and every endeavour will be made to render it as instructive, and attractive to the general public, as possible.

14. *Lectures.*—The lectures enumerated in the following list have been delivered in the Theatre of the Institution to members and their friends during the past winter, and they have been largely attended. Thanks are due to S. Brandram, Esq., M.A., Admiral Sir E. Belcher, K.C.B., Lieut.-Colonel A. W. Drayson, R.A., Lieut. W. H. Collins, R.E., Capt. M. C. Newall, R.A., and Lieut. J. R. Slade, R.H.A., for gratuitous service rendered in this matter.

Rev. A. J. D'Orsey, B.D.	"On Elocution as applied to Public Speaking."
Rev. Martyn Hart, M.A................	"The World of the Sea."
S. Brandram, Esq., M.A.	Readings from various authors.
Lt.-Col. Drayson, R.A., F.R.A.S. ...	"On the coming Transit of Venus."
Admiral Sir E. Belcher, K.C.B.	"The great Equatorial Current, misnamed the 'Gulf Stream.'"
Lieut. W. H. Collins, R.E., F.R.A.S.	"The Eclipse of December, 1870."
Captain M. C. Newall, R.A.	"An Hour with the Poets."

The excellent geological collection of the Institution has not hitherto yielded all the results of which it is capable, from the absence of a qualified instructor. The science of geology is of such practical value, and officers in visiting remote and unexplored countries have such special opportunities of contributing to its progress, that due facilities should be offered in the way of its study. Before however making definite arrangements on this head, the Committee has resolved to ascertain by the experiment of a short course of lectures, the extent of interest taken by members in the subject.*

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* These lectures are now in course of delivery.

In consideration of the number of lectures given at the Institution gratuitously by Mr. C. L. Bloxam, F.C.S., as well as his prompt willingness at all times to give assistance to members studying chemistry, the Committee, on the part of the members, presented him with a silver salver, bearing the following inscription:—

PRESENTED TO

C. L. BLOXAM, Esq.,

Professor of Chemistry in the Department of Artillery Studies, and at the
Royal Military Academy, Woolwich,
&c. &c. &c.,

BY THE MEMBERS OF

The Royal Artillery Institution,

As a mark of their esteem, and in grateful acknowledgment of the many valuable
services rendered by him to the Institution.

Woolwich, June, 1870.

15. *Afternoon Meetings.*—These meetings have been well attended, and some very interesting professional discussions have taken place. Their success during the past year argues well for their continued usefulness.

The thanks of the Institution are due to the undermentioned officers for the papers read by them:—

Captain J. P. Morgan, R.A.	"A Proposal for a Very Heavy B.L. Gun of Novel Construction."
Lt.-Col. C. C. Chesney, R.E.	"The Reform of Prussian Tactics."
Lieut. C. Jones, R.A.	"The Future Armament of our Field Artillery."
Captain C. O. Browne, R.A.	"Development of Artillery Missiles during the past year."
Lt.-Col. E. W. Bray, 4th King's Own Royal Regiment	I. "Prussian mode of conducting large manœuvres, and the manner in which a Staff of Umpires is used for the purpose of controlling and regulating such manœuvres. II. "The necessity of introducing a more intelligent system of manœuvre, and a higher system of training amongst the Officers of the English Army."
Lieut. J. Sladen, R.A.	"The Merits of a Large Bore and Small Bore Contrasted, with reference to Rifled Artillery and Small-Arms."
Captain J. P. Morgan, R.A.	"The Determination of the Explosive Force of Gunpowder."

Four of these papers have been published in the "Proceedings," and the remainder will appear as soon as possible.

The following members have left the Garrison, and the vacancies thus occasioned have been filled up by the Committee, subject to the approval of the general meeting:—

Colonel G. T. Field,	by	Colonel O'B. B. Woolsey.
〃 G. Rotton,	〃	〃 J. Desborough.
Captain G. B. B. Hobart,	〃	Major H. V. Timbrell.
〃 F. A. Whinyates,	〃	Lieut.-Colonel C. H. Owen.
〃 C. O. Browne,	〃	Captain J. P. Morgan.
〃 J. C. J. Lowry,	〃	〃 M. C. Newall.
〃 F. W. de Winton,	〃	〃 J. P. Nolan.
Major H. V. Timbrell,	〃	〃 R. Oldfield.
Captain J. P. Nolan,	〃	〃 A. Ford.
Lieut. A. B. Brown,	〃	Lieut. J. Sladen.

In compliance with Rule V., the following officers retire from the Committee, and are not eligible for re-election:—

Colonel G. H. Vesey.
Lieut.-Colonel G. A. Milman.
Captain T. B. Strange.
Captain F. Duncan.
Lieut. E. Kensington.
Asst.-Surg. F. R. Hogg, M.D.

The following officers were elected to serve on the Committee, viz.:—

Lieut.-Colonel J. S. Tulloh,	*vice*	Colonel Vesey.
Major H. Le G. Geary,	〃	Captain Strange.
Captain Le Mesurier,	〃	〃 Duncan.
〃 E. H. Cameron,	〃	Lieut.-Colonel Milman.
Lieut. H. Geary,	〃	Lieut. Kensington.
Surg.-Major S. H. Fasson,	〃	Asst.-Surgeon Hogg.

The following resolutions were proposed:—

1. *Proposed by Colonel Domville, seconded by Colonel Phillpotts, and carried unanimously:—*

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

2. *Due notice having been given, in accordance with Rule XX., the following alterations and additions to the Rules were submitted by the Committee:—*

Change in Rule II. (*printed in italics*) *proposed by the Committee:—*

> "II. Officers of the Royal Engineers, and of the Militia Artillery, and professors and masters of the Royal Military Academy, *and officers who have passed through the Staff College, or studying there,* are eligible to become honorary members. They may obtain the *future* periodical publications of the Institution on the annual payment, in advance, of the sum of 10*s.* 6*d.*"

Colonel Domville proposed as an amendment to the alteration in Rule II. now submitted to the meeting, that the words, *and officers who have passed through the Staff College, or studying there,* be omitted, and that the first paragraph stand as at present; and instead thereof, that the second paragraph of the same rule be altered so as to give power to the Committee to extend the privilege now proposed to be conferred upon the officers of the Staff College to any officers of the Army or Navy who, from their scientific or literary acquirements, the Committee might deem it desirable to have as honorary members of the Institution, and who should notify their wishes to the Committee so to become honorary members, without reference to the accidental circumstance of such officers residing temporarily in the Garrison or neighbourhood. He did not desire that the number of honorary members should be inconveniently increased, but he thought that the hands of the Committee should not be tied to the election of honorary members from one particular class only, to the exclusion of many officers of both services who, although it might not be desirable to bring them in under the provisions of the last paragraph of Rule II., yet it might be nevertheless both an honour to the Institution and a valued privilege to the officers in question to have their names enrolled as members thereof.

The Chairman ruled that an amendment affecting the Rules of the Institution could not be proposed at a general meeting without previous notice of 14 days had been given.

Colonel Domville thought it was quite within the power of this general meeting to adopt any amendment to a proposed alteration, although such amendment might not have been posted for 14 days; indeed, that a rigid adherence to such rule would be exceedingly inconvenient, and prevent business being done at general meetings; but in deference to the decision of the Chairman, he would with all respect withdraw the proposed amendment, and give his vote for the rejection of the alteration proposed. In so doing he did not wish to oppose the election of officers of the Staff College as honorary members temporarily, but did not think it desirable that they should be permanent members.

After considerable discussion, the proposed change in Rule II. having been put to the vote was negatived.

Addition to Rule IV., proposed by the Committee and carried unanimously:—

"*Members failing to pay their annual subscription after two applications, shall have their names removed from the list of members at the discretion of the Committee.*

"*No numbers of the "Proceedings" will be sent to any member who is one year in arrear of his annual subscription.*"

Addition to Rule V. (printed in italics), proposed by the Committee and carried unanimously:—

"V. H.R.H. the Field Marshal Commanding-in-Chief to be Patron and President of the Institution. *The Inspector-General of Artillery*, the Commandant of the Garrison, the Director of Artillery and Stores, and the Deputy Adjutant-General to be Vice-Presidents. The affairs of the Institution to be under the direction of a Committee, consisting of the above officers, the Assistant Adjutant-General, the Director of Artillery Studies, the Brigade Major, the Secretary, Department of Director of Artillery and Stores, and fifteen officers elected at the annual general meeting, of whom four shall be Colonels or Regimental Field Officers, and one Medical Officer, the senior to take the chair. The Medical Officer to retire every two years; one Colonel or Field Officer, and four members to retire annually, by rotation, and none of these to be eligible for re-election until the expiration of one year after leaving office."

Alteration in Rule XV. (printed in italics), proposed by the Committee and carried:—

"XV. No alterations shall be proposed, or discussions allowed at special meetings, *whether general or of the Committee*, on any subjects not specified in the written notice of meeting."

Addition to Rule XVII. (printed in italics), proposed by the Committee and carried unanimously:—

"XVII. The Committee to appoint the days on which meetings are to be held for the communication of reports, or papers on professional and scientific subjects. *At which meetings, no address or discussion is to be allowed on any subject not specified in the preliminary notice issued by the Committee.*"

Addition to Rule XVIII., to be inserted after 2nd paragraph, proposed by the Committee and carried unanimously:—

"*Honorary members joining any class will pay double; officers of the Royal Engineers excepted, who will only pay one-third more than members. And in the event of their requiring the use of the surveying or other instruments, they must make application to the Secretary.*"

3. *Proposed by the Committee:—*

"That a refracting telescope of 7 inch aperture, equatorially mounted, be procured for the Observatory of the Institution, at a cost of about £500."

Colonel SMYTHE explained, on the part of the Committee, how unusually favourable present circumstances were for entertaining such a proposition, and gave some details of the intended instrument and of the means that would be taken to ensure its excellence.

The proposition was carried unanimously.

4. *Proposed by Colonel Phillpotts, seconded by Colonel Domville, and carried unanimously:—*

"That the thanks of the meeting be voted to the Chairman."

Colonel BENN expressed his acknowledgment of the compliment paid him, and brought the proceedings to a close.

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 Inspector-General of Artillery.
The Commandant of the Garrison, Woolwich.
The Director of Artillery and Stores.
The Deputy Adjutant-General.

MEMBERS:

The Assistant Adjutant-General.
The Director of Artillery Studies.
The Brigade Major, Woolwich.
The Secretary, Department of Director of Artillery and Stores.

Colonel W. J. Smythe.
„ J. Desborough.
Lieut.-Colonel O'B. B. Woolsey.
„ J. S. Tulloh, C.B.
„ C. H. Owen.
Major H. Le G. Geary.
Captain R. Oldfield.

Captain C. B. Le Mesurier.
„ A. Ford.
„ J. P. Morgan.
„ M. C. Newall.
„ E. H. Cameron.
Lieut. J. Sladen.
„ H. Geary.

Surg.-Major S. H. Fasson, M.D.

Captain A. D. Burnaby, *Secretary and Treasurer*.

(Signed) A. BENN, Colonel R.A.,
in the Chair.

23rd May, 1871.

LIST OF MEMBERS

OF THE

ROYAL ARTILLERY INSTITUTION, WOOLWICH.

[ARRANGED ALPHABETICALLY.]

APRIL 1871.

COLONEL.

FIELD MARSHAL H.R.H. THE DUKE OF CAMBRIDGE, KG., KP., GCB., GCMG., *fm.*
Patron and President.

COLS. COMMANDANT.

Bell, Sir W. KCB., 𝔚 *lg*
Bloomfield, Sir J. KCB., 𝔚 *lg*
Burn, R., *lg*
Chesney, F. R., *g*
Cuppage, B., 𝔚 *lg*
Dacres, Sir R. J., GCB., *g*
England, P. V., *lg*
Flude, T. P., *lg*
Griffith, J. G., *g*
Higgins, T. G., *lg*
Ingilby, Sir W. B. KCB., 𝔚 *lg*
Sabine, Sir E., KCB., *g*
Teesdale, H. G., *mg*
Thorndike, D., *lg*
Warde, F., 𝔚 *lg*
Williams, Sir W. F., KCB. Bt., *g*
Willis, B., *lg*
Wylde, W., CB., *g*

GENERAL OFFICERS.

Abbott, J., *mg*
Anderson, J. R., CB.
Anstruther, P., CB., *mg*
Arbuckle, B. H. V., *lg*
Askwith, W. H., *mg*
Aylmer, H., *mg*
Black, B. W., CB., *mg*
Boxer, E. M.
Brind, Sir J., KCB., *mg*
Buchanan, G. J. L., *mg*
Burnaby, R., *lg*
Burrows, A. G., *mg*
Campbell, H. A. B., CB., *mg*
Christie, H. P., *mg*
Cockburn, C. V., *mg*
Crawford, R. F., *mg*
Crofton, R. H., *mg*
Dennis, J. B., *mg*
Devereux, Hon. G. T., *mg*
Dick, F., *mg*
Dickson, Sir C., KCB., 𝔙ℭ *mg*
Dixon, M. C., 𝔙ℭ *mg*
Dunlop, F., CB., *lg*
Eardley-Wilmot, F. M., *mg*
Fitzmayer, Sir J. W., KCB., *mg*
Forster, H., CB., *mg*
Francklyn, J. H., CB., *mg*
Freer, J. H., *mg*
Gambier, G., CB., *mg*
Gardner, W. B., *mg*
Graham, A. H., *mg*
Graydon, G., *mg*
Hanwell, J., *mg*
Huyshe, D. F., *mg*
Knox, T., *mg*
Lucas, C., *mg*
Maclean, P., *mg*
Marriott, T. B. F., *mg*
Mountain, R. F., *mg*
Paynter, D. W., CB., *mg*
Riddell, C. J. B., CB., *mg*
Romer, R. F., *lg*
Rowan, H. S., CB., *mg*
Sandham, G.
Simpson, G. W. Y.
St. George, Sir J., KCB., *mg*
Stow, H., *lg*
Taylor, A. J., *lg*
Tuite, H. M., *mg*
Tulloh, A., CB., *lg*
Turner, F., CB., *mg*
Warde, Sir E. C., KCB., *mg*
Wingfield, C. W., *mg*
Wood, Sir D. E., KCB., *mg*

COLONELS.

Adair, A. Shafto
Adye, J. M., CB., *bg*
Barrow, J. L., CB.
Benn, A.
Brougham, T.
Cadell, A. T.
Campbell, F. A.
Carleton, H. A., CB.
Clerk, H.
Clifford, M.
Colomb, G. H.
Cox, C. V.
Cox, W. H.
D'Aguilar, C. L., CB.
De Teissier, H. P.
Dixon, W. M. H.
Domville, J. W.
Douglas, C.
Du Plat, C. T.
Eaton, G. P.
Elgee, J. L.
Elwyn, T.
Fisher, E. H.
Franklin, C. T., CB.
Gardiner, H. L.
Gibbon, J. R., CB.
Gilbert, W. R.
Goodenough, H. P.
Grant, W. J. E.
Green, A. P. S.
Hammond, H.
Hatch, W. S.
Hawkins, A. C.
Kaye, E., *bg*
Kemball, Sir A. B., CB., KCSI.
Lefroy, J. H., CB., *mg*
Lennard, J. F.
Lewis, H.
Lovell, C. N.
Maberly, E., CB.
Maude, F. C., CB., 𝔙ℭ
Maude, G. A., CB.
Middleton, W. A., CB.
Milward, T. W., CB.
Morgan, E.

O'Connell, R.
Paget, L. G.
Petrie, J. G., CB.
Phillpotts, A. T.
Price, E., CB.
Radcliffe, R. P.
Romer, R. C.
Selby, G., *bg*
Shakespear, G. B., *bg*
Shakespear, J. D.
Smyth, J. H., CB.
Smythe, W. J.
Spencer, Hon. R. C. H.
Taswell, E.
Thompson, B.
Turner, J., CB.
Tylee, A.
Ward, F. B.
Williams, E. A., CB.
Woollcombe, J. D., CB.
Worgan, J.
Wray, E., CB.
Wright, C. J.
Wynne, C. R.
Younghusband, C. W.

LIEUT.-COLONELS.

Anderson, D. G.
Anson, A. E. H.
Arbuthnot, C. G., CB., *c*
Atlay, E., CB., *c*
Barry, W. W., CB., *c*
Barton, C. J.
Bedingfeld, P.
Bent, H.
Biddulph, M. A. S., *c*
Bolton, J. L.
Bond, F. W., *c*
Boothby, J. G.
Bourchier, G., CB., *c.*, *bg*
Bowie, C. V., *c*
Bradford, W. J.
Brown, G. G., *c*
Cadell, R., *c*
Calvert, A. M.
Campbell, J., *c*
Carleton, G.
Carthew, E. J.
Chandler, G. L., *c*
Chermside, H. L., *c*
Colclough, G., *c*
Connell, A. F., *c*
Conybeare, F., *c*
Couchman, E. H.
Desborough, J.
Drayson, A. W.
Dumaresq, W. L.
Elgee, C. W.
Evans, C. R. O., *c*
Farmer, R. O.
Field, G. T., *c*
Fitz Hugh, H. T.
Forde, M. B.
Fraser, Hon. D. M., CB., *c*
Fraser, G. H. J. A.
Freeth, R. K., *c*
Gage, Hon. E. T., CB., *c*
Gibb, J. S.
Glanville, F. R.
Gleig, A. C.
Godby, J.
Gordon, S. E., CB.
Gosling, W. C. F.
Govan, C. M.
Grant, E. F.
Gray, W. J.
Greene, D. S.
Greville, H. L. F.
Haggard, T. T., *c*
Hamilton, A. G. W., *c*
Hamilton, F. S., *c*
Hamley, E. B., CB., *c*
Harrison, E.
Hastings, F. W., *c*
Haultain, F. W., *c*
Hay, R. J.
Henry, C. S., CB., *c*
Heyman, H.
Holmes, G. B. B., *c*
Hoste, D. E., CB.
Ingilby, C. H.
Inglefield, S. H. S.
Johnson, G. V., *c*
Lennox, A. F. F., *c*
Leslie, G.
Light, A.
M'Crea, R. B., *c*
Macintyre, J. M. K.
Magrath, J. R.
Maxwell, H. H., *c*
Michell, J. E., CB., *c*
Milman, G. H. L., *c*
Moubray, E.
Murray, A. M., *c*
Newall, D. J. F.
Newton, H. P., *c*
Ommanney, F. M. M., *c*
Ord, F. W. C.
Phillipps, P. W., *c*
Pigou, A. C., *c*
Pipon, P. G., *c*
Reilly, E. M., CB.
Robinson, S., *c*
Rotton, G., *c*
Russell, W. C.
Saunders, W. B.
Shaw, G., *c*
Shekleton, J.
Singleton, J.
Sladen, J. R.
Smith, C. H., CB., *c*
Smyth, H. A., *c*
Soady, J. F.
South, C., *c*
Spurway, J.
Stallard, S., *c*
Stewart, A., *c*
Talbot, H. L.
Thring, J. E.
Travers, J. F. E.
Tulloh, J. S., CB.
Tupper, G. Le M.
Vesey, G. H., *c*
Voyle, G. E., *c*
Wallace, H., CB., c
Williams, W. J.
Wintle, A., *c*
Woodcock, C. S., *c*
Woolsey, O'B. B.
Yates, H. P., CB., *c*

CAPTAINS.

Addington, Hon. L., *m*
Alderson, H. J.
Alexander, J. H.
Anderson, H.
Anderson, J. H. P.
Andrewes, W. G., *lc*
Anley, F. A.
Annand, J. H.
Arbuckle, C. V.
Arbuthnot, G., *m*
Arbuthnot, H. T., *m*
Archdall, A. M.
Armstrong, H. L.
Auchinleck, J. C.
Bainbridge, A. P.
Baker, R. A.
Balfour, H. L.
Barlow, W. R.
Barrington, J. T.
Basevi, C. E.
Battiscombe, E. G.
Baylay, F. G.
Bayly, A. A.
Beamish, E. S.
Behenna, H.
Beresford, D. W. P.
Berthon, T. P.
Betty, J. F.
Biddulph, R., *lc*
Bishop, H. P., *lc*
Blackburne, H. B.
Blakeley, J. H.
Blackwell, J. E.
Blackwood, G. F.
Blunt, A.
Bolton, E. C.
Bolton, W. J.
Bonar, A. M.
Bond, H.
Bonham, J., *m*
Booth, W.
Borton, H. M.
Boyle, E. V.
Boylin, W.
Brackenbury, C. B.
Brackenbury, H.
Brancker, W. G.
Bredin, E. G., *lc*
Brendon, A., *lc*
Briscoe, H. W.
Broadrick, E.
Brown, J. H.
Brown, J. T. B.
Browne, C. O.
Browne, M. G.
Bruce, E. J., *m*
Budd, G.
Budgen, W. T.
Burn, J. M.
Burnaby, A. D.
Burnett, E. S.
Burt, C. E., *lc*
Byrne, T. E., *m*
Caine, W. H., *adjt.*
Cairnes, R. J.
Callander, G. E.
Cameron, D. R.
Cameron, E. H.
Campbell, G. M. L.
Campbell, J. M'C., *lc*
Campbell, Sir J. W., Bt.

Campbell, P. J., *m*
Campbell, R. C. W.
Candy, G. H.
Cane, R. E.
Cardew, H.
Carey, F.
Carey, T. P.
Carey, W.
Carey, W. D.
Carpenter, C.
Chaldecott, M. A.
Chalmers, C. D.
Chambers, G. F. S.
Chamier, S. H. E., *m*
Chancellor, F. H., *m*
Chichester, H.
Childers, E. W.
Clarke, H. S.
Clarke, J. L.
Clarke, T.
Close, F., *m*
Cockburn, C. F.
Collington, J. W.
Collingwood, C.
Cooke, J. R. D.
Cookes, C. H.
Cottingham, E. R.
Craster, W. R.
Crawford, G. A.
Cruikshank, A. R.
Cuming, T.
Cumberland, W. B.
Curtis, R., *lc*
Curzon, W. S.
Dames, T. L.
Darling, A.
Darwall, H. P.
Davidson, A. C.
Davidson, A. H.
Davis, G., VC *lc*
Davis, T. A.
Dawson, A. H.
De Cetto, L. C. A. A.
De Havilland, J., *lc*
De Moleyns, T. A.
De Montmorency, Hon. A. B.
Deedes, G.
Denis-de-Vitre, W.
Denne, L. H.
De Vismes, H. A. D.
De Winton, F.
Dillon, Hon. R. V.
Dirom, T. A. Pasley-, *m*
Downes, M. F.
Drysdale, R. C.
Duncan, A. W.
Duncan, F.
Dunlop, S.
Dyce, J. R.
Dyer, H. C. S., *m*
Eden, M. P.
Edmeades, H.
Edwards, J. G.
Elliott, E. D.
Ellis, C. H. F.
Ellis, W. B. E.
Elton, F. C.
Engström, G. L.
Eveleigh, J. E.
Farrell, H. C.
Field, T. S. P., *lc*
Finch, W. J.
FitzGerald, M. M.
Fletcher, T. C.
Forbes, G. H. A., *lc*
Ford, A.
Ford, J.
Forster, B. L., *m*
Forster, W. D.
Franklen, C. R.
Fraser, E.
French, W., *m*
Frith, J. S., *lc*
Gallwey, P. F. G.
Garrett, N. D.
Geary, H. Le G., *m*
Gillies, G. J.
Gilmour, C. D.
Gilmour, W.
Girardot, H.
Gloag, A. R.
Gloag, H. D.
Goodenough, O. H.
Goodenough, W. H., *lc*
Gordon, E. S.
Gore, J., *m*
Gore, R.
Gorham, C. A.
Gossett, A., *m*
Graham, W. H.
Griffiths, L.
Grimston, W. J., *m*
Gubbins, J. E.
Haig, R. W., *m*
Hall, L. F.
Hall, W. B. R.
Hall, W. J.
Hamilton, A. H. C.
Hamilton, T. B.
Hamilton, Sir W., Bt.
Hannen, G. G.
Hanwell, J.
Hardy, C.
Hardy, J. B.
Hare, Hon. R.
Harness, A.
Harris, N. H.
Harris, T. M.
Harrison, T. A. J.
Harvey, J. S.
Haughton, J.
Heberden, H.
Henry, G. C., *lc*
Heyland, A. S.
Hickes, H. J. F. E., *m*
Higgon, J. D. G.
Hill, C. R., *m*
Hill, F. J. G.
Hill, P. E.
Hills, J., VC *lc*
Hobart, G. B. B.
Holberton, T. N.
Holcombe, F., *m*
Holdsworth, J. R.
Hollist, E. O.
Hope, J. E., *lc*
Hope-Johnstone, C. J.
Hoskins, A. R.
Howlett, F.
Hoyes, J.
Hughes, T. E., *m*
Hume, E. T.
Humfrey, B. G.
Hunter, A. S.
Hunter, C.
Hunter, J.
Hutchinson, A. H.
Hutchinson, W. F. M.
Irvine, H., *lc*
Isaacson, H. de S.
Isacke, H. W.
Izod, W. H.
Jackson, C. S.
Jervis, H. J. W., *lc*
Johnson, A. C., *lc*
Johnson, C. G.
Johnson, C., *m*
Jones, H. L.
Jones, R. R.
Joy, A. P.
Kaye, N. L.
Keate, E.
Kelly, J.
Kemmis, W.
Kerrich, W. D'O.
Ketchen, J.
King, A. H.
King, J. R.
King-Harman, W. H.
Kinsman, H. J.
Knox, G. U.
Kyle, S. C.
Lascelles, C. G. W.
Law, F. T. A.
Lawrence, W. H.
Le Cocq, H.
Le Grice, F. S.
Leishman, J. T.
Le Marchant, H. St. J. T.
Le Mesurier, C. B.
Le Mottee, O. F.
Lempriere, H., *m*
L'Estrange, C.
L'Estrange, P. W., *lc*
Lewes, F. E.
Lewes, H. C.
Lindsay, A. H.
Lloyd, F. T.
Lloyd, J. H.
Lloyd, W.
Lluellyn, W. R.
Lowis, R. F.
Lowry, J. C. J.
Lukin, W. W. A., *lc*
Lumsden, H. W.
Lyle, H. C.
Lynes, S. P.
Lyon, F.
Lyon, F. L. H.
Lyons, E.
Macartney, A. S.
Macdonell, G. B.
Macfarlan, D., *m*
Mackenzie, H. M.
Mackenzie, R., *lc*
Maclachlan, T. J., *lc*
M'Causland, W. H.
M'Grigor, D. J.
M'Laughlin, E.
M'Mahon, C. J.
Magenis, H. C.
Mahon, T.
Maitland, E.
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THE MINOR TACTICS OF FIELD ARTILLERY.

BY

LIEUT. H. W. L. HIME, R.A.,

["TRUNNION."]

THE R.A. INSTITUTION PRIZE ESSAY OF 1871.

"Die vermehrte Feuerwirkung der Geschütze auf weitere und die verminderte auf nähere Distanzen hat die Artillerie gezwungen dem Kampf auf weitere Entfernungen mehr Aufmerksamkeit zuzuwenden, den auf nähere zu vermeiden."—*Boguslawski.* "*Entwickelung der Taktik.*"

THE officer commanding a battery of field artillery in action is called upon to solve a series of questions which may be classed under six heads, namely—

1. Where to fire.
2. When to fire.
3. What to fire at.
4. What to fire.
5. When to move.
6. How to move.

There are many other questions of the highest importance connected with the use of artillery in the field—such as the proportion which the artillery of reserve ought to bear to the artillery of division, the proper constitution of the artillery of reserve, the circumstances under which artillery ought to be used in masses, &c., &c. But with such questions I am not at present concerned, because they belong to grand, not to minor tactics, and present themselves for solution rather to the Commander-in-Chief of an army in consultation with the officer commanding the artillery than to officers commanding batteries.

It remains, then, to consider successively the six great problems on whose correct solution the safety and success of a battery in action essentially depend.

1. *Where to fire.*

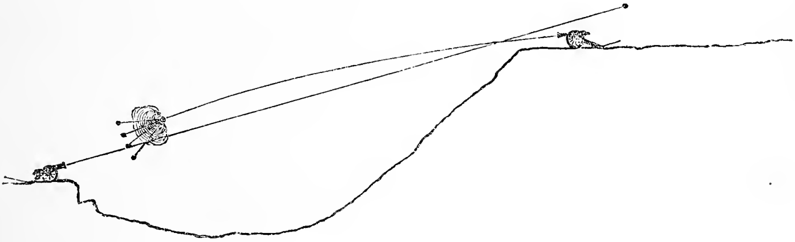
In selecting the position for a battery, the ground must be considered both in plan and profile.

As regards the profile of the ground, the guns must be placed neither too high nor too low. If they are placed in a hollow, not only are they confined in what may be looked on as a shell-trap, but all view of the surrounding country and the movements of the enemy is cut off, and any attempt to carry on an effective fire is hopeless. Fig. 1 will illustrate my meaning.

Fig. 1.

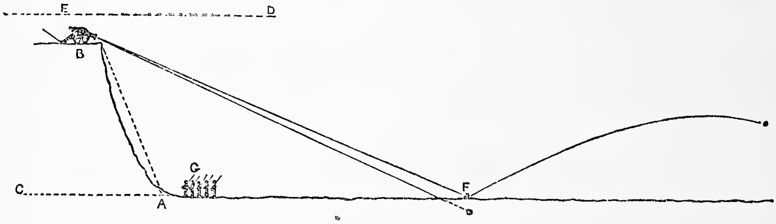
Nor should the guns, even when otherwise well placed, be brought into action on ground very much below the level of the position occupied by the enemy, as in Fig. 2; first, because while the enemy has a clear view of every part of the battery, his own position is entirely hidden from sight; secondly, because even if his position be partly visible, the velocity of projectiles on reaching such heights is necessarily reduced to some extent, and the success of such projectiles as shrapnel depends almost entirely on the velocity of the fragments on striking the object fired at.

Fig. 2.



The evils which result from perching guns on the highest eminence at hand are sevenfold. In the first place, as Frederick the Great pointed out in his Potsdam Regulations, all the advantages of a flat trajectory are lost by this "pernicious practice." Secondly, solid shot, shell with percussion fuzes, and shell with time fuzes bored somewhat too long, will stick fast in the ground and prove almost innocuous, owing to their very great final velocity, especially if the ground be in any degree soft. It was to this circumstance that Wellington's Light and 7th Divisions owed their escape from destruction at the crossing of the Huebra in 1812. To protect the English artillery, which was crossing the river, from the attacks of the French cavalry, these divisions were placed in columns on the bank, exposed to a heavy fire from the French artillery; yet they "suffered little loss, because the saturated clayey soil swallowed the shot and smothered the shell."[1] If, in the third place, the enemy occupies hard ground, solid shot and blind shell will break up on the first graze, or rebound to such heights as to render their ricochet of no value. Fourthly, if the inclination of the height on which the guns are posted, *BAC* (Fig. 3), greatly exceeds the extreme depression that can be given to field guns, *DEF*—about 5° in the British service—the enemy can form in perfect security for an attack on the guns, at the base of the height *G*. This happened to the Russian artillery at Kunersdorf, 1759,[2] and, by an accident that could not have been foreseen, to our own guns at Waterloo. "The enemy rushed down the hill" (having been driven back by the fire of the English infantry and artillery) "forming again under its shelter, and in a great measure covered from the fire of our guns, which by recoiling had retired so as to lose their original and just position. But in a deep stiff soil, the fatigue of the horse artillerymen was great, and their best exertions were unable to move the guns again to the crest without horses; to employ horses was to ensure the loss of the animals."[3] Fifthly, a battery posted as in Fig. 3 may happen to form a target for a number of the enemy's guns. Solely from this cause, Senarmont was forced to order a battery which he had at first placed on a hillock into lower ground, at the beginning of the battle of Eylau.[4] Sixthly, the ineffective fire of the guns, enfeebled by these causes, will raise the courage of an advancing enemy and will proportionally depress the spirits of our own men; and seventhly, the ammunition, which is worth its weight in gold, is uselessly frittered away.

Fig. 3.



The most obvious lesson to be learned from the campaigns of 1866 and 1870 is, that it is not alone desirable but necessary to cover the guns and horses of a battery from the enemy's fire, either by field entrenchments or by the accidents of the ground; for it is only when so covered that the battery can be ensured against destruction from the enemy's infantry and artillery fire, and that the men can preserve that *sang froid* which is essential for carrying on an effective fire.

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[1] Napier's "Peninsular War," Vol. IV. p. 385.

[2] De Ternay's "Traité de Tactique," Tom. I.

[3] Frazer's "Letters during the Peninsular and Waterloo Compaigns," p. 588.

[4] "Mémoires sur le Gén. Senarmont," pp. 26, 27.

The most favourable position for guns is a gentle hillock, sloping gradually to the front and more abruptly towards the rear, with a command over the ground occupied by the enemy of about 1 in 100—such as is shown in Fig. 4. In case the ground does not rise in front of the guns, as in Fig. 4, it is by all means desirable to throw up a small entrenchment, or form a gun-pit, to supply the necessary cover, as in Fig. 5.

Fig. 4.

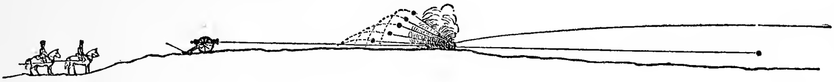
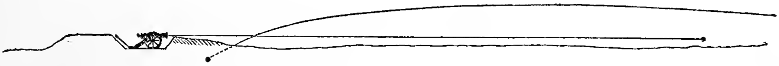
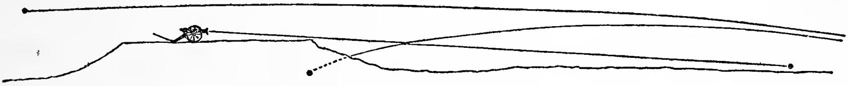


Fig. 5.



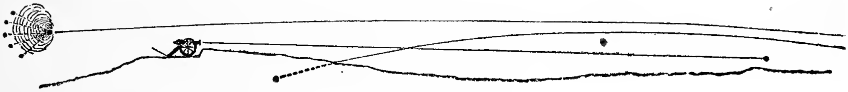
If the top of the hillock be flat and its command sufficient, as in Fig. 6, the guns will not require any epaulment.

Fig. 6.



If the top of the hillock be rounded off sharply, as in Fig. 7, a small level platform must be dug out on the rear slope; for otherwise it would be not only impossible to give sufficient depression to the gun, but the force of the recoil would drive the gun down the back slope of the hill.[1] This course might be adopted with success in case the guns occupy a railway embankment, where the breadth and command are not sufficient to defilade the guns in the way shown in Fig. 6.

Fig. 7.



If a canal, a sunken road, or a railway cutting be at hand, parallel to the front of the battery, the guns should be run close up to the edge,

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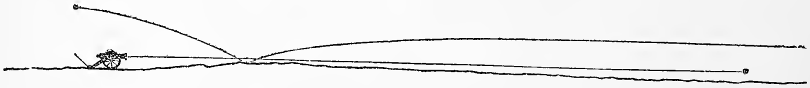
[1] This actually happened to a battery in Bhootan in 1864, at the attack on Dewangiri.

as in Fig. 8; because all shot or shell falling slightly short are caught by the slope in front and prevented from ricochetting.[1]

Fig. 8.

A low bank, a hedge-row, or a furze-bush may be made use of in the same way as the epaulment in Fig. 5; and even a slight irregularity of ground, as in Fig. 9, may prove highly useful.[2]

Fig. 9.



As regards the ground in plan, guns may be drawn up with good effect behind a marsh, a pond or river, or a ravine; provided always that such obstacles do not render an advance to the front impossible, and that in the case of the ravine, it is not occupied by the enemy. Such ground is not only unfavourable to the enemy's artillery fire, but secures the guns against any sudden rush of cavalry or infantry. The flanks of the battery are secured in the same way as the flanks of other troops. If the guns are placed in the neighbourhood of woods, brushwood, or other cover of which the enemy's skirmishers may take advantage, these positions must be attacked and occupied by our own infantry, or the gunners will be annihilated. Heavy, muddy ground, as well as stony ground, should be avoided; as it is difficult to move the guns by hand in the former, and the men and horses may be wounded by fragments of stones in the latter. In fine, the ground for 50 to 100 yds. in front of the battery should be as unfavourable as possible to the enemy's artillery fire, and the ground both in front and flank should be of such a nature as to render a *coup-de-main* impossible.

The importance of a thorough knowledge of a position cannot be overestimated by officers of the field artillery; for the security of a battery depends almost entirely, and the efficacy of its fire to a large extent, upon the use that is made of the accidents of the ground.[3]

2. *When to fire.*

If the ground and atmosphere be favourable, and there be means in the battery of finding the range accurately, the guns may open fire at

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[1] Decker's "Artillerie à cheval, &c.," p. 107. Jervis' "Manual of Field Operations," p. 114. The American "Field Artillery Tactics," p. 43.

[2] "Mémoire sur Senarmont," p. 22.

[3] Thiroux, "Instruction de l'Artillerie," p. 365. I need hardly say that guns should never be posted near combustible materials, such as wooden houses, haystacks, and the like.

2500 yds.[1] Under exceptional circumstances, they may commence firing at 3000 yds.; but practice ought not to be carried on beyond this limit, not because the guns cannot reach greater distances, but because it is impossible even with a good telescope to ascertain the effect of projectiles at longer ranges.

Frederick the Great directed that in case the general of the brigade or division ordered the artillery to open fire before the enemy came within effective range, the order was to be obeyed, but the guns were to be fired as slowly as possible.[2] No well-ordered battery, as Decker remarks,[3] should pay attention to the outcries of staff officers who, while the enemy is still many thousand yards distant, gallop wildly among the guns, shouting out amain to open fire. There is not an artillery officer in France, says the Maréchal de Peretsdorf, commenting on this sentence, who has not a hundred times witnessed such humiliating scenes. I dwell on this subject, because staff officers destitute of all knowledge of artillery tactics and of all control over their own feelings are not confined to Germany and France. It is so much the more necessary for artillery officers to bear in mind that success in battle depends now more than ever upon the efficacy of their fire, and that the efficacy of that fire depends almost entirely upon the gunners preserving their self-possession and calmness.[4]

I have laid it down that if the atmosphere be in a favourable state, and if there be means in the battery of accurately finding the range, fire may be opened at 2500 yds. Nothing remains to be said on the first of these conditions, but I must strongly insist on the importance of the second. The probable errors in judging distances from a fixed spot by the eye are, practically speaking, directly proportional to the distance of each object from the observer; the greater the distance of the object, the greater being the probable error. It is therefore of the greatest moment that a range-finder of some description be issued to the field artillery without delay; because the campaigns of 1866 and 1870 prove clearly, as Boguslawski says, that while the importance of artillery fire at long ranges has been largely increased by the recent improvements in guns, its value at short ranges has considerable fallen, partly from the diminished calibre of the guns and the proportionally

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[1] See the sensible and excellent remarks of the Prince of Hohenlohe-Ingelfingen, Commandant of the Artillery of the Prussian Guards, in his "Ideen über die Verwendung der Feld-Artillerie," Berlin, 1869, p. 10, et seq.; Taubert's "Gebrauch die Artillerie im Feldkriege," Berlin, 1870, p. 23; Boguslawski's "Entwickelung der Taktik," Berlin, 1869, p. 124; Witte's "Artilleristisches Taschenbuch," Berlin, 1870, p. 231; Field-Marshal von Moltke's "Bemerkungen über den Einflusz der verbesserten Schutzwaffen auf das Gefecht," in the "Beilage zu Nr. 27 des Militair-Wochenblattes, für den 8 Juli, 1865;" "Aide-Mémoire portatif de campagne à l'usage des officiers d'Artillerie," Paris, 1864 (the last edition), p. 174.

[2] Taubert's "Field Artillery" (Maxwell's Trans.), 1856, p. 78.

[3] Decker's "Cavalry and Horse Artillery" (Begbie's Trans.), p. 82.

[4] "In order to take advantage of the increased powers of modern firearms, the following conditions are necessary;—the object aimed at should be well defined, the range accurately determined, and the fire delivered with calmness and deliberation."—Field-Marshal von Moltke's "Bemerkungen, &c." Translated by Lieut. H. R. G. Craufurd, R.A. See also von Hoffman's "Feld-Kanonier,' Berlin, 1869, p. 265.

diminished efficacy of canister,[1] and partly from the greater range and greater effect of infantry fire.

3. *What to fire at.*

"In the different phases of an action," says Taubert, "one arm is wont to be of predominant importance."[2] It is on this arm of an enemy's force, be it his cavalry, his artillery, or his infantry, that the captain of a battery should bring his guns to bear. Should any doubt arise as to which arm of the opposing force is really predominant, then as a general rule, to which there are many more exceptions when our own army is acting offensively than when acting defensively, the guns should be directed on the enemy's cavalry and infantry, and not on his artillery. The reason is that if the cavalry and infantry of the enemy's army are broken by artillery fire, the artillery is almost sure to be captured, while infantry and cavalry may succeed in escaping after their artillery has been silenced. That no doubt may remain on this subject, I shall quote the opinions of a number of generals and military writers on it.

Napoleon said at St. Helena that the chief object of the artillery ought to be the enemy's infantry and cavalry.[3] The Marquis de Ternay almost repeats Napoleon's words;[4] Jomini lays down that at least two-thirds of the guns should exclusively confine their fire to the opposing infantry and cavalry;[5] and Vial supports Jomini.[6] These may be regarded as representing the general convictions of French officers.

The Russian General Okouneff,[7] and the Swiss General Dufour,[8] express a similar opinion, which is coincided in by the American General Halleck,[9] and the American Colonel Lippitt.[10] The Italian General Giustiniani agrees, as far as defensive battles are concerned.[11]

Colonel Hamley supports the principle I have laid down,[12] followed by Colonel Macdougal[13] and Lieut. Steward;[14] it is approved of by the Prussian General Taubert,[15] by Boguslawski,[16] and by Witte;[17] and it is

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[1] "Ranges, and Nolan's Range-finder," by Capt. Nolan, R.A., in the "Journal of the United Service Institution," Vol. XIV. No. 57, p. 6. "L'Artillerie de campagne Belge," par. Cap. Nicaise, p. 37–42; and Field-Marshal von Moltke's "Observations" in the "Beilage zu Nr. 27 des Militair-Wochenblattes für den 8 Juli, 1865."

[2] "On the use of Field Artillery" (Maxwell's Trans.), p. 54.

[3] Las Cases' "Mémoires," Vol. II. p. 285.

[4] "Traité de Tactique," Tom. I. pp. 293, 348, 349.

[5] "Précis de l'art de la guerre," ch. 7, art. 46.

[6] "Cours d'Artillerie et de l'Hist. Mil.," p. 228.

[7] "On the use of Artillery in the Field," p. 31.

[8] "Strategy and Tactics," p. 313.

[9] "Elements of Military Art and Science," p. 129.

[10] "Tactical use of the Three Arms," p. 71.

[11] "Essai sur la Tactique," p. 252.

[12] "Operations of War," p. 334.

[13] "Theory of War," p. 237.

[14] "Elementary Treatise on Artillery." Bombay, 1864.

[15] "Gebrauch der Artillerie im Feldkriege." Berlin, 1870, p. 20.

[16] "Entwickelung der Taktik." Berlin, 1869, p. 151.

[17] "Artilleristisches Taschenbuch." Berlin, 1870, p. 231, et seq.

implied by the Austrian Captain Müller,[1] if I rightly understand his remarks on this subject.

It may be concluded, then, that guns should bear on that arm of the enemy's force which threatens us most, and that if doubt should arise as to which the predominant arm be, our artillery should devote its attention to the infantry and cavalry, rather than to the artillery of the opposing force.[2]

4. *What to fire.*

The nature of the object fired at determines the ammunition that is to be used.

Common shell is used, with time fuze set long, against ordinary buildings, wooden houses, earthworks, and combustible materials. It is laid down in most books that common shell may also be used against troops in mass or behind cover, with time fuzes so adjusted as to burst the shell on the first graze. This is one of those rules which it is so easy to preach and so hard to practice, and I have heard some of our best officers say that they had no confidence in such a fire, because it demands a delicacy of fire almost unattainable.

The Prussians made good practice against troops with common shell in 1870; but they used percussion, not time fuzes.[3]

The difference between segment shell and shrapnel is so fine as in no way to compensate for the complication to which the supply of both descriptions of ammunition to a battery gives rise; and there can be no doubt that either kind should be withdrawn, and the proper number of projectiles made up by a corresponding increase of the other. Segment or shrapnel may be used with time fuzes against skirmishers, or with time or percussion fuzes against troops in line or column. They may be used with time fuzes against artillery, if it be desired to kill the gunners, drivers, and horses; or with percussion fuzes, or blind, if the intention be to smash the carriages.[4]

The extreme useful range of canister from rifled guns is about 350 yds. Its use, therefore, has become rare and exceptional; for if the campaigns of 1866 and 1870 teach anything, they teach us that a battery is in danger when the enemy's infantry has arrived within

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[1] "Das Oesterreichische Feld-und Gebirgs-Artillerie." Wien, 1868, p. 114. "Studie über die Taktik der Artillerie bei der neuen Infanterie-Bewaffnung." Wien, 1868, pp. 26, 27. I believe I have not misrepresented Captain Müller's principles. The apparent contradiction between his statements and mine arises principally from the fact that he looks at the question as one of grand tactics, while I look at it as one of minor tactics.

[2] I merely lay down general principles on this subject. It would be unpardonable impudence to lay down definite rules on a question which must be practically decided almost entirely by the peculiar circumstances of each individual case.

[3] The use of percussion fuzes depends, of course, to a great extent on the nature of the ground on which the enemy stands; for if the ground to his immediate front be marshy, or even soft, shells with percussion fuzes will do him but little damage.

[4] See Capt. C. O. Browne's remarks on shells and fuzes in the "Proceedings of the R.A. Institution," Vol. VII. p. 29 et seq. When possible, percussion fuzes should be invariably used with segment shell, and time fuzes with shrapnel.

900 yds. from it, and that it is *in extremis* when the enemy's infantry is 350 yds. from it.[1] An Austrian rifled battery which galloped up to case range from the Prussian infantry at Sadowa, suffered such terrible losses that not a single shot was fired from it;[2] and a Prussian field battery which unlimbered at 600 yds. from the French infantry at Gravelotte, for the purpose of firing case, had so many men and horses struck down that only two guns could be got into action, and these guns were withdrawn as soon as practicable.[3] Each subdivision of our field batteries is at present supplied with 16 rounds of case—a much too large proportion in the present state of tactics. Six rounds, three in each axle-tree box, would be amply sufficient, and room would thus be gained in the limber boxes and wagon-body for twelve additional rounds of segment or shrapnel; either of which are infinitely more useful than case.[4]

By depriving it of its most destructive projectile, canister, rifled small-arms have inflicted a heavy blow upon the field artillery. But the evil is not an irreparable one, for the mitrailleur is capable of delivering a fire of case far more extended and deadlier than anything before known in the artillery service. By adding two mitrailleurs to our present 6-gun batteries, or by equipping one of the divisions of our batteries with mitrailleurs instead of guns, our field artillery would be enabled to deliver a destructive fire of case up to 1500 yds.[5] A certain number of mitrailleurs should also be equipped on the horse artillery system, to act as batteries of reserve.

To distribute mitrailleurs among the infantry as battalion guns would be to revive a system which for a century and a half, from the Thirty Years' War to the close of the 18th century, exerted a most pernicious influence on the progress of field artillery.[6] As the innumerable evils entailed by the battalion guns are so well known that it would be waste of words to re-state them, it seems incredible that a return to this system should be advocated at the present day by professional military men in Prussia, Austria, and England.[7] Yet such is the case—a further proof that "in this age the quiet surface of routine is as often ruffled by attempts to resuscitate past evils, as to introduce new benefits."[8] Unless mitrailleurs are recognised to be what they really are, powerful, although complicated pieces of artillery, and organised as such, the

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[1] "Ideen über die Verwendung der Feld-Artillerie." By the Prince of Hohenlohe-Ingelfingen. Berlin, 1869, p. 5.

[2] General Soudain de Niederwerth, in the "Journal de l'armée Belge," No. 213.

[3] "Observations amongst German Armies during 1870." By Col. H. A. Smyth, R.A., in the "Proceedings of the R.A. Institution," Vol. VII. p. 196.

[4] "The Prussians carry ten rounds of case per gun, of which, however, they have no opinion." Col. H. A. Smyth's "Observations, &c.," p. 201.

[5] "Machine Guns," by R. J. Gatling, in the "Journal of the Royal United Service Institution." Vol. XIV. p. 520.

[6] See "Proceedings of the R.A. Institution," Vol. VII. p. 130 et seq.

[7] "Mitrailleurs, and their place in the Wars of the Future," by Major Fosberry, V.C., in the "Journal of the Royal United Service Institution," Vol. XIII. p. 560. "Proceedings of the R.A. Institution," Vol. VII. p. 201. "Das Jahr 1870, und die Wehrkraft der Monarchie," Vienna, 1870, p. 27—said to be written by the Archduke Albrecht of Austria.

[8] Mr. J. S. Mill's "Essay on Liberty," p. 18.

advantages that arise from their invention will be almost neutralised by the ills their defective organisation will give rise to.

Rockets have never been largely used in the field since their invention, and it cannot be said that their success, on the whole, has warranted a more extensive use of them; for, like the elephants of the ancients, they are occasionally as dangerous to friend as to foe.

English rockets were successfully used at the battle of Leipsig, at the passage of the Adour in 1814,[1] and at the battle of Toulouse;[2] and the failure of Capt. Mercer's rockets during the retreat on Waterloo[3] was amply atoned by the success of Major Whinyates' rockets, under Serjeant Dunnett, at Waterloo.[4] They were used, with effect occasionally, during the Italian war of 1848–49,[5] and the Hungarian campaign of the same date;[6] and our troops suffered much annoyance at the siege of Delhi from English rockets discharged from the city by the natives. The Austrians used them at Solferino, without effect according to the French account;[7] but they seem to be falling gradually into disuse, and little is to be heard of them in the campaigns of 1866 and 1870. They may be used against infantry, but are especially useful against mounted troops, as they terrify horses and throw them into great disorder.

5. *When to move.*

I have laid it down that 2500 yds. is the extreme useful range of our field guns under ordinary circumstances. In case, therefore, the enemy be falling back, it will be necessary to limber-up and advance when the enemy's line has reached that distance from the guns. On the other hand, if the enemy be advancing, it should be laid down as a rule, to which there is only one exception, that the battery should limber and retire when the enemy's infantry has arrived at a distance of 900 yds. from the guns; for at that range the fire of infantry becomes effective, and the campaigns of 1866 and 1870 have proved beyond question that artillery cannot live under infantry fire.[8] The enemy's infantry may be looked on as an ironbound coast, bordered by a belt of deadly rocks that stretch out 900 yds. from the shore; and to attempt to navigate within that fatal line is to court certain destruction.

The exception I have alluded to is the case of guns occupying a

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[1] Napier's "Peninsular War," Vol. VI. p. 91.

[2] Ibid. Vol. VI. p. 644.

[3] Mercer's "Diary of the Waterloo Campaign," Vol. I. p. 279.

[4] Siborne's "Hist. of the Waterloo Campaign," Vol. II. p. 105.

[5] "Military Events in Italy." Translated by Lord Ellesmere, p. 108.

[6] "Memoirs of the War in Hungary," by the Baroness von Beck, Vol. I. p. 150. "Histoire de Hongrie," par Balleydier, pp. 52, 54, 94.

[7] A French staff officer, describing the effect of the rockets, says:—"Nous avons été exposés au feu d'une batterie de fusées, qui nous a couvert de ses saletes."

[8] I do not lay down dogmatically that 900 yds., to an inch, is the exact effective range of infantry at the present time. I am obliged to select some definite distance, and I select 900 yds. approximately, as being in all probability the minimum distance at which artillery should fight infantry.

position which the general has determined to hold to the last. In this case, let the distance of the enemy be what it may, the gunners must stand by their guns, and, if so be, die by them.

6. *How to move.*

In dealing with the movements of field artillery, three questions must be settled: first, the pace; secondly, the number; and thirdly, the direction of the movements that should be made. The third question belongs rather to grand than to minor tactics, and is a function of three variables—the position and spirit of our own troops, the nature of the ground, and the position and spirit of the enemy's troops. With it I have but little to do. It is a problem which lies beyond the sphere of artillery commanders, and must be dealt with by the generals of our own force. Were artillery officers ever called upon to take command of brigades and divisions in the English army, it might be interesting to touch briefly on this subject; but under existing circumstances it would be a waste of time and thought to discuss a question in theory which we shall never be permitted to solve in practice.

The axiom that guns are useless when limbered-up, underlies the whole theory of the movements of field artillery, as far as their rapidity and number are concerned.

From this axiom it follows, in the first place, that all the movements of a battery ought to be executed at as rapid a pace as the nature of its equipment will permit; for the slower the pace of manœuvre the longer the guns will remain limbered-up. It is therefore evident that the French and English field batteries fail to fulfil one of the primary conditions of a good field artillery. In both systems the guns are capable of moving at a brisk trot; in neither system would a trot be practicable in actual warfare. For in the present state of tactics, as everybody knows, artillery wagons dare not accompany their guns under fire; and if the wagons do not accompany the guns, the gunners must be dismounted, and it is a physical impossibility for men on foot to keep pace with horses moving at a trot. There is no alternative, therefore, between bringing field battery guns into action at a walk, and bringing them into action without their gunners. If a walk be a sufficiently rapid pace for field batteries to move at, then 12-prs. should be at once withdrawn, and 40-prs., or some such gun, should be given to them. On the other hand, if 12-prs. are indeed the fit guns for this branch of the field artillery service, then let the gun-carriage be fitted with seats for the conveyance of the gunners, so as to confer upon the system the mobility which 12-prs. are capable of attaining. This is not a question which is now raised for the first time, nor is it one which involves either experiment or expense. We have only to cast our eyes around us and imitate the Prussian, the Austrian, the Swedish, the Belgian, or the Italian system, or to reproduce that used for half a century by the Bengal Artillery. We have, indeed, to look no further than our own volunteer artillery, among whose carriages the latest continental improvements may be found.[1]

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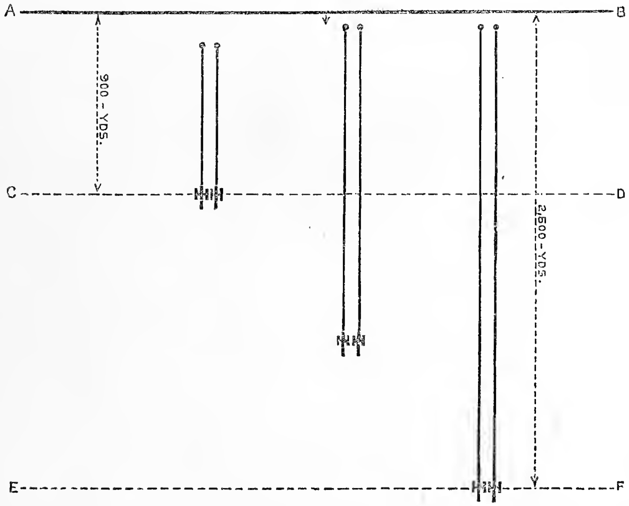
[1] I refer to the 1st Middlesex Artillery Volunteers.

Until a step be taken in either one direction or the other, our field batteries, with the French, will remain, as far as mobility is concerned, the most inefficient field batteries in Europe.

From the axiom that guns are useless when limbered-up, it follows, in the second place, that the movements of a battery should be minimum in number;[1] for in order to move, the guns must cease firing and limber-up. If an advancing enemy reaches 900 yds. from the battery, it should at once limber-up and retire, unless it be necessary to hold to the last the position which it occupies; and if a retiring enemy reaches a position much beyond 2000 yds. from the guns, they must be rapidly advanced to within 900 yds. of the enemy's line; but within these limits it is undoubted that the calmer, the steadier, and the less interrupted the fire of the guns is the better.

At the present day, the old principle that guns must move whenever the brigade of infantry or cavalry to which they are attached moves, is still in full action in the English army. Field guns must be aligned on the infantry, must move when they move, and must fire when they fire; or to use the ordinary phrase, they must "conform to the movements of the infantry." This mode of handling guns is utterly and diametrically contrary to the whole spirit of modern tactics; for

Fig. 10.



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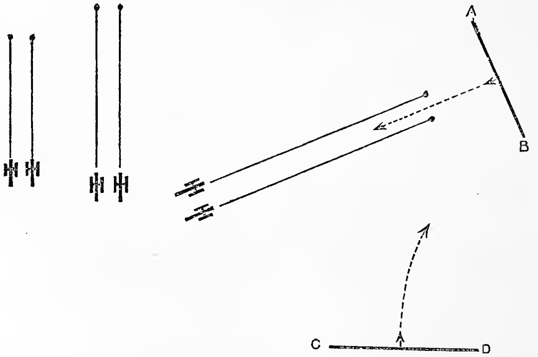
[1] Baron von Moltke lays down this principle with admirable clearness:—"Rifled guns are not in themselves wanting in mobility, but their peculiarities require that they should keep a position as long as possible when once they have taken it up; for every change of position demands a fresh calculation of the ranges, on the accurate knowledge of which the result chiefly depends. On account of their extensive range, it is possible for properly placed rifled guns to be effective from one and the same position in all the different stages of a battle. It is not necessary to advance a few hundred yards in order to reach the enemy, for this object is gained by altering the elevation, without essentially diminishing the efficacy of the fire."—"Beilage zu Nr. 27 des Militair-Wochenblattes, für den 8 Juli, 1865." Translated into English by Lieut. H. R. G. Craufurd, R.A.

nothing can be more certain, if my facts be indeed facts and if my reasoning be correct, than that the action of modern field artillery ceases just where the action of infantry begins. For example, if *AB* represent the enemy's infantry, in Fig. 10, then our artillery would, as a general rule, open fire at *EF*, and would gradually advance to *CD*, beyond which line it could not advance, without the risk of annihilation, as long as the enemy's infantry stands firm.[1] On the other hand, *CD* is the extreme position at which infantry could commence firing upon *AB*, without risk of wasting their ammunition. It is therefore clearly evident that if our infantry and artillery are to fight with effect they cannot fight in line, and that, although co-operating to effect the same end, they must for the future act far more independently than in the past.

The independent action of artillery, necessitated by the introduction of arms of precision, makes it the more important that guns should be accompanied on all occasions by strong and well-instructed escorts. The duty of an escort, be it cavalry or infantry, is a simple one—to protect the battery from sudden attacks on its vulnerable parts, its flanks and rear. With the front of the battery it has nothing whatever to do. Yet at the present day, it is not unusual to see the escort in the intervals between the guns, impeding and obstructing the movements of the officers and gunners, occasionally putting a stop to the fire altogether by getting in front of the muzzles,[2] and, worse than all, absent from the positions where its presence is really required—the flanks and rear of the battery. Far from being in the battery, the escort should be well in its rear, and well to a flank, as in *CD* (Fig. 11).

Fig. 11.



It should be well to the rear, in order to be able to take in flank any

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[1] The Prince of Hohenlohe-Ingelfingen's "Ideen über die Verwendung der Feld-Artillerie," p. 5 et seq. "L'Artillerie de campagne Belge," par Capt. Nicaise. Bruxelles, 1870, pp. 40, 41.

[2] This happened to the horse artillery at the battle of Vittoria. See Frazer's "Letters during the Peninsular and Waterloo Campaigns," p. 160.

body of the enemy, such as *AB*, which endeavours to outflank the guns; and well to the flank, in order to watch and give notice of any attempt on the part of the enemy to creep round the flank of the battery and attack it in rear.[1]

A cavalry escort should lose no time in charging an enemy who attacks the flanks or rear of the battery, but it should never pursue. If the gunners are annoyed by sharpshooters, the escort, of whatever arm, should endeavour to drive them off, or at least to occupy their attention. In case the enemy attacks the battery in front, the escort should form in line immediately in rear of the limbers, and there await the result of the attack. If it be successful, the escort will rush in to protect the defenceless gunners and save the guns.[2] If it be unsuccessful, the escort will resume its former position. It is almost needless to say that in posting an escort every advantage should be taken of the accidents of the ground.

If it be necessary to subdivide a 6-gun battery, it should be broken into divisions,[3] not half batteries; for the half battery formation violates every principle on which the formation of a 6-gun battery is founded. In 4-gun, and 8-gun batteries, half batteries are, on the contrary, convenient and useful.

On the formation of guns when manœuvring it is not necessary to say much. The nature of the ground will occasionally necessitate the use of column, but as a general rule, line at full intervals is the best of all orders.[4]

What I have endeavoured to prove in the foregoing pages may be summed up in a few words.

As regards the mobility of field artillery, its movements in action, although made at the maximum speed which its equipment renders possible, ought to be minimum in number, and executed beyond the effective range of the enemy's infantry.

As regards the fire of the guns, field artillerymen require time to choose their position; they require time to determine their object; they require time to select their ammunition; they require time to find their range; they require time to load their guns; and they require time to lay their guns. They require time to do these things; and unless time be given to do them, it is vain to hope that, in our next war, our batteries will gain that superiority over those they will encounter which, from the excellence of our *matériel* and the stubborn courage of our gunners, we might reasonably expect.

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[1] Giustiniani's "Essai sur la Tactique," pp. 80, 206. The directions given in Robins' "Cavalry Catechism" for the position of an escort are absurd, and it is unsatisfactory to find them quoted with approval in Sir Sidney Cotton's "Field Exercises of the Peshawur Brigade," p. 104.

[2] An excellent example of this principle is afforded by the conduct of the cavalry escort (15th Hussars) of the guns attacked in the action fought on the 2nd Dec. 1799 in Holland. See the "British Military Library," Vol. II.

[3] "Les deux canons d'une même section" (division) "sont des camarades de combat qu'on ne doit jamais séparer."—"Instruction du Général Le Bœuf pour le camp de Châlons."

[4] The reason is explained by the Prince of Hohenlohe-Ingelfingen in his pamphlet before quoted, p. 42.

Such is a brief outline of the minor tactics of modern field artillery. If the principles I have laid down be untrue, let their falseness be exposed; if they are true, let them be practically adopted, or let us take for our motto—

> " . . . . video meliora proboque,
> Deteriora sequor. . . . . "

A FEW NOTES ON THE

HANDLING OF HORSE ARTILLERY & CAVALRY.

BY

CAPTAIN I. KETCHEN, R.H.A.

I FEEL strongly that a great many officers already know all that is contained in the following sentences, and that it seems presumptuous in me to ask a place for them in the Institution papers; but they are not meant for such officers, but for the few who, although I feel sure they will assent to what I have written, have not thought much on the matter before.

Simple although the ideas are, they certainly are not generally acted upon; in fact I have never yet seen them acted upon at any brigade parade I have taken part in. For these reasons, possibly some few may think them worth reading.

Except when preparing for an attack, horse artillery and cavalry should never be *in motion* in the same line.

By "preparing" is meant, advancing in good open country together to meet an enemy, but at such a distance from him as would be beyond the proper limit for commencing actual fighting.

In advancing to attack, the horse artillery should do so as soon as the order is given, and, if the ground admits, at full gallop. (By "full gallop" here and throughout this paper is meant, as fast as the nature of the ground will allow with safety.) The cavalry escort should move off at the same time, and follow on the outer flank at a trot, but never remain quite so far away from the guns as the enemy is from them; so that should the guns be suddenly charged by the enemy, the escort may intercept and at least check him.

By the time the guns have come into action, or very soon after, the escort will have arrived at its proper position (on the outer rear of the guns), men and horses perfectly fresh and fit for work if really required.

When the horse artillery have advanced about one-third of the distance between the cavalry and the enemy, the cavalry should *then* move off at a trot, watching the guns, and should on no account go past them (in fact, keep out of the enemy's fire as long as possible) until the guns are actually in danger by the rapid advance of the enemy, or the latter thoroughly thrown into confusion. In either case it will be the duty of the commander of the cavalry to decide *when* he should pass the guns and charge the enemy; and the officer commanding the horse artillery should always be held to be intelligent enough to know that when the cavalry advance so far as to be in danger from the fire of the guns—but not one second before then—firing must cease.

The horse artillery horses may become regularly blown by their rapid advance, and although while galloping to the front the guns were perfectly useless, yet now, standing still in action, they are doing their work in their proper place, and the horses are being rested; *i.e.*, horse artillery when in motion are of no use against an enemy, they are of use only when "standing still." The longer they are kept standing still, the greater the number of rounds that can be fired, of course, and the longer the breathing time for the horses. Hence, position should be changed as seldom as possible; but when necessary, it should be done at full gallop, for until the change is *completed* the guns are quite useless—until, in fact, they are "standing still" again.

It is therefore quite clear that the gallop, when practicable, is the *only* horse artillery (proper) pace during an engagement.

On the other hand, with the cavalry nearly the opposite holds good.

If the cavalry are working with horse artillery, they should endeavour to obtain from the guns as much work as possible; and the more damage the guns are allowed to perpetrate on the enemy, the more successful is the cavalry charge afterwards likely to be. The guns, therefore, should be permitted to go ahead to do their work; and while this is going on, the cavalry commander, saving his men and horses, should come up at the *very* slowest safe pace. By galloping now, he would only "wind" both men and horses, and if he passed the guns (and how very often this is done), they would, for his safety, have to cease firing before they had (possibly) given the enemy one round; and further, his men and horses would be "done" at the very moment when they should be at their best.

In actual warfare, as a rule, except in the charge over about the last 100 yds., and the canter for about the previous 50, cavalry should never go beyond a trot.

A sort of rivalry now exists, most pernicious, as to which goes the faster. This would be thoroughly put an end to if the absurdity of horse artillery and cavalry advancing together were stopped, and the following rules borne in mind:—

At the time of actual conflict with the enemy, cavalry should be at full gallop.

At the time of actual conflict with the enemy, horse artillery should be standing still.

In advancing to the attack, cavalry should not go faster than a trot (so that men and horses may be fresh for the "clash.")

In advancing to the attack, horse artillery should go at full gallop (so as to get into "standing still," and therefore use, as soon as possible; for the sooner in action, the greater the number of rounds the guns can fire before the cavalry pass).

Were these points attended to, there could be no rivalry. The one would then see that a distinct part has to be played by the other, and that both combined make a splendid whole; and were this feeling once secured, it would more than ever be the object of the officers of the one branch to try to become acquainted with the details of the other, with the ultimate view of being able to act at the proper moment and in such a manner as to obtain the greatest possible advantage by the correct combination of the powers of the two arms.

To return, then, to the subject.

The guns should remain unlimbered after the cavalry have passed on to the charge, so as to be ready to open fire, should a favourable opportunity offer, in the case of their being beaten back. As soon, however, as it is seen that the cavalry have got the best of the affair, the horse artillery should limber up and advance to the front, so as to give the retreating enemy a few farewell shots on the cavalry desisting from further work.

Then in retreating, a brigade of horse artillery and cavalry should be worked on the same principles.

On the order being given to retire, the guns of that part of the brigade which is to go back first should do so—about 200 yds.—at full gallop (an exception must be made in favour of the horse artillery to the general rule that all retirements should be done at a walk, or at most at a trot), so as to bring the guns into use again as soon as possible; but the cavalry of this retiring part of the brigade should go back at a walk, and the guns in front should not cease firing until the retiring cavalry have fronted in line with their own guns.

It is now usual for the guns in front to cease firing as soon as the retired guns have opened fire, but this should not be done. The retirement, as a whole, should be accomplished slowly—that is, at a walk by the cavalry; but by allowing the horse artillery to gallop back, it is evident that a great deal more effect is gained than by the usual way of making them walk back in line with the cavalry; for during the whole retirement every gun is actually in action, except for the few minutes taken up in the 400-yard gallops (200 to the already retired guns and 200 beyond them), whereas, as a rule, at present only one gun out of every two is actually in use during the whole time taken up in walking to the rear.

The slow retirement of the cavalry next the enemy is well covered the whole time by the first retired guns, and *nearly* the whole time by its own guns as well. The cavalry should not get the order to go about until the horse artillery with which it is associated has actually moved off to the rear. As a rule now, the cavalry commander forgets that after the order to retire is given, the horse artillery have to discharge their guns, sponge them out, limber up, and mount their horses before they can start; and very frequently he goes off leaving the guns behind him, instead of seeing them clear off before he moves.

By this method of retiring, should an opportunity offer for the cavalry to charge, their men and horses are quite fresh and fit for such work at any moment; and the horse artillery horses have abundance of breathing time while standing still between the successive gallops to the rear.

The reason for the horse artillery being made to gallop to the rear should not only be known to the horse artillery themselves, but published to the army; so that, should retreat ever become necessary, no panic would be occasioned by the now unusual sight of a portion of an army going back at a dashing pace.

The same arguments apply to all changes of front in the face of an enemy, except to meet a sudden and unexpected flank attack; in which case it will be necessary for the cavalry to get into their new *direction* at a gallop. As soon as that is gained, however, the guns should be allowed to do all they can before the cavalry pass them; in fact, all the foregoing then again comes into full force.

To sum up. During an engagement, horse artillery and cavalry should never be in motion in the same line; *the* pace for horse artillery is the gallop; cavalry should rarely (except when charging) go beyond a trot.

What I have written in no way refers to the conduct of the drilling of either the horse artillery or cavalry. Of course, the horse artillery must in great part be taught and exercised at a walk and trot, as the best of all means leading to safe galloping; and the cavalry, too, must very frequently be manœuvred at a gallop, to ensure their being able to do so on an emergency.

I may add that the horse artillery should expect great assistance from good Rifle skirmishers. They are generally to be found in the front, and when the horse artillery come up the protection that might be afforded by such men would be immense; for the enemy's sharpshooters have always been a thorn in the side of the horse artillery, whereas, if we could only keep down their fire by our own skirmishers, many a shot that now has at least the chance of disabling one of our teams could never be fired at all. I cannot, however, pretend to any knowledge of the *manner* in which this protection may be best afforded; that may safely be left in the hands of our Rifle officers.

THE

PRUSSIAN MODE OF CONDUCTING LARGE MANŒUVRES.

A LECTURE DELIVERED AT THE R.A. INSTITUTION, WOOLWICH, FEB. 7, 1871,

BY

LIEUT.-COLONEL E. W. BRAY,

4TH KING'S OWN ROYAL REGIMENT OF INFANTRY.

MAJOR-GENERAL C. DICKSON, C.B., V.C., INSPECTOR GENERAL OF ARTILLERY, IN THE CHAIR.

SUBJECTS :—

I.—Prussian mode of conducting large manœuvres, and the manner in which a staff of Umpires is used for the purpose of controlling and regulating such manœuvres.

II.—The necessity of introducing a more intelligent system of manœuvre and a higher system of training amongst the Regimental Officers of the English army.

CAPTAIN ALEXANDER DICKSON BURNABY, R.A., Secretary of the Royal Artillery Institution, having introduced the lecturer to the meeting,

Lieutenant-Colonel BRAY said: Gentlemen, I visited Berlin and Pomerania in the autumn of 1868, with Major-General Sir Charles Staveley and three other officers, for the purpose of witnessing the field manœuvres of the Prussian army, which I had long been anxious to do from what I had read of the practical teaching given to the troops, superior officers, and staff, by the peculiar manner in which their sham battles, campaigns, and attacks were carried out. I was, at the time, greatly impressed with the skill and military science with which these manœuvres were carried out—the wonderful similarity and reality to war itself which was made apparent by the manner in which the work was executed, and the great practical results attained by the high training in the higher branches of military knowledge of the art of war which was given to the troops—cavalry, artillery, and infantry, and intendance or control departments—and the immense advantages conferred on generals, colonels, majors, captains, lieutenants, and staff officers of every degree.

The instruction conferred on officers by witnessing the execution of manœuvres in a time of peace by the Prussians is so great, that I consider I learnt more of my profession in Prussia in six weeks than in the previous many years of peace training in the English army. Of course I exclude the training of actual service, which is the true training of an officer; as in one campaign a man learns more than in ten years of common barrack-yard training, which is so unlike real war, that General Trochu says in his pamphlet on the then state of the French army in 1867 (three years ago), "that the exercise of troops in time of peace gives them absolutely no conception of a real struggle in real warfare."

This is, I am afraid, to a great extent, perfectly true; and the only exercises that I have ever seen, in my tolerably wide experience, that can possibly make troops, and especially officers—and by officers I mean leaders of troops—are such exercises as are conducted in Prussia either on the Prussian system or one founded upon it.

When I speak of officers I mean commanders or leaders of men; for, on looking into the English dictionary, I find an officer defined as a "commander" or "leader of men."

This should be borne in mind; for I find English people have strange ideas of an "officer." Some think him a man finely dressed, with nothing to do; others, again, think anything an officer in a sash and gold lace. There are officers, again, who write "Captain" on their cards on the strength of having been lieutenants in the "Bungay" militia! The officers I speak of are commanders or leaders of men; and the instruction of all officers should be to make them leaders of men.

In the piping or, more correctly speaking, in the pipe-claying times of peace, the object of an officer's training is greatly lost sight of; and his time is taken up principally with small regimental duties and small regimental details, many of which have been invented to give him occupation and fill up his time.

In war-time, about one-half of these regimental duties and details go by the board, and officers are thus all at once and suddenly thrown on their natural resources—their energy, and their real professional knowledge. Then comes the time for the exhibition of military talent and professional training. It is too late then to look at books, and study the art of war; generally, on a campaign, no books are to be had. A perfect knowledge of the "Queen's Regulations," "Royal Warrants," and "Regimental Standing Orders," though all good and necessary books in their way, will not help you out of a mess, nor make you a commander or leader of men!

Officers must be taught the higher branches of the profession—as well as the lesser and smaller parts—in time of peace, and before they arrive at the rank of field officer.

If there is one thing we pride ourselves upon more than another it is this, that our "regimental system is perfect." How a system can be perfect which neglects the training of regimental officers in the highest branches of the profession (which is admitted *now* to be one which requires the highest and best qualities which an educated man can possess), I cannot understand; in fact, such a regimental system must be allowed to be imperfect in one of its most important parts.

Object of Lecture.

The object of my lecture is therefore to try and explain the Prussian mode of conducting their manœuvres, and so to interest my audience as to get the matter thoroughly discussed in Woolwich (the head-quarters of the Royal Artillery) and in Aldershot (our English military school), where all changes and improvements are expected to be initiated and tried, and, if possible, such changes and improvements made in the existing system as may appear desirable, and at the same time practicable, and introduce a more intelligent system of manœuvring.

I am not myself an advocate for adopting every novelty introduced by Prussia, France, Austria, or Russia, as we have very many good points in our military system which should not be changed: and in considering the organisation of armies, the temperament and peculiarities of the nation must be considered, of which the army is but a part, after all.

In the Prussian army I did not see many things worth copying; and in many things I thought we were better, and ahead of them; but the one very important point in which they were decidedly superior to us was, in the TRAINING OF THEIR OFFICERS. And this is the subject of my lecture.

The introduction of an efficient system of higher training for the officers of the English army, and especially the captains and field officers, I consider a matter of such vast, in fact, I may say, of such vital, importance to our army, that I trust I may be able to use a sufficient amount of eloquence to fix your attention, and to convince even those who are sceptical and think " we are very well as we are."

I think myself that we have much to learn—that we must march with the age—that we must recognise the great changes in the art of war. We must study these changes. We must modify our dress, our equipments, our drill, our training, our organisation, to meet the changes which are demonstrated to us from day to day by the graphic descriptions of the war now raging in France. If we do *not* do so—if we move with the sluggishness peculiar to this nation, with the sluggishness peculiar to us in matters military—then depend upon it the day of retribution is drawing nigh; a huge disaster will fall upon this country, similar to that which has fallen upon France, and from which we should suffer more, as we have not a population trained to arms, no organisation to meet an invasion, no fortresses to stop an enemy. Our collapse would be sudden and terrible, rapid and astounding.

Our part, as soldiers, is to recognise the military facts of these great questions, and to prepare ourselves by study and training to make the military machine—the army—as perfect as we can; so that, when the day comes, we may play our part with credit.

I must mention that some parts of the Prussian system cannot be introduced without special Acts of Parliament and an expenditure of money for damage to property. In Prussia, everything gives way to the army; in England, the army gives way before everything—" a pretty considerable difference," as Jonathan would say.

Sir Charles Staveley's Book.

In 1861, all the orders, instructions, and traditions of the Prussian army were embodied in a book of regulations, which, by order of the King of Prussia, dated June, 1861, became the rules and regulations of his army for the exercise of "troops in large bodies."

This is the handbook; and I now hold a translation of these orders in my hand, made by Major-General Sir Charles Staveley, K.C.B., who now commands at Plymouth, and who is an ardent and distinguished soldier, eager in everything connected with his profession, and who was the senior officer with our small party of English officers in August and September, 1868, and who was also greatly struck with the practical knowledge of war attained by the Prussian officers and troops, by their intelligent and scientific mode of working their troops across country in mimic war. This book I have carefully read over, and I will take it as the foundation of my lecture, filling it up with my own personal experience and recollection of what I saw myself.

I must mention that last year Major Milligan (late A.D.C. to Sir Yorke Scarlett) visited Berlin, on which occasion there were, I believe, twenty-five English officers present at the reviews, and some, I hear, are now at Aldershot. Major Milligan, on his return, published a translation of the same regulations. Sir Charles Staveley's and Major Milligan's translations are very similar up to a certain point; but Sir Charles Staveley has gone further, and translated the orders for outpost duties, encampments, drawing up troops in order of battle, &c., &c.

I found, on asking some experienced and intelligent colonels, last autumn, what they thought of Milligan's translations? they said, "The rules are good, the principles are correct; but we do not see how the Prussians work it out in the field, or how the umpire staff can regulate or improve matters. In fact, we cannot see how it works." This was my own opinion; and I feel that no officer will understand the "working of these rules," unless he has seen it for himself, or the working has been explained to him by one who has.

Review of the Prussian Guards.

On the 7th of August, 1868, the whole of the Prussian Guards, cavalry, artillery, and infantry, and numbering nearly 20,000 men, were drawn up in grand review order for the inspection of the King, on a sandy plain, three miles beyond the gates of Berlin. At this review our small party of five English officers were present. We were furnished with horses and orderlies by the 2nd Dragoons of the Guard; and Lieutenant Count Seckendorff, of the 2nd regiment of Guards, was attached to us as our guide. This officer is now A.D.C. to the Crown Prince, and took the greatest pleasure in repaying to all of us in Prussia the attention which he had received from English officers in Abyssinia.

I will merely here say of this review, that we were most favourably impressed with the bearing, physique, and general appearance of the

Prussian Guard corps, and we were much surprised to see what well-trained soldiers could be turned out in three years. The men are not so well set up as English or French soldiers; but it must be remembered that their service is very short. The officers and sergeants are very smart and well set up. The officers are a strikingly fine body of men.

The morning after the review all Berlin seemed to be on the move, as the whole of the Guards marched out early to their various rendezvous, about twelve miles from Berlin, for a week's campaign in the open, without tents and in war-service order.

Maps and Plans.—General Idea.

We joined the head-quarters staff at about ten o'clock next morning, at an appointed place, at some village; and here maps of the surrounding country, and the printed "general idea" of the day's work, were distributed to the officers.

I must mention here that at the field manœuvres every officer—from general to lieutenant—carries his map in his belt, which is consulted at every halt, and at every opportunity. And every officer carries an opera glass, the maps and glasses being considered much more essential than swords. And in this particular we might, with great advantage, *at once, and without further delay,* take a leaf out of the Prussian book.

In Abyssinia, most of the regiments packed up their red sashes, and substituted opera glasses of all colours and sizes; so, in practice, the opera glass is carried; and therefore it might be well to recognise it at once as an absolute and necessary part of an officer's dress.

When we arrived on the ground occupied by our army, the other army was miles away, quite out of sight; and it was only known that the enemy was trying to outflank our army and seize the road to Berlin.

Cultivated Land.

The country about Berlin is sandy, with plenty of villages, woods and ditches, small lakes, and very few hedges; the fields being open and large, but defined by ditches, instead of hedges. All fields under cultivation which may be damaged by the passage of troops are marked with poles, and bunches of straw stuck upon the top of them. This means, "Avoid this field, if you can;" but if unavoidable, the troops pass where they please; and at the end of the day's work all damage done to property is assessed by a board of staff officers and civilians, and the amount paid by the government. This is the law of the land; and it is done in a regular and methodical way, and, I heard, did not cost very much, as in the autumn, when the crops are down, there is not much to injure.

I cannot myself see why some attempt should not be made in this neighbourhood to introduce some such plan, as the surrounding neighbourhood, farms, and estates must benefit largely by the cantonment of such a large body of troops in Aldershot; and therefore the landlords should allow the troops to pass over the lands and farms for ten or twelve miles round. The damage done would be slight, as the pioneers follow the troops, and repair at once any damage done to ditches, fences, &c. The manœuvres could be confined to a week or a fortnight at such time of the autumn as would do least damage. Any way, the subject might be seriously considered, and the co-operation of the landlords tested.

Our army was drawn up, with its front towards the expected advance of the enemy; the troops all posted according to the nature of the ground, and as much under cover and out of sight as possible; arms piled; dragoons and artillery dismounted; and animated discussions with maps in hand going forward everywhere, as reports came in of the enemy's movements from the cavalry outposts, which had started early in the morning, to feel for the enemy, and were spread out like a fan for miles in our front and flanks. Every wood, every hillock, every village, every farm, every bridge, every road, every steeple, every railway station, was occupied by cavalry videttes of one, two, three, four, or more, men; officers, cavalry, and staff looking out with the greatest earnestness and interest for the movements of the enemy, which were reported rapidly to the main body in writing; the supports to these outposts—consisting of troops, half-troops, sections, squadrons—were concealed all over the country, behind haystacks, farms, barns, woods, &c., receiving reports from the front, and communicating them to their reserves. In fact, so perfectly, intelligently, and earnestly was this duty carried on, that nothing could escape the "eyes and ears" of this army, and every movement of the enemy was brought back.

The duty is varied by enterprises and constant attempts to capture videttes, patrols, officers, and orderlies carrying messages; and it is so earnestly executed, that it is common to see officers, patrols, or single dragoons riding as for their lives, pursued at racing pace by single lancers, or parties of horse.

So it will be seen that the rules of war are strictly carried out, and that the information acquired by the outposts, or staff officers, must be obtained, as in the field, at the risk of capture.

Infantry outposts are thrown out, also, where necessary. The Prussians have an excellent plan, by-the-bye, which should be adopted by us: that is, having two or three dragoons with every advanced infantry piquet. I think myself that an officer's piquet should never be without *one* dragoon or hussar, at least.

At our exercises at Aldershot it is common to see generals and staff officers surveying the positions of their enemies under a deadly rifle fire, or under the immediate fire of field guns. Such things are not allowed in Prussia. They soon let slip a party of hussars, or lancers, at any officers attempting to get a near view. I saw a general and his staff who had, in this way, gone forward in their eagerness, charged by a party of lancers at full gallop. The general fled, followed by his staff—a most exciting pursuit, which ended by some officers, who were not given to hard riding across country, being captured by the Uhlans, and carried off in triumph to their own side!

Cavalry Outpost Duty.

Nothing struck me more than the splendid manner in which the duties of the cavalry outposts were carried out in a real, intelligent, skilful, and soldier-like style, which I have never seen even approached. I may say the same of the manner in which the cavalry was handled in these mimic wars by the Prussian officers throughout. And the skill displayed gave me a new idea of the power of cavalry in war, and which I certainly had not realised before. When I found, in the present war, particularly at the beginning, the French troops out-manœuvred, surprised, and deceived by the Prussian cavalry, I was not in the least surprised; it was to be expected from their very high training in the most important part of a dragoon's duties—outpost duty.

I would strongly advise every English cavalry officer to carefully study the Prussian rules for outpost duty, contained in Sir Charles Staveley's translation, and to thoroughly recognise and understand the most important duty of this branch of the service; for as our cavalry are few in number, so they should be perfect in this knowledge of how to be the "eyes and ears" of our army.

A Prussian colonel of cuirassiers, when we were going through the bivouacs, after a heavy and long day's work, when told that we had observed that their horses were badly groomed and the saddlery only half-cleaned, according to our notions, even for bivouacs, replied thus: "We Prussians try in three years to make a thorough dragoon, a perfect outpost soldier, a reliable and intelligent vidette. Our horses are sufficiently groomed for war purposes, and as much as they ever can be in the field. Our saddlery is clean enough for war. You English pass your time in turning your officers and troopers into grooms, polishing bits and stirrup-irons, and covering yourselves with pipe-clay. We don't—and we don't want to; for we know that such things are useless in war."

Whether this Prussian cavalry colonel was right or not, I leave those to judge who read a few days ago a description of the Prussian cavalry, evidently from the pen of an English dragoon, in the advance from Orleans on Tours and Le Mans. This English officer said that their horses were in perfect condition after five months' hard campaigning, and that the troopers looked as if they had only just left their barracks in Berlin. Yet it must be remarked, notwithstanding the Prussian cuirassier colonel's opinion, that we have twelve years to make a dragoon instead of three years, and consequently we are able to turn out our cavalry in a style that must excite the envy of a Prussian dragoon; for our cavalry are certainly in beautiful order, and the attention which is paid to dress, appearance, equipment, riding, and horses, has great advantages too, and is most useful to discipline. I question whether any army in the world could turn out such a splendid division of cavalry as that at Aldershot last summer—viz., 1st Life Guards, 3rd Dragoon Guards, 6th Inniskilling Dragoons, 9th and 12th Lancers, and 10th Hussars.

Now, it is as well to see ourselves as others see us. I have the highest opinion of the English cavalry, and I am a great admirer of it.

I think the material of which both officers and men is composed is splendid—first-rate—and that they can hold their own with any cavalry in Europe, in point of appearance, officers, men, and horses. I have always, however, thought that our cavalry outpost duty was imperfectly performed in the field. There is a want of elasticity, quickness, and intelligence; but I am certain that when these facts are thoroughly understood and recognised by our cavalry, there will be no difficulty in getting cavalry officers to study the new duties of this branch of the service.

From my experience, I would say that some of the Indian irregular horse regiments perform outpost duty better than we do; they are quick, intelligent, and much more alert on piquet than English soldiers. I would say that the 12th Punjaub Cavalry and 23rd Punjaub Pioneers performed outpost duties better than any troops in Lord Napier's army in Abyssinia. This is my opinion, and I had good opportunities of judging.

The written and verbal reports from the outposts enable the commanding general to guess pretty well the intentions of the enemy long before his main body is seen, and preparations for attack or defence are made accordingly.

Umpires.

The business of the umpire staff now begins. The chief umpire is the senior general commanding in the absence of the king or commander-in-chief. At Aldershot, the commander-in-chief would be the umpire; in his absence, the lieutenant-general commanding. The commanding general selects other officers, in sufficient numbers, of sufficient rank and acknowledged excellence as soldiers. They all wear a white band round the right arm, their names are published in orders, and they are attended each by a couple of intelligent dragoons on fast horses, who also wear the white band of neutrality.

The following are rules for the umpires:

Rules for Umpires.

1. The umpire-in-chief will be the lieutenant-general, or other senior general officer commanding at Aldershot.

2. All orders from the umpire staff to be considered as directly emanating from the lieutenant-general, and to be carried out and obeyed with alacrity.

3. The umpire staff to be under the orders of the lieutenant-general. The staff to consist of four, five, or six selected officers, as many as possible being colonels and lieutenant-colonels. No officer under the rank of major to be so employed.

4. The umpire's staff to be distinguished by a broad white silk band round the right arm, above the elbow. Each umpire to be accompanied by two dragoon orderlies, who will also wear the white band above right elbow.

5. No general or other commanding officer of regiments, brigades, or batteries, is, on any account, to enter into a discussion with the umpires.

6. The umpire staff will report any officer infringing this necessary rule to the lieutenant-general.

7. The opposing files are to be either dressed differently (dress and undress), or one side to be distinguished by wearing forage caps.

8. The umpires may halt any body of troops, and order them to retire behind the first line, or to any position indicated.

These officers scatter themselves along the front between the contending armies, placing themselves on high ground, or where they can get a good view, and can watch the movements on both sides. They are thus ready to check any breach of the rules and regulations as contained in Sir Charles Staveley's book. This is done by the umpire at the spot halting any body of troops on either side, ordering it to retire a certain distance, or not to move or advance further for a given time. A note of the umpire's decision is at once forwarded to the general commanding on either side, as may be necessary.

Umpires prevent the attacking troops advancing too quickly, and not allowing sufficient time for the effect of the fire of the defence. They prevent lines getting too close, skirmishers from closing, cavalry from making absurd or ineffective charges, or placing themselves under the fire of artillery or infantry. They prevent artillery from taking up exposed positions, or placing themselves under the effective fire of infantry, or where they are liable to immediate capture.

The umpires decide whether a position has been carried—a bridge, or village, or wood, for instance—with sufficient force; whether a battery has been fairly captured; whether a cavalry charge has been effective and properly timed. While the umpire is looking at the positions and making his notes, the troops order arms, officers return swords, and cavalry dismount, until the decision is given; when matters either go on, or cease.

I will read a summary of some of the principal rules which must be learnt by heart, and thoroughly recognised by all, in order to work this system of manœuvring. The Prussians know these rules as well as they do their catechisms—perhaps better.

Rules to be Observed by the Troops.

1. Infantry and cavalry are *not* to approach each other nearer than 60 yards. If they come nearer, the officers halt, order arms, return swords, until the umpire decides which is to retire.

2. Lines are *not* to exchange volleys nearer than 250 yards.

3. Skirmishers must *not* fire when within 200 yards of each other.

4. Cavalry charges, to be considered effective by the umpires, must be delivered with proper energy, and halted within 60 yards of infantry.

5. Cavalry and artillery must *not* remain halted under effective fire of infantry.

6. Skirmishers and artillery must *not* move across a plain commanded by enemy's cavalry.

7. Guns limbered-up may be captured by cavalry or skirmishers if unsupported or weakly protected.

8. Beaten cavalry must retire at a trot. The victorious cavalry may follow at a walk at 500 yards interval, if they think proper to do so.

9. A battalion in square (unshaken) can *not* be attacked by single squadrons of horse. Three or four squadrons may do so, if the square is so placed as to be assailable from different sides.

10. When infantry are defeated by infantry (according to the umpire's decision), the victors may pursue at a reasonable distance.

11. Obstructions are only to be considered tactical obstructions when they form actual natural obstructions.

It must be borne in mind that no officer is allowed to interfere with, or enter into discussions with, the umpires, who report to the umpire-in-chief.

Now the effect of the umpires is this, that the crisis of the battle is delayed, and individual commanders are not permitted to go careering forward, and upsetting all arrangements, refusing to halt, or to retire, or to cease firing, and doing, in fact, just as they please, regardless of the general plan, and the necessary regard to combinations and the probable effects of the fire.

With us, at all our sham fights and battles, the crisis is precipitated; and almost as soon as the engagement commences there is a jam, and the whole often ends in confusion and no intelligible result —*because each commander tries to win, and there is no controlling power.*

I maintain that such always must be the case, as no game can be played successfully *without* umpires; and war is the greatest and most difficult game of all.

Strange to say, we English use umpires for every game, except the most difficult game—war.

I will give you two cases which occurred last season at Aldershot to show the absolute necessity of using umpires when two bodies of troops are pitted against each other in a sham fight. I might give you many cases, but I will take two only.

In taking these two cases, I beg distinctly to disclaim any intention whatever of criticising these two manœuvres. I only take them as two cases requiring umpires; and allowing that the greatest skill and talent were exhibited on both sides, and that the attack and defence were both perfectly carried out, does not alter the two cases as examples for illustration. I do not criticise any part of the movements; I only use them to show how the inevitable jam occurs *without* umpires.

General Lysons' brigade took up a strong position last autumn, on the Frimley Ridges, near the railway bridge, which was barricaded, and he was attacked by the rest of the division. The position was a very strong one. The 4th regiment defended the bridge; the 42nd regiment the railway, with 33rd and 67th regiments in reserve, also a cavalry regiment in reserve under cover. The two field batteries were in good commanding positions, from which they could pound the attacking brigades. The attacking troops, after reconnoitring our position, advanced to the attack; and as we had received orders from our general not to yield an inch, as our position was so good, we held on. The attacking troops continued to advance, until the two forces crossed rifles, amidst loud cries from the staff officers of the attack of "Why don't you retire?"—"You ought to go back!" —"You're beaten!—you're outflanked and outnumbered!" We replied, "We won't go back!—we are ordered to hold our ground. If you come to 'going back,' you had better 'go back' yourselves!"

Here was a difficulty. According to Aldershot practice, we should have given up our position as soon as the attacking force got within a hundred yards of us; but, as we did not, the whole thing ended in a jam. The troops got mixed up, and the affair collapsed.

Can there be anything more absurd than the general of the attack ordering the general of defence to retire, and abandon his position!

Here was a clear case for umpires. They would have halted the attacking regiments before they got jammed, examined the position; the numbers of men on each side, and then decided whether we should give up our position and retire, or whether the attacking force should retire, and commence the attack from another direction, and make us let go our hold.

General Lysons' camp at Sandhurst was attacked by the remainder of the division on the right of our camp, with a faint attack on our front. I covered the concentration of our brigade by two companies of the 4th regiment in a very strong position, with plenty of wood and cover, while Colonel Wilby brought up the remainder of his regiment; and while the 4th King's Own held the enemy in check, the remainder of our brigade was assembled in our rear. The enemy came on, as usual, without a check, refused to be repulsed, or even stopped; and of course the usual jam very soon occurred, when it was necessary to stop the fight.

There were *no* umpires to regulate the advance, or give us credit for our position and dispositions. Moreover, with us the troops are never evenly divided. One brigade is generally attacked by the rest of the division, always outnumbered two or three to one.

I think myself that we only require to lay down certain necessary rules for general guidance, like the Prussians, and we should very soon take to the system. The Prussians only use umpires when troops are divided, and placed in opposition, to manœuvre against each other.

Crisis of the Battle.

When the crisis of the battle has arrived, and the reserves have been brought into action, and it is clear that nothing more can be done, the halt and officers' call is sounded by the commanding general, which is repeated all over the field. The movements are then criticised by the commanding general, and either the troops march to their bivouacs, or an interval of time is allowed for the withdrawal of one side and the renewal of the fight. By this means a premature jam, or block, on any part of the field, can be rectified, without spoiling the whole morning's work and marching home, as we do.

Advance of Prussian Troops.

Standing on a hill, and watching a Prussian army advancing to attack, is highly interesting. They attack with heavy broken lines of skirmishers, supported by company columns, which keep close to the skirmishers to give them moral support, and even the advantage of volley firing, by getting into the skirmishers' line, when they think it necessary to increase the fire.

The company columns certainly get under cover when they can do so close at hand; but they do not commit the error that English supports do, of remaining under cover so far in rear of the skirmishers as to be unable to give them much assistance, as they are generally too far behind to come up with a rush in time to save or help the skirmishers. We use skirmishers to cover a movement, the Prussians use them to fight; which is a great difference, and requires different management.

The company columns are scattered all along the first or fighting line, acting under their different captains, who are always trying to improve the occasion, and make a gap in the enemy's line; and these companies (250 men in number) are doubtless sacrificed in large numbers, to "make the running," as a jockey would say.

But the colonel of the regiment—that is, three battalions—is in rear, watching the advance; and he can keep one or two battalions in hand, to send help.

Certainly, the first line has a very elastic look, from being worked in small bodies, under so many skilled leaders; and it appears to advance very quickly, seizing every available spot as it comes on. The second line comes on in double company columns; but they deploy with great rapidity, when necessary, in attacking or trying to outflank. They lose no unnecessary time, *as we do*, in dressing lines which are going to advance immediately.

I would offer as a suggestion here that lines about to advance immediately should be deployed without points; the order being, "Deploy without points on the leading company."

When Prussian infantry are advancing to storm or attack, all the drums in rear of each company take up the attack, and beat the attack step, which throws all the lines and columns into step, *even over the worst ground*, and makes the men advance in perfect order and with spirit.

It is very curious to see the effect of the drum on several thousand men advancing to attack in every direction. An Austrian officer who had served in Bohemia told me that the effect of the Prussian advance with the drum was very imposing, and by no means calculated to exhilarate the attacked!

Cavalry.

The cavalry commanders, I observed, ride well in front of their regiments several hundred yards, with their staff officers (adjutants), to watch the progress of the fight, the regiments being kept under cover as much as possible; and the moment they saw a favourable opportunity they sent back full gallop or signalled back to an officer who was looking out, and down came the regiment at a gallop, and generally in the nick of time.

The cavalry, as I have already said, appeared to be beautifully handled, and their charges most brilliant, full gallop for long distances, to be up in time; and it did not appear to me that they troubled themselves much about a few men going down, as, after the successive charges of several regiments, a good many men went down.

I observed, also, that the cavalry, when advancing rapidly, had officers a good way in front, to see the ground they were coming to, and who made signals to the advancing squadrons, who steered clear of obstacles by this means.

The cavalry throughout played a very important part in these manœuvres, and required to be very closely watched by the opposing generals.

I would give two instances which I myself saw. A field battery and a regiment of dragoons were being pressed by infantry towards a bridge across a small stream with marshy banks. Suddenly, three regiments of cavalry swooped towards the bridge from behind some cover at full gallop. The battery got across, but followed by a regiment of hussars, who surrounded them at the other side. The regiment of dragoons first tried to get across the morass; several got bogged in trying to cross, and the whole regiment was surrounded and captured by two regiments of cuirassiers.

An umpire was on the spot, of course, to give his decision.

I saw three batteries of artillery captured behind a village, where they had taken up a position under cover; and somehow they allowed a regiment of cavalry to creep round their flank, and fall on them at full gallop.

The mistake and error on the part of the artillery colonel were so glaring and unpardonable that the halt was sounded all over the field, the colonel was called into the middle of a large circle of staff, and required to explain the loss of his batteries. His explanation not being deemed satisfactory, he was most severely rebuked before all the generals and staff officers.

After an interval of half-an-hour, to allow for the correction of the mistake, the fight was resumed.

Artillery.

The Prussian artillery appeared to keep more out of infantry fire than with us. They take up good positions, and remain there as long as possible, and pound and demoralise the enemy's infantry at distances where they are safe from infantry fire.

We thought their artillery inferior in appearance. There was a want of finish and smartness about the gunners, and the guns and harness were not so bright and clean as we are accustomed to see them. But we must recollect that their term of service is short, and they cannot afford time for cleaning and polishing of iron-work and brass-work. They have done their work, in the campaign in France, in a way that shows that they are masters of the essential parts of their profession.

Finish.

When the battle has terminated both armies retire to their different bivouacs, when piquets and outposts are at once taken up for the night, as in the presence of an enemy. The next morning operations begin again, but over new ground, and several miles away from where they were executed the day before. The operations generally last one week for each corps d'armée.

The operations near Berlin lasted one week; and we then went with the Crown Prince to Pomerania, near Stettin, and saw the operations of H.R.H. the Crown Prince's corps d'armée—that of Pomerania—*which* lasted one week.

Twenty thousand men complete in "all arms," and differing very little indeed in height or appearance from the guard corps d'armée.

These movements were carried out in the same way. The troops bivouacked in the open fields; but it was much colder up near the Baltic, and there was sufficient rain to make the bivouacs very uncomfortable.

On this occasion, the Crown Prince and his adjutant-general were the principal umpires.

The successes of the Prussians in the present war against the French have been attributed to various causes. I attribute them to four principal causes, viz. (1) better organisation; (2) perfect outpost duty; (3) the practice of great manœuvres every year on an intelligent and scientific system; and (4) superior application of artillery power.

On the advantages derived from their system of practising large manœuvres — an intelligent system — I am positive, and to it I attribute much of their present success in war: for their generals, their colonels, their captains, their staff officers, are only practising in reality in France what they have been practising for years past in Prussia!

In proof of what I say, the Prussian generals now commanding and leading their troops in France are the very men we saw two years ago handling their troops so skilfully in Prussia.

I would name the Crown Prince (the most popular man in the Prussian army), Prince Frederick Charles, Prince Albrecht, General Von Blumenthal, General Von Alvensleben, the Duke of Treskow, Von Steinmetz, Von Goeben, Von Lowenthal, and many others whose names are now familiar to the English reader.

These men have been carefully and intelligently practising war every year for several years past, and the result of such training is "magnificent success."

I hope I have succeeded in interesting my audience, and drawing particular attention to the two subjects I have tried to work out, viz. (1) practical, scientific, and intelligent manœuvring of large bodies of troops, and (2) the use and practice of umpires. I hope, further, that I may succeed in making an impression, and demonstrating the necessity of some change in our manner of doing things; as I am myself—a soldier of thirty-two years' experience—absolutely impressed with the necessity of our changing many of our ways to meet the requirements of modern war.

Since the Battle of Waterloo and the Peninsular campaigns, our wars, with the exception of the Crimean campaign, have been against Chinese, Burmese, Kaffirs, Maories, Affghans, Sikhs, natives of India, and Abyssinians; in fact, against semi-civilised or barbarous nations. I need scarcely say that tactics which have been successful in such wars would not succeed against a European army, led by highly-trained officers, and using all the appliances of modern science and skill, including railways, telegraphs, and rifled artillery and small arms.

English Officers.

Taken as a body, English officers are as good as any body of officers in Europe, and I think ready enough to receive instruction, if properly administered; but, as matters now stand, they are professionally "untaught officers," as the great majority of officers of the army know nothing of their profession beyond what may be called "barrack-yard knowledge;" that is, drill, interior economy of regiments, some military law and practice of courts-martial, and certain experiences of military practices and customs; and it is the general knowledge of things, good liberal education, large amount of travel and experience of foreign countries, hunting and shooting experiences all over the world, and mixing with general society, which make the English officer a better man "all round" than the officers of most continental armies.

His natural energy, dash, and high temper and spirit, pull him through war generally successfully.

There can be no reason why the English officer should not be made as good at his profession as he is at other things.

Captains should be responsible and highly-trained officers; but, in order to make them so, the companies, of infantry especially, must be increased considerably in strength. An English captain with a weak company feels that he is a cypher in the battalion, with nothing to command, and scarcely any responsibility or power.

Staff College.

If Aldershot is to be a real military school, all military information ought to be obtainable at Aldershot. I would therefore advocate the transfer of the Staff College to Aldershot, and the turning of the Staff College at Sandhurst into a barrack. The officers at Aldershot would then be able to attend the lectures of the Professors of Military Science, and see the model works of all kinds constructed; and the officers training for the staff would have the advantage of practical work with the troops on the staff of the generals, which they lose at Sandhurst, seven miles off.

Skeleton Army.

The Prussians use a skeleton army differently from us. At Aldershot we use sometimes a small skeleton army, which is attacked by the division, and driven from position to position. This is infinitely preferable to manœuvring at nothing; a visible enemy is necessary to excite interest in the troops; but, with us, the skeleton army is an independent command.

With the Prussians the commanding general orders the different movements of the skeleton army and manœuvres against it; in fact, it is used as a target. The skeleton army, from want of troops, may be represented by lines of flags, placed by an intelligent staff officer, assisted by a few men.

Deductions.

My lecture may be reduced to the following practical points :—

(1) That an improved system of large manœuvres should be tried on the Prussian model.

(2) That the "umpire system" should be tried.

(3) That outpost duty should be rigidly practised, both by cavalry and infantry. That, in the summer months, the troops should take up long lines of outposts (without tents), and that those outposts should be attacked with skill.

(4) That every officer should be obliged to carry a map of the country (on a large scale, larger than is now obtainable), and instructed in the use of it by lectures from the educational staff officers.

(5) That every officer should carry a field glass as a part of his equipment.

(6) That every colonel and lieutenant-colonel at Aldershot should command brigades in succession, according to a divisional roster.

(7) That all the field officers of regiments should command their battalions in succession on divisional days.

(8) That an improved system of half-yearly inspections should be adopted; and that the capability of captains should be tested as to their ability to manœuvre one body of infantry against another; and that the field officers (majors) of cavalry and infantry should be required to show their power of commanding and manœuvring a brigade (composed of the three arms) against another brigade of similar strength and composition; and that, in fact, a higher standard of efficiency should be exacted from all regimental ranks—especially the higher ranks—as upon their training depends our success in war.

The "general idea" of the operations of the day should be printed in larger numbers, and distributed to *every officer* in the field on division days, and communicated by the captain to their men, as no officer or troops can be expected to take an interest in matters which are not even communicated to them, and which they do not understand. I think this very essential. Officers and troops should always be informed, as much as possible, of what is really happening, or what is supposed to be happening, at a sham fight or large manœuvre.

At the conclusion of the lecture, which was frequently and warmly applauded,

Major-General Dickson, as president of the meeting, invited discussion, saying that there were many points in the admirable lecture they had heard calculated to improve their knowledge and induce remarks by officers who might be able to give their information on the subject, or by others who might desire further details. Any officer, therefore, who wished to make observations on the subject would now be at liberty to do so, and the meeting would be happy to hear him.

Lieutenant-Colonel Biddulph, R.A., said: There was one point which Colonel Bray had not exactly explained in describing the week's peace campaign of the Prussian army. They were informed that at the end of the first day the troops returned to their bivouacs, and that on the second day another series of operations took place some miles distant; but they were not told how both army corps moved to the new ground, so as to begin a new and separate series. He should like to hear this explained, and also another point. In mimic engagements like those described, villages would generally constitute *points d'appui* for the opposing forces; but, if they established batteries of artillery there, and kept up an ordinary fire, it appeared to him that there must be a considerable destruction of glass and other property. He asked whether it was usual for the Prussians to fire the whole of their guns as in real warfare, or to adopt the Austrian system of firing one gun and hoisting a flag to show that they were in action?

Lieutenant-Colonel BRAY replied to the first question that at the end of the first day's operations the successful force bivouacked on the ground, while the beaten army had to march four or five miles farther, ready for the manœuvres of the next day, when the plan of operations might be quite separate and distinct, and altogether different, or it might be a continuation of the same operation—the beaten army retiring, for instance, on another position, wherei t might be attacked next day, or from which it might assume the offensive. In reference to the other question, he explained that really the destruction of property by artillery fire was very small, for the officer commanding the batteries, as soon as he took up his position, fired a gun to show that he was in action, and perhaps two or three guns when he was being attacked, but there was neither the waste of ammunition nor damage to property which would result from a heavy fire. The same thing had been copied at Aldershot last year, and it was now usual for the artillery to go out with four rounds of ammunition to do the work in which they would formerly have expended twenty rounds. The same system was adopted in the infantry, it being found possible to carry out the same manœuvres with an expenditure of much less ammunition. (Applause.) In fact, with breech-loaders, if the old system of infantry firing—rapid volleys, followed by file firing, on the completion of each manœuvre—were continued in these days, the consumption of blank ammunition would be enormous.

Lieutenant-Colonel VESEY, R.A., asked how the Prussian troops were fed during these campaigns?

Lieutenant-Colonel BRAY said: Their control department did all that for them. (Laughter and applause.) Each of the two armies had its military train and intendance complete. The military train, in fact, did as much work as any infantry regiment. (Applause.) The military train and commissariat worked as they would in war; they fed the troops and horses, and carried everything requiring transport. The military train was supplemented with country carts when necessary, as, being on a peace establishment, they were unequal to the performance of the whole duty. Besides, even in war time, country carriage is always used by an army to increase its power of transport.

Major-General Sir LINTORN SIMMONS, K.C.B., R.E., governor of the Royal Military Academy, said: There was one argument which was often used in opposition to the introduction of the Prussian system of field manœuvres into England, which had, he thought, been much exaggerated. This was, that there would be great difficulty in finding a sufficient tract of flat country suitable for carrying on extensive manœuvres in time of peace without a very great destruction of property; and, therefore, that this nature of instruction must necessarily be neglected. It appeared to him, however, that this was a difficulty which ought to be capable of being overcome. (Hear, hear.) A day or two since he saw a return prepared for Parliament by the Inclosure Commissioners, which showed that twenty per cent. of all the land in the country was uninclosed, and that even around the Metropolis, within a few miles of Charing Cross, the uninclosed land was four and a half per cent. of the whole area. He thought that out of all this common, or uninclosed land, sufficient space could be found for manœuvring large bodies of troops. The country in the neighbourhood of Aldershot was suitable for the purpose, but great parts of it were strictly inclosed, and if any of the troops engaged in a particular manœuvre chanced to go out of the beaten track, they heard immediately of actions for trespass. There was an important result of the Prussian system to which the lecturer had not referred. It not only trained the officers, but enabled the government to discover and select the officers best qualified to command. (Hear, hear). This experience alone had enabled Von Moltke to obtain the officers who had carried out the grand achievements of the present war. He had himself seen a similar system in the Russian army, where opposing forces of 25,000 or 30,000 a-side were handled to perfection; and he had also seen it in Switzerland. The Swiss system was very similar to that described by Colonel Bray as having been witnessed by him in Prussia, the manœuvres extending over a tract of country twenty-five miles in one direction and forty miles in the other, lasting for several days, and the men bivouacking at night as in an actual campaign. The effect of these manœuvres was good in other ways; it settled many moot points of detail about which in England there are endless discussions, such as the best mode of supplying troops with ammunition, the efficiency of their control system, the supply of provisions to the army in the field, the removal of sick, the establishment of field hospitals, and so on. All these subjects might be thoroughly tested by the practice the lecturer had described and advocated, and the experience which would be gained thereby would be most valuable. The expense of the manœuvres would be amply repaid by the settlement of many of these moot and contested points, the discussion of which was so subversive of discipline and disparaging to the position which our army ought to occupy. (Applause.)

Lieutenant-Colonel Bray, in reply, said he could fully bear out the remarks of Sir J. L. A. Simmons, for when he asked an officer of the Prussian service to explain the extraordinary earnestness which the officers displayed in this duty, the answer was, that the capacity of an officer for command and employment in high and important offices was tested by his efficiency in practice. A brigadier or colonel who made serious and inexcusable mistakes in the field, and showed incapacity for command, want of energy, and want of knowledge of his profession, had little chance of promotion. He did not, however, wish to dwell too strongly upon this part of the subject in his lecture, because his object was to have the system introduced, and its probable consequences referred to might not favour that result. (Laughter and applause.)

Major-General F. M. Eardley-Wilmot, R.A., said that an obstacle to adopting in England the Prussian system of campaigns in time of peace was the well-known fact that the English farmers were in the habit of working their land all the year round. In most cases, as soon as the crops were off the plough was on, and the seed was put in for next year. There was, therefore, seldom more than a week during which troops could pass over the ground without doing considerable damage. Sir Lintorn Simmons had spoken of the acres of waste or uninclosed land in the country; but could he tell them where there was sufficient at one spot for the purpose required? He knew there were a number of small open spaces scattered about here and there, but they were seldom more than a few acres in extent, and could not afford room for extensive manœuvres. A main point of the admirable lecture they had heard was one which many officers had striven for years past, namely, a better and higher class of instruction for themselves and their men. It might strike some of those present as remarkable, after the education to which they had been subjected, that they should still complain of the want of instruction; but that they did want such instruction, especially in the higher ranks, no man who had not taken leave of his senses would deny. (Hear, hear.) His observations amongst officers, and especially the junior ranks, convinced him that there was a great desire for better information as to the duties of their profession; and he regretted that scarcely anyone of sufficient authority had come forward to impress upon the country what was necessary to be done in this direction. (Applause.) It was certain, however, that nothing would be done unless the men who led the army exerted themselves. They might hear and see in the newspapers all sorts of quack propositions—(laughter)—for increasing, controlling, re-organising, and bothering the army in all manner of ways. (Laughter and applause.) The army wanted to improve itself—(applause)—and what it needed most was some directing power in each branch, which would take officers and soldiers by the hand, to supervise and assist them in becoming efficient, instead of grasping to itself all the credit and all the power. (Applause.) They wanted greater enlightenment throughout the service, and improvements in their organisation and efficiency would then emanate from themselves. (Hear, hear.) That royal commission appointed to enquire into these subjects, of which he was a member, had sat for more than twelve months, and had done good service to the cause; but everything considered by that commission might and ought to have proceeded from the army itself, and not have required a royal commission to point it out. (Applause.) The army wanted leading men who understood its requirements, and would come forward and show, clearly and forcibly, what ought to be, and where national confidence was eminently deserved it would not long be withheld. (Applause.)

Major-General Sir L. SIMMONS said he was not personally acquainted with any particular locality out of the uninclosed land he had spoken of which would be suitable for the purpose indicated, but he had no doubt that there were some districts, called mountainous, but no worse than the country over which an army would have to operate in time of war, which might be available. He believed that Wales especially had such districts, and there were some in Yorkshire; certainly there were among the moors of Scotland extensive districts, to which there need be no difficulty in conveying the troops by rail or steamer, and where the principal sacrifice would be a few fat bags of grouse. (A laugh.) As to the duty which devolved upon those in high positions to force on the education of officers, he quite agreed with General Eardley-Wilmot. The monstrous difficulty was to bring sufficient pressure to bear to induce those in authority to see the necessity which existed for improvement. (Hear, hear.) General Eardley-Wilmot well knew that officers who saw defects in the system, and desired to press upon the government the need of a change, must first make a representation to the authorities; and he was sorry to say that changes almost invariably involved expenditure of money, which was the great obstacle to their adoption. Unless an idea was well written up in the papers—and he doubted very much whether such a proceeding was within the province of an officer—(hear, hear)—it was difficult to press it home. No one had felt this difficulty more than his friend General Eardley-Wilmot, who had been the anxious and energetic advocate of higher professional instruction among the officers of the army, and to whom were due, in a great measure, the advantages in this respect enjoyed by the officers of his own corps, it being through his exertions that had originated many of the opportunities afforded to them to improve themselves, and thus to maintain and raise the position of the royal regiment to which they belonged. (Applause.)

Major-General DICKSON said that, as no other gentleman rose to offer any remarks, it became his pleasing duty to propose that the thanks of the meeting be returned to Colonel Bray for his valuable and interesting lecture. (Applause.) The subject was a most important one, as it dealt with the much-desired improvement of the British army, and the lecturer had given them much to think about, which he hoped would hereafter conduce to the well-being of the nation. (Hear, hear.) Colonel Bray had well described and ably commented on many points of interest in the Prussian system, and, although in some small essentials they might differ as to their advantages, they must acknowledge that in the main point—the instruction of their officers—the Prussian plan was excellent beyond doubt. (Applause.) The Prussian government had given itself up to make an army, and for that purpose they had an advantage which we have not, and that was a military despotism. (Hear, hear.) It was fortunate for this country in some respects that they had not a despotic form of government, but for the advancement of the army there was no government so useful. Here, if any vital improvement is proposed, it has to be submitted to parliament, and then the money question cropped up, very properly perhaps, and the result was that nothing was done. (Applause.) And they never heard one word concerning how and where they were to get the proper men to do the work that would be required. (Hear, hear.) The system such as Colonel Bray proposed would remedy many defects and introduce valuable improvements in the army. No one could doubt that it was the desire of everyone present, and of the young men especially, to get on in their profession, and try to become the men of the future; and he hoped that Colonel Bray, General Wilmot, General Simmons, and other officers of position and ability who had engaged in the work, would still persevere, and that it would be taken up by others, and never cease until they had put the army into such a position that, instead of the cry being "What will become of us when the Prussians come?" it would be, "What shall we do with them if they do come?" (Applause.) While they had been discussing suitable places for large manœuvres he had in his mind Dartmoor, where a committee, of which he was president, had recently carried out a series of dangerous experiments with shell at long ranges. On that large and open tract of land, about twenty-two miles long and fourteen wide, embracing every description of country—bog, morass, and mountain—a very large corps of all arms could be manœuvred; and General Staveley, when he was there during the experiments, represented to him how desirable it would be to have all the troops under his command instructed there every year or every two years on the Prussian system. The land was all open, and the only difficulty would be with the owners of cattle; but the cattle could be driven off as they were during the experiments, and very little would satisfy the owners. The important garrison of Plymouth was close by, and altogether the place offered such advantages that he hoped it would be further considered. In concluding the proceedings he thanked Colonel Bray, in the name of the meeting, for the enlightenment he had afforded them by his lecture, and expressed a hope that he and others, in bringing these reforms under the notice of the authorities, would continue perseveringly until they had accomplished complete success. (Applause.)

TABLES OF

REMAINING VELOCITY, TIME OF FLIGHT, AND ENERGY OF VARIOUS PROJECTILES,

CALCULATED FROM THE RESULTS OF EXPERIMENTS MADE WITH THE BASHFORTH CHRONOGRAPH,[1] 1865-1870:

BY

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ALTHOUGH the amount of the resistance of the air to the motion of *spherical* and *elongated* projectiles has at length been satisfactorily determined for ballistic purposes for all practical velocities above 800 or 900 f.s., it unfortunately happens that no simple law can be found to express the resistance of the air to the motion of a projectile in terms of the velocity of that projectile. For ogival-headed elongated shot, the resistance of the air may be considered to vary roughly as the *sixth* power of the velocity for velocities 900–1100 f.s.; to vary as the *third* power for velocities 1100–1350 f.s.; and to vary as the *second* power for velocities above 1350 f.s.; which last is the Newtonian law of resistance, and is based on the supposition that the shot is at every moment penetrating *an undisturbed medium*, which supposition only holds for velocities higher than the velocity of sound.

Under these circumstances the resistance of the air to the motion of projectiles has been expressed by the help of a *variable* coefficient, which depends (1) upon the form of the projectile and (2) upon the velocity with which it moves. Table 1 gives the values of the variable coefficients for velocities of 900 f.s. and upwards, for both spherical and ogival-headed elongated projectiles for both the cubic and Newtonian laws of resistance.[2] As the coefficients given for elongated shot were derived from experiments made with muzzle-loading guns, in calculating resistances, no further allowance will be necessary on account of the studs of shot. Also it appears that the coefficients derived from experiments with ogival-heads struck with radii of one and a half diameter, may be used without much error for all ogival-heads of practical utility, and for other approximate forms, differing only in a more or less pointed apex, for it was found

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[1] For a description of the Bashforth Chronograph, see Vol. V. p. 161.

[2] Reports on Experiments made with the Bashforth Chronograph, pp. 114 and 152.

from experiments made with a 40-pr. gun, that the coefficient did not sensibly differ for a hemispheroidal-head (prolate) and for ogival-heads struck with radii of one and of two diameters.[1]

When the resistance of the air is expressed by the help of a variable coefficient of some power of the velocity, it is a mere question of convenience what power shall be used. In the reports on experiments made with my chronograph the retarding effect of the air was expressed by $2b'v^3$, where v is the velocity of the shot, and b' a varying coefficient. The cubic law has been preferred, because of the simplicity of the formulæ to which that law gives rise, for calculating the velocity and time of flight. The tables of the values of the coefficient b' were arranged to give $2000\ b'w \div d^2$, because that quantity is independent of w, the weight in lbs. of the projectile, and of d its diameter in inches. The values of this quantity have been found for all velocities ranging from 900 to 1700 f.s., for *elongated* shot, and from 850 to 2150 f.s. for *spherical* shot. The following tables of remaining velocities, &c., have in each case been carried to the limits for which the values of b' have been experimentally determined. It is not likely that the extremely high experimental velocities, which were obtained by using high charges and hollow shot, will be employed in practice, while velocities below 900 f.s. are not of great importance.

Tables of Initial Velocity.—The experiments made with the 3, 5, 7, and 9-inch guns were carried out with a view to determine the resistance of the air, and for this purpose great care was taken to secure accuracy in weight and in diameter of projectile. As there was considerable variation in the weights of charges and of shot employed, the opportunity was taken to deduce systematic tables of initial velocities of the shot used, for all practical charges within the limits of our experiments. But inasmuch as the lengths of the experimental guns followed no particular law depending upon their calibres, and it is probable that the amount of windage varied according to the age and wear of the several guns used, the results cannot be expected to agree when different guns are compared. The initial velocities of the 3-inch gun appear to fall much below the average. The tables of initial velocities here reprinted may be looked upon as examples of the purely practical manner in which the subject of initial velocities should be treated when the service guns, and the kind of powder to be used, have been finally decided upon. It has been the custom to carry out costly experiments merely to determine isolated initial velocities, but here we have determined the *law* of initial velocity for each particular gun with great accuracy, and at the same time have secured other most important results from our experiments. The following will suffice as examples of the practical use of these tables. Suppose that it was required to find the charge which must be used to give an initial velocity 1300 f.s., to a 5-inch elongated shot weighing 47·68 lbs.

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[1] Reports, &c. pp. 10-17; and Phil. Trans. 1868, p. 417.

Referring to Table 2, it appears that a charge of 7 lbs. gives an initial velocity of 1306 f.s., and a charge of 6·75 lbs. gives 1292 f.s.; or 4 oz. of powder additional gives an increment of 14 f.s. in velocity. By proportional parts, it follows that $2\frac{1}{4}$ oz. of powder gives an increment of 8 f.s. in velocity, and therefore the charge of 6 lbs. 12 oz. + $2\frac{1}{4}$ oz. = 6 lbs. $14\frac{1}{4}$ oz. of powder gives an initial velocity of $1292+8$ f.s. $=1300$ f.s. Again, suppose it required to find what charge must be used to give an initial velocity of 1260 f.s. to a 250-lb. shot fired from a 9-inch gun. It appears that 36 lbs. of powder gives an initial velocity of 1257 f.s., and that an addition of 1 lb. to the charge gives an increment of 9 f.s. in the initial velocity, and therefore an addition of $\frac{1}{3}$ of a lb. would give an increment of 3 f.s. in initial velocity. Hence, $36\frac{1}{3}$ lbs. of powder would give the required initial velocity of $1257+3=1260$ f.s.

Further, when tables are prepared for three different weights of shot, as for the 3-inch gun, it is possible to calculate with great exactness the initial velocity which would be given to any intermediate weight of shot by any given charge. Thus, a charge of 1 lb. 8 oz. gives initial velocities of 1050, 1176, and 1394 f.s. to shot of 12, 9, and 6 lbs. respectively. Here the differences are too large to allow proportional parts to be used. But by interpolation we find that the charge of 1 lb. 8 oz. would give initial velocities of 1050, 1102, 1176, 1273, and 1394, to shot of 12, $10\frac{1}{2}$, 9, $7\frac{1}{2}$, and 6 lbs. respectively. By a new interpolation we might find what velocities would be given to other intermediate weights of shot. For the larger guns it would be desirable to make experiments with four different weights of shot of the kind indicated. Thus, by a purely practical process, the law of initial velocity can be found, which may lead to some useful formulæ.

Calculation of Resistances.—The coefficients given in Table **1** may be used to calculate the resistance of the air to spherical and elongated shot. If the Newtonian law be used, the resistance $=2c'v^2w \div g$ lbs.; or if the cubic law be used, the resistance $=2b'v^3w \div g$ lbs. In all cases w denotes the weight of the shot in lbs.; v the velocity of the shot in f.s.; d the diameter of the shot in inches; and g the force of gravity $=32·191$. Suppose that the shot is spherical, and that $d=8$ inches. In Table **1** we find opposite 1200 f.s. the value of $2000b'w \div d^2 = ·0001534$; and $2000c'w \div d^2 = ·1841$. By the cubic law, the resistance of the air $=2b'v^3\frac{w}{g}=\frac{·0001534 \times 8^2 \times (1200)^3}{1000 \times 32·191}$ $=527$ lbs. and by the Newtonian law the resistance

$$=2c'v^2\frac{w}{g}=\frac{·1841 \times 8^2 \times (1200)^2}{1000 \times 32·191}=527 \text{ lbs.}$$

And in precisely the same way, using the proper coefficients, we may calculate the resistance of the air to ogival-headed projectiles. In this manner Tables **3** and **4** have been calculated. As the resistance varies as the square of the diameter of the shot, the resistance of the air to a shot one inch in diameter has been given with great exactness to facilitate the calculation of resistances of the air to other shot besides those specified in the tables. For a velocity of 1200 f.s. the resistance of the air to a round shot one inch in diameter$=8{\cdot}2335$ lbs., and therefore the resistance to a round shot 8 inches in diameter$=8{\cdot}2335\times8^2=526{\cdot}944$ lbs.$=527$ lbs. nearly, as before and as in Table **3**. This method can be usefully employed for diameters not given in the table (as for a round shot 7·5 inches in diameter), moving with a velocity of 1450 f.s. specified in the tables. The required resistance$=13{\cdot}0393\times(7{\cdot}5)^2$ $=733{\cdot}455$ lbs. Suppose, in the next place, that we have the given diameter specified in the table, but not the velocity, we may then proceed by proportional parts. Thus, suppose the projectile of the ogival form 9 inches in diameter, moving with a velocity 1320 f.s. The resistance to an elongated shot 9 inches in diameter, for a velocity 1300 f.s. is 596 lbs., and for a velocity of 1350 f.s. it is 659 lbs., showing an increment of 63 lbs. in the resistance, corresponding to an increment of 50 f.s. in the velocity, or there would be an increment of 25·2 lbs. in the resistance, corresponding to an increment of 20 f.s. in the velocity. Hence the resistance to the ogival-headed 9-inch shot moving with a velocity 1320 f.s., would be $=596+25{\cdot}2$ lbs.$=621{\cdot}2$ lbs. Lastly, if neither the diameter nor the velocity be specified in the table, find first by proportional parts the resistance of the air to the motion of a similarly-formed shot one inch in diameter moving with the given velocity, and then multiply this by the square of the diameter given, and the result will be the required resistance.

Calculation of Remaining Velocities.—The simple formulæ of the cubic law of resistance, previously referred to, are the following. Let V and v denote the velocities of a shot at two points of its course s feet apart, and t the time in which this space is described under the action of a retarding force $2b'\times(\text{vel}^3)$ acting in a direction opposed to the motion of the shot, then

$$\frac{1000}{v}=\frac{1000}{\mathrm{V}}+2000\,b's \quad . \quad . \quad . \quad (1.)$$

and

$$1000t=\frac{1000s}{\mathrm{V}}+1000\,b's^2 \quad . \quad . \quad . \quad (2.)$$

When the above formulæ were used to calculate the following tables for intervals of 100 feet, s was replaced by $n\times100$ feet, so that $\frac{1000}{v}=\frac{1000}{\mathrm{V}}+200{,}000\,b'n$ (3), where n was made equal to 1, 2, 3, &c., in succession, and thus the values of v were found for intervals of 100 feet. The value of b' requires to be varied to suit approximately the value of v. The values of b' used for elongated shot were those given in Table **1** for velocities 1700, 1650, 1600, 1550, 1500 f.s., &c., and they were changed when v was nearly equal to 1675, 1625, 1575, 1525 f.s. &c. Thus making $\mathrm{V}=1700$ f.s., $w=700$ lbs., and $d=11{\cdot}52$ inches; for $v=1700$ f.s. we find by Table **1**, $2000b'={\cdot}0000839\times d^2\div w={\cdot}00001591$, and for $v\neq1650$ we also find $2000b'={\cdot}0000854$

$\times d^2 \div w = \cdot 00001619$. For values of v from 1700 to 1675 f.s. we have $\frac{1000}{v} = \frac{1000}{1700} + 20\,000\,b'n = \cdot 588\,235 + \cdot 001\,591n$, and if v_1, v_2, v_3, v_4, &c., denote the values of v corresponding to $n=1, 2, 3, 4$, &c., respectively, we have

$$\frac{1000}{v_1} = \cdot 588\,235 + \cdot 001\,591 = \cdot 589\,826, \text{ or } v_1 = 1695 \cdot 4.$$

$$\frac{1000}{v_2} = \cdot 588\,235 + \cdot 003\,182 = \cdot 591\,417, \text{ or } v_2 = 1690 \cdot 8.$$

$$\frac{1000}{v_3} = \cdot 588\,235 + \cdot 005\,773 = \cdot 593\,008, \text{ or } v_3 = 1686 \cdot 3.$$

$$\frac{1000}{v_4} = \cdot 588\,235 + \cdot 006\,364 = \cdot 594\,599, \text{ or } v_4 = 1681 \cdot 8.$$

$$\frac{1000}{v_5} = \cdot 588\,235 + \cdot 007\,955 = \cdot 596\,190, \text{ or } v_5 = 1677 \cdot 3.$$

Here, as v_6 will be less than 1675, we must change the co-efficient b', and treat v_5 as the initial velocity, thus

$$\frac{1000}{v_6} = \cdot 596\,190 + \cdot 001\,619 = \cdot 597\,809, \text{ or } v_6 = 1672 \cdot 8.$$

$$\frac{1000}{v_7} = \cdot 596\,190 + \cdot 003\,238 = \cdot 599\,428, \text{ or } v_7 = 1668 \cdot 3.$$

&c. = &c. See column headed v in Table **6**.

It must be remarked the value of b' for a *given velocity* varies as $d^2 \div w$, consequently when a table of values of v_1, v_2, v_3, &c., has been calculated for a given value of $d^2 \div w$, that table serves equally well for all other shot of *similar form* which have the same value of $d^2 \div w$.

If the law of resistance be supposed to be the cubic, and if the time over a given distance be measured by a chronograph, then the velocity at the middle point of that distance in feet per second will be found *exactly* by dividing the space in feet by the time in seconds.

Calculation of the Times of Flight of Shot.—In the following tables the numbers in the column t denote the time occupied by the shot in passing over the distance standing opposite in the column of distances, the shot being supposed to have started with the velocity opposite the distance zero. They have been calculated by the help of the formula (2), where $s = 100n$ feet. This gives

$$t = \left(\frac{1000}{\text{V}} + 100\,000 b'n\right) \frac{n}{10}$$

where the values of b' must be varied to agree with the corresponding velocities. Let $n=4$, $\text{V}=1700$ f.s., $t=t_4$, then, as we have seen, $1000b' = \cdot 00000796$; $t_4 = (\cdot 588\,235 + \cdot 000\,796) \times \cdot 4 = 0'' \cdot 236$: see column t, Table **6**, opposite distance 400 feet.

Tables of values of t made for a given value of $d^2 \div w$ apply equally well to all other shot of *similar form* which have the same value of $d^2 \div w$.

Calculation of Energy.—The numbers in the columns headed E denote the energy of the shot moving with the velocity placed opposite. E equals one-half of the vis viva of the shot due to translation $= wv^2 \div 4480g$. The numerical values of E denote that if a shot struck an object which opposed a *uniform* resistance of E tons to the shot, it would penetrate *one* foot before it was brought to rest. If the *uniform* resistance opposed to the shot's motion was $\frac{1}{2}$ E tons, then it would penetrate just *two* feet. If the *uniform* resistance was $E \div n$ tons then the shot would penetrate n feet. And generally if the shot penetrated a medium which opposed a *uniform* resistance of P tons, it would penetrate m feet, so that $E = m \times P$. The energy of the shot due to rotation is usually neglected, as being small compared with the energy due to translation. It also probably continues nearly constant during the flight of the shot. As the energy of a shot depends upon its weight and velocity, it is plain that the numbers in column E will be the energy of a shot of equal weight of *any form* when moving with the velocity placed opposite. Thus, referring to Table 7, 5503 will be the energy of a 600lb. shot of *any form* when moving with a velocity of 1150 f.s. Also 2652 is the energy of a 250lb. shot of *any form* when moving with a velocity ·1237 f.s. Strictly speaking, these tables of values of v and t are calculated on the supposition that the shot, having been projected, is acted upon by the resistance of the air alone, and is therefore not drawn out of the straight line by the action of gravity. When, therefore, the initial velocity of the shot is high, and the angle of elevation of the gun is not great, as in attempts to pierce iron plates, the following tables will be applicable for ranges of 1000, 2000, or 3000 yards, according to the weight of shot. But if the elevation of the gun be considerable, and the path of the shot much curved, the following tables will only serve to give a general idea of the comparative powers of different guns and projectiles. In the case of vertical fire and long ranges recourse must be had to other and more extensive tables, which are in preparation, and to calculations which require considerable mathematical knowledge. But the following tables may be used with great facility and profit by all artillery officers and by many non-commissioned officers.

These extended tables have been adapted, as far as possible, to guns permanently in the service or likely to be adopted. It is, however, already contemplated to bore out the 11·6-inch gun to make it a 12-inch gun. Also it is urged that a bore of 3·6 inches is too large for a shot of 16lbs., and that a bore of 3·3 or 3·4 inches would be more in accordance with the rules which govern the service bores and shot. It has been already pointed out that in the following tables the columns v and t apply exactly to all *other shot of similar forms* which have the *same value* of $d^2 \div w$. Often, for a limited range, in such cases it will suffice to take the table having the value $d^2 \div w$

nearest to that of the shot whose loss of velocity is required. So that if some of the guns for which tables have been prepared should be abandoned, the tables might still be of use. But to facilitate calculations respecting the powers of any other guns, General Tables have been prepared for both spherical and elongated ogival-headed shot.

Use of the Tables for calculating the remaining Velocity.—The elongated shot are in general supposed to start with a velocity of 1700 f.s., and the spherical shot with a velocity of 2100 f.s., and the calculations are continued till the velocities are reduced to 1000 or 900 f.s., because the coefficients of resistance have been accurately determined within those limits. It is not, however, intended that the full extent of the table should be used on any one occasion, but only so much as corresponds to ranges which the shot may be supposed to describe *approximately in a straight line.* Any velocity within the limits of the table may be supposed to be the initial velocity. For instance, suppose the initial velocity of a 9-inch elongated shot be 1310 f.s.; this is found in Table **9**, opposite 5700 feet in the distance column. Let it be required to find the loss of velocity in 1000 yards = 3000 feet. Adding 3000 to 5700 the distance opposite the given initial velocity, we obtain 8700, and opposite this number in the distance column we find 1153 f.s., so that the loss of velocity in 1000 yards = 1310 − 1153 = 157 f.s. If the given initial velocity be not exactly found in the table a little calculation is required. Thus suppose that in the above case the given initial velocity had been 1300 f.s., by proportional parts it is found that the shot would have a velocity of 1300 f.s. at a distance 5867 feet, and adding 3000 to this, we get 8867, and the velocity at this distance = 1145, and the loss of velocity in 1000 yards would be 1300 − 1145 = 155 f.s. It may be remarked that in simple cases of this kind it will suffice to adopt the velocity *nearest* to the given velocity. In this case it would be 1298 opposite 5900 in the distance column, and adding 3000 as before, we obtain 8900, and opposite this number in the distance column we get 1144. So that the loss of velocity in 1000 yards = 1298—1144 = 154 f.s. If the initial velocity be supposed 1310 f.s., as before, opposite this we find $3''\cdot830$ in the column t, and 2973 in the column E; and adding 3000 to 5700 we get 8700, opposite which in the distance column we find 1153 in the column v, and $6''\cdot277$ in the column t, and 2305 in the column E. So that the time of flight $= 6''\cdot277 - 3''\cdot830 = 2''\cdot447$, and the loss of energy = 2973—2305 = 668 foot-tons.

Suppose it to be required to find with what velocity a 700lb. elongated shot, 11·52 inches in diameter, fired with an initial velocity of 1400 f.s. would strike an object at a distance of 500 yards = 1500 feet. Turning to Table **6**, we find the velocity 1400 f.s. opposite 7100 feet in the distance column, to which, adding 1500 feet, we obtain 8600 feet. Opposite 8600 feet in the distance column we find 1344 f.s. for the striking velocity. The energy of the shot on striking would = 8768, and the time of flight $= 5''\cdot699 - 4''\cdot606 = 1''\cdot093$. The energy lost in 500 yards = 9518 − 8768 = 750 foot-tons, which represents the work consumed by the resistance of the air in a range of 500 yards.

Let now a Rodman spherical shot weighing 452 lbs. be supposed to be fired with an initial velocity of 1400 f.s. and strike an object 500 yards from the gun. Referring to Table **5**, we find 1396 f.s. $=1400-4$ f.s. opposite 4100 feet in the distance column, and adding 1500 feet, we obtain 5600 feet. Opposite 5600 feet in the distance column we find the velocity 1212 f.s. $=1216-4$, or the striking velocity would be 1216 f.s. As the energy has not been tabulated we must calculate it independently from the formula $E=wv^2\div 4480g$. We thus find the initial energy $=6143$ and the striking energy $=4604$; giving a loss of energy in 500 yards $=6143-4604=1539$ foot-tons, which work is consumed by the resistance of the air in a range of 500 yards.

For experimental purposes suppose that it is required to fire a 250lb. elongated shot from a 9-inch gun with such an initial velocity that it may strike a target at a distance of 200 yards $=600$ feet, with the same velocity as if the shot had been fired with a charge of 43 lbs. from a distance of 1000 yards. Referring to Table **2**, the initial velocity given to an elongated shot of 250 lbs. by a charge of 43 lbs. of powder is found to be 1314 f.s. When the shot has passed over 800 yards $=1000-200$ yards, it has that velocity which ought to be the initial velocity of the shot fired from the experimental gun at a distance of 200 yards from the target. Referring to Table **9**, we find a velocity 1315 f.s. $=1314+1$ opposite 5600 feet in the distance column, to which we must add 800 yards $=2400$ feet, making 8000 feet, opposite which we find 1186 f.s. $=1185+1$. So that the velocity given by the distant gun 800 yards in advance of the gun, or 200 yards from the target, is 1185 f.s. The initial velocity to be given by the nearer or experimental gun is 1185 f.s. Referring to Table **2**, we find that a charge of 29 lbs. gives an initial velocity of 1171 f.s. and that an addition of 1 lb. to the charge causes an increment of 16 f.s. in the initial velocity. It is plain, therefore, by proportional parts, that 14 oz. would give the required increment of 14 f.s. Thus the charge to be used by the experimental gun is 29 lbs. 14 oz., which will give an initial velocity of $1171+14=1185$ f.s. Again, turning to Table **9**, opposite 8000 feet we find $1186=1185+1$, and 200 yards or 600 feet further on, i.e. opposite 8600 feet, we find $1158=1157+1$. Therefore 1157 f.s. is the striking velocity. In the same manner if we reckon from the distant gun fired with a charge of 43 lbs. we shall obtain a striking velocity at a distance of 3000 feet $=1157$ as before.

Calculation and Use of the General Tables **20** & **21**.—These tables have been most carefully calculated, the value of b' having been changed for every change of 10 feet in the velocity. Since $(V-v)\div Vv=2b's$ $=$ (a number given in Table **1**) $\times s\times d^2\div w$, if we suppose $d^2\div w=1$ we can calculate the values of $(V-v)\div Vv$ for intervals of 10 feet in range. Afterwards, if we wished to know in what range any other *similarly-shaped* shot would lose a given velocity, we should have to find from the General Table in what space the given velocity is lost, and then dividing this space by the value of $d^2 \div w$ for the given shot, the space is found in which the given shot would lose the specified velocity. In this way the tables adapted for particular shot have been tested. In the General Table **21** for elongated shot $v = 1400$ f.s. corresponds to $s = 1348{\cdot}5$ feet, and $v_1 = 1300$ f.s. corresponds to $s_1 = 1865$ feet, and $v_2 = 1200$ f.s. corresponds to $s_2 = 2455$ feet. Hence the space in which the velocity of an elongated projectile, where $d^2 \div w = 1$, would be reduced from 1400 to 1300 f.s. $= 1865 - 1348{\cdot}5 = 516{\cdot}5$ feet. Again the space in which the same shot would have its velocity reduced from 1300 to 1200 f.s. $= 2455 - 1865 = 590$ feet. Suppose now we wished to know in what ranges the velocity of a 600lb. 11·52-inch elongated shot would have its velocity reduced by the resistance of the air from 1400 to 1300 f.s. This will $= 516{\cdot}5 \div {\cdot}2212 = 2335$ feet. Also the velocity of the same shot would be reduced from 1300 to 1200 f.s. in a range of $590 \div {\cdot}2212 = 2667$. If now we refer to Table **7**, we find a velocity of 1400 f.s. opposite 6100 feet, and 1300 f.s., about 8425 feet—showing that the velocity is reduced from 1400 to 1300 f.s. in a space $8425 - 6100 = 2325$ feet. Opposite a velocity of 1200 f.s. we find in the distance column 11100, showing that the velocity of the shot is reduced from 1300 to 1200 f.s. in a distance $= 11100 - 8425$ feet $= 2675$ feet. In the same manner all the other tables may be tested, by simply dividing 515 feet by the proper value of $d^2 \div w$, which would give the distance in which the velocity of the shot would be reduced from 1400 to 1300 f.s.

Suppose it was desired to compare the powers of a 16lb. elongated shot of 3·52, 3·32, and 3·22 inches in diameter. The corresponding values of $d^2 \div w$ are ·7744, ·6889, and ·6480. Hence the shot fired from the 3·6, 3·4, and 3·3-inch bores would have their velocities reduced from 1400 to 1300 f.s. in the ranges $516{\cdot}5 \div {\cdot}7744 = 667$ feet; $516{\cdot}5 \div {\cdot}6889 = 750$ feet, and $516{\cdot}5 \div {\cdot}6480 = 797$ feet respectively; and from 1300 to 1200 f.s. in ranges of $590 \div {\cdot}7744 = 762$ feet; $590 \div {\cdot}6889 = 856$ feet, and $590 \div {\cdot}6480 = 911$ feet respectively. Thus there is a fall in velocity from 1400 to 1200 f.s. for the 3·6-inch gun in a range of $667 + 762 = 1429$ feet; for the 3·4-inch gun in a range of $750 + 856 = 1606$ feet; and for the 3·3-inch, in a range of $797 + 911 = 1708$ feet. The General Table for spherical shot is used in precisely the same manner.

Suppose it be now required to find, by the use of the General Tables, what velocity a shot starting with a given velocity would lose in a certain range. First multiply the given range by the value of $d^2 \div w$ to obtain a *reduced* range. Find, then, in the usual manner by the help of the proper General Table **20** or **21**, what would be the loss of velocity in this *reduced* range with the given initial velocity. This would be the same as that which the given projectile would lose in the given range. For example, let an elongated projectile of 400 lbs. be fired from a 10-inch gun with an initial velocity of 1270 f.s., and let it be required to find what would be the velocity at a distance of 1000 yards $= 3000$ feet. Here $d^2 \div w = {\cdot}246$ and the reduced range $= 3000 \times {\cdot}246 = 738$ feet. Referring to General Table **21**, the initial velocity 1270 f.s. is found corresponding to the distance 2033 feet, to which adding the *reduced* range 738 feet, we get 2771 feet, and at this distance the velocity=1152·6 f.s., which is the velocity which the 400lb. shot would have at a distance of 1000 yards from the gun. Or, the loss of velocity of the 400lb. shot in 1000 yards=1270 −1152·6=117·4 f.s. By the help of the Special Table 8, the loss of velocity is found to be=1270−1152=118 f.s. in a range of 1000 yards.

In cases where great exactness is required the results given by the General Tables are to be preferred, because the coefficients have been changed for every change of 10 f.s. in the velocity, and the results have been given to one place of decimals. But it was deemed sufficient to change the coefficients for the Special Tables for every 50 f.s. in the velocity, and to neglect fractions of a foot in stating the velocities.

Small Arms.—The following Tables for Small Arms are calculated by the coefficients obtained from experiments with guns of 3 to 9 inches in calibre. They are given with some little doubt, as the leap from a 3-inch to a $\frac{1}{2}$-inch bore is too great. Considering, however, that the experiments made by Hutton with round balls of small diameter gave very fair results when applied to large shot, the following tables may be of value until proper experiments are made:—

Snider:—$d=0·577$ in.; $w=480$ grs.$=0·06857$ lb.; $d^2\div w=4·855$.
Chassepot:—$d=0·44$ in.; $w=380$ grs.$=0·05428$ lb.; $d^2\div w=3·566$.
Martini-Henry:—$d=0·45$ in.; $w=480$ grs.$=0·06857$ lb.; $d^2\div w=2·953$.

Distance	Snider		Chassepot		Martini-Henry	
feet	v. f.s.	t. ″	v. f.s.	t. ″	v. f.s.	t. ″
0	1400	0·0000	1400	0·0000	1400	0·0000
50	1352	0·0364	1364	0·0362	1371	0·0359
100	1306	0·0740	1330	0·0733	1342	0·0728
150	1262	0·1130	1297	0·1114	1314	0·1105
200	1222	0·1532	1265	0·1504	1287	0·1489
250	1183	0·1948	1235	0·1904	1261	0·1882
300	1148	0·2377	1206	0·2314	1236	0·2284
350	1114	0·2820	1179	0·2733	1212	0·2691
400	1083	0·3275	1152	0·3162	1189	0·3108
450	1056	0·3742	1127	0·3601	1167	0·3532
500	1031	0·4221	1104	0·4049	1145	0·3965
550	1012	0·4708	1081	0·4506	1125	0·4405
600	993	0·5209	1061	0·4974	1105	0·4853
650	976	0·5718	1043	0·5449	1086	0·5310
700	960	0·6234	1026	0·5933	1068	0·5774
750	946	0·6759	1011	0·6424	1053	0·6247
800	931	0·7292	998	0·6922	1038	0·6725
850	918	0·7832	985	0·7427	1025	0·7209
900	905	0·8381	973	0·7938	1013	0·7700
950	892	0·8938	961	0·8455	1001	0·8197
1000	880	0·9503	950	0·8979	991	0·8699
1050	—	—	939	0·9508	980	0·9207
1100	—	—	929	1·0044	970	0·9720
1150	—	—	919	1·0585	961	1·0238
1200	—	—	909	1·1132	952	1·0761
1250	—	—	900	1·1685	943	1·1289
1300	—	—	890	1·2244	934	1·1821

1 *Table of Values of b′ and c′ corresponding to Velocities at intervals of* 50 *feet per second, for the Cubic Law of Resistance* $2\,b'\,v^3$, *and also for the Newtonian Law of Resistance* $2\,c'\,v^2$.

Velocity	Cubic Law $2000\,b'\,\frac{w}{d^2}$		Newtonian Law $2000\,c'\,\frac{w}{d^2}$		Velocity	Cubic Law $2000\,b'\,\frac{w}{d^2}$		Newtonian Law $2000\,c'\,\frac{w}{d^2}$	
f.s.	Spherical shot	Elongated Ogival Hd.	Spherical shot	Elongated Ogival Hd.	f.s.	Spherical shot	Elongated Ogival Hd.	Spherical shot	Elongated Ogival Hd.
850	·0001384	—	·1176	—	1500	·0001341	·0000972	·2012	·1458
900	·0001382	·0000644	·1244	·0580	1550	·0001308	·0000930	·2027	·1442
950	·0001388	·0000674	·1319	·0640	1600	·0001275	·0000890	·2040	·1424
1000	·0001411	·0000750	·1411	·0750	1650	·0001241	·0000854	·2048	·1409
1050	·0001461	·0000928	·1534	·0974	1700	·0001208	·0000839	·2054	·1426
1100	·0001514	·0001060	·1665	·1166	1750	·0001174	—	·2055	—
1150	·0001536	·0001082	·1766	·1244	1800	·0001142	—	·2056	—
1200	·0001534	·0001089	·1841	·1307	1850	·0001113	—	·2059	—
1250	·0001511	·0001087	·1889	·1359	1900	·0001087	—	·2065	—
1300	·0001478	·0001079	·1921	·1403	1950	·0001063	—	·2073	—
1350	·0001447	·0001064	·1953	·1436	2000	·0001039	—	·2078	—
1400	·0001413	·0001040	·1978	·1456	2050	·0001017	—	·2081	—
1450	·0001377	·0001009	·1997	·1463	2100	·0000992	—	·2083	—

2 *Table showing the connection between Initial Velocity and Weight of Charge for each Gun and Shot used in the Experiments made with the Bashforth Chronograph,* 1867–9.

ELONGATED SHOT											
3-inch Gun				**5-inch Gun**			**7-inch Gun**			**9-inch Gun**	
Charge	12-lb. shot.	9-lb. shot	6-lb. shot	Charge	47·68-lb. shot	23·84-lb. shot	Charge	123-lb. shot	61-lb. shot	Charge	250-lb. shot
lbs. ozs.	f.s.	f.s.	f.s.	lbs.	f.s.	f.s.	lbs.	f.s.	f.s.	lbs.	f.s.
0 12	614	693	815	3·00	—	1179	7·0	—	1111	22	1019
0 13	658	745	876	3·25	—	1246	8·0	865	1208	23	1046
0 14	700	794	935	3·50	—	1308	9·0	933	1293	24	1071
0 15	741	841	991	3·75	—	1364	10·0	995	1367	25	1095
1 0	782	886	1044	4·00	1039	1416	10·5	1023	1402	26	1117
1 1	820	928	1095	4·25	1072	1463	11·0	1050	1435	27	1137
1 2	857	969	1144	4·50	1103	1505	11·5	1075	1466	28	1155
1 3	893	1008	1191	4·75	1131	1543	12·0	1099	1495	29	1171
1 4	927	1045	1235	5·00	1158	1577	12·5	1122	1522	30	1187
1 5	960	1080	1277	5·25	1182	1608	13·0	1143	1549	31	1202
1 6	991	1114	1318	5·50	1205	1635	13·5	1163	1575	32	1215
1 7	1021	1146	1357	5·75	1225	1659	14·0	1182	1601	33	1227
1 8	1050	1176	1394	6·00	1244	1680	14·5	1200	1626	34	1238
1 9	1077	1205	1429	6·25	1261	1698	15·0	1218	1651	35	1248
1 10	1103	1233	1463	6·50	1277	1715	15·5	1235	—	36	1257
1 11	1127	1260	1495	6·75	1292	1730	16·0	1251	—	37	1266
1 12	1151	1285	1525	7·00	1306	1743	16·5	1265	—	38	1274
1 13	1173	1309	1554	7·25	1319	1755	17·0	1279	—	39	1282
1 14	1194	1333	1582	7·50	1331	1766	17·5	1293	—	40	1290
1 15	1213	1356	1609	7·75	1342	1776	18·0	1307	—	41	1298
2 0	1231	1378	1634	8·00	1353	1785	18·5	1320	—	42	1306
—	—	—	—	—	—	—	19·0	1333	—	43	1314
—	—	—	—	—	—	—	19·5	1346	—	44	1322
—	—	—	—	—	—	—	20·0	1357	—	45	1329

3

Tables showing the Resistance of the Air in lbs. to Spherical and Ogival-headed Elongated Shot, from 1 *to* 15 *inches in diameter, for specified Velocities, calculated by the help of the Coefficients in Table* 1.

Velocity	**Diameters of Projectiles.** SPHERICAL SHOT.														
	1-in.	**2**-in.	**3**-in.	**4**-in.	**5**-in.	**6**-in.	**7**-in.	**8**-in.	**9**-in.	**10**-in.	**11**-in.	**12**-in.	**13**-in.	**14**-in.	**15**-in.
f.s.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
900	3·1293	13	28	50	78	113	153	200	254	313	379	451	529	613	704
950	3·6964	15	33	59	92	133	181	237	299	370	447	532	625	725	832
1000	4·3827	18	39	70	110	158	215	281	355	438	530	631	741	859	986
1050	5·2533	21	47	84	131	189	257	336	426	525	636	757	888	1030	1182
1100	6·2592	25	56	100	156	225	307	401	507	626	757	901	1058	1227	1408
1150	7·2560	29	65	116	181	261	356	464	588	726	878	1045	1226	1422	1633
1200	8·2335	33	74	132	206	296	403	527	667	823	996	1186	1392	1614	1853
1250	9·1666	37	82	147	229	330	449	587	743	917	1109	1320	1549	1797	2063
1300	10·0860	40	91	161	252	363	494	646	817	1009	1220	1452	1705	1977	2269
1350	11·0582	44	99	177	277	398	542	708	896	1106	1338	1592	1869	2167	2488
1400	12·0432	48	108	193	301	434	590	771	976	1204	1457	1734	2035	2361	2710
1450	13·0393	52	117	209	326	469	639	835	1056	1304	1578	1878	2204	2556	2934
1500	14·0579	56	126	225	351	506	689	900	1139	1406	1701	2024	2376	2755	3163
1550	15·1293	60	136	242	378	545	741	968	1226	1513	1831	2179	2557	2965	3404
1600	16·2213	65	146	260	406	584	795	1038	1314	1622	1963	2336	2741	3179	3650
1650	17·3157	69	156	277	433	623	849	1108	1403	1732	2095	2494	2926	3394	3896
1700	18·4344	74	166	295	461	664	903	1180	1493	1843	2231	2655	3115	3613	4148
1750	19·5433	78	176	313	489	704	958	1251	1583	1954	2365	2814	3303	3831	4397
1800	20·6871	83	186	331	517	745	1014	1324	1676	2069	2503	2979	3496	4055	4655
1850	21·8890	88	197	350	547	788	1073	1401	1773	2189	2649	3152	3699	4290	4925
1900	33·1583	93	208	371	579	834	1135	1482	1876	2316	2802	3335	3914	4539	5211
1950	24·4823	98	220	391	612	881	1200	1567	1983	2448	2962	3526	4138	4799	5509
2000	25·8179	103	232	413	645	929	1265	1652	2091	2582	3124	3718	4363	5060	5809
2050	27·1609	109	244	435	679	978	1331	1738	2200	2716	3287	3911	4590	5324	6111
2100	28·5355	114	257	457	713	1027	1398	1826	2311	2854	3453	4109	4823	5593	6421

4

ELONGATED SHOT (Ogival Head).

Velocity	**1**-in.	**2**-in.	**3**-in.	**4**-in.	**5**-in.	**6**-in.	**7**-in.	**8**-in.	**9**-in.	**10**-in.	**11**-in.	**12**-in.	**13**-in.	**14**-in.	**15**-in.
900	1·4584	5·8	13	23	37	53	72	93	118	146	176	210	246	286	328
950	1·7951	7·2	16	29	45	65	88	115	145	180	217	258	303	352	404
1000	2·3299	9·3	21	37	58	84	114	149	189	233	282	336	394	457	524
1050	3·3373	13·3	30	53	83	120	164	214	270	334	404	481	564	654	751
1100	4·3829	17·5	39	70	110	158	215	281	355	438	530	631	741	859	986
1150	5·1121	21·4	46	82	128	184	250	327	414	511	619	736	864	1002	1150
1200	5·8457	23·4	53	94	146	210	286	374	474	585	707	842	988	1146	1315
1250	6·5952	26·4	59	106	165	237	323	422	534	660	798	950	1115	1293	1484
1300	7·3641	29·5	66	118	184	265	361	471	596	736	891	1060	1245	1443	1657
1350	8·1322	32·5	73	130	203	293	398	520	659	813	984	1171	1374	1594	1830
1400	8·8650	35·5	80	142	222	319	434	567	718	887	1073	1277	1498	1738	1995
1450	9·5556	38·2	86	153	239	344	468	612	774	956	1156	1376	1615	1873	2150
1500	10·190	40·8	92	163	255	367	499	652	825	1019	1233	1467	1722	1997	2293
1550	10·759	43·0	97	172	269	387	527	689	871	1076	1302	1549	1818	2109	2421
1600	11·325	45·3	102	181	283	408	555	725	917	1132	1370	1631	1914	2220	2548
1650	11·917	47·7	107	191	298	429	584	763	965	1192	1442	1716	2014	2336	2681
1700	12·805	51·2	115	205	320	461	627	820	1037	1281	1549	1844	2164	2510	2881

5

Table showing the Velocities of Spherical Solid Shot for the undermentioned Guns at intervals of 100 *feet, supposing the Shot to move in a straight line, subject only to the Resistance of the Air.*

Distance	15-in.	150-pr.	100-pr.	68-pr.	32-pr.	24-pr.	18-pr.	12-pr.	9-pr.	6-pr.	3-pr.	Distance
ft.	f.s.	f.s.	f.s.	f.s.	f.s.	f.s.	f.s.	f.s.	f.s.	f.s.	f.s.	ft.
0	2100	2100	2100	2100	2100	2100	2100	2100	2100	2100	2100	0
100	2079	2072	2067	2059	2048	2043	2038	2030	2022	2011	1990	100
200	2058	2044	2033	2019	1998	1988	1978	1962	1947	1926	1886	200
300	2037	2016	2001	1980	1948	1935	1920	1896	1875	1845	1788	300
400	2017	1988	1970	1942	1900	1883	1863	1833	1806	1768	1696	400
500	1996	1962	1938	1905	1854	1833	1808	1772	1742	1694	1606	500
600	1976	1935	1907	1868	1809	1784	1755	1713	1679	1623	1527	600
700	1956	1909	1877	1832	1764	1737	1704	1656	1618	1555	1450	700
800	1937	1883	1848	1797	1721	1691	1654	1601	1560	1490	1377	800
900	1917	1858	1819	1763	1679	1646	1606	1548	1504	1429	1309	900
1000	1898	1833	1790	1729	1637	1602	1559	1497	1450	1371	1245	1000
1100	1879	1808	1762	1696	1598	1559	1514	1448	1398	1316	1186	1100
1200	1860	1784	1734	1664	1559	1518	1470	1401	1349	1264	1131	1200
1300	1842	1760	1707	1632	1521	1478	1428	1356	1302	1215	1081	1300
1400	1823	1737	1680	1601	1484	1439	1388	1313	1257	1169	1035	1400
1500	1805	1714	1654	1571	1449	1402	1349	1272	1215	1126	994	1500
1600	1787	1691	1628	1541	1415	1366	1311	1233	1175	1086	957	1600
1700	1769	1668	1603	1512	1381	1331	1275	1196	1137	1049	925	1700
1800	1752	1645	1578	1484	1349	1297	1241	1161	1101	1015	897	1800
1900	1735	1623	1553	1456	1318	1265	1208	1128	1068	984	873	1900
2000	1717	1601	1529	1429	1288	1234	1176	1097	1036	956	—	2000
2100	1700	1580	1505	1403	1258	1204	1146	1068	1007	930	—	2100
2200	1683	1559	1482	1377	1230	1175	1117	1040	980	906	—	2200
2300	1667	1538	1459	1352	1203	1147	1090	1014	955	884	—	2300
2400	1650	1518	1437	1327	1176	1121	1065	990	932	—	—	2400
2500	1633	1498	1415	1303	1151	1096	1041	968	911	—	—	2500
2600	1617	1479	1394	1280	1127	1072	1018	946	892	—	—	2600
2700	1601	1459	1373	1257	1104	1050	997	926				
2800	1585	1440	1352	1235	1082	1029	977	907				
2900	1570	1422	1331	1214	1061	1009	958	889				
3000	1554	1403	1311	1193	1041	990	940	871				
3100	1539	1385	1292	1172	1022	972	922	854				
3200	1524	1367	1273	1152	1004	955	905	—				
3300	1509	1349	1254	1133	987	938	888	—				
3400	1494	1332	1236	1115	971	922	872	—				
3500	1479	1316	1219	1097	955	906	857	—				
3600	1465	1299	1201	1080	940	891	—	—				
3700	1451	1282	1184	1064	925	—	—	—				
3800	1437	1267	1168	1048	911	—	—	—				
3900	1423	1251	1152	1033	897	—	—	—				
4000	1409	1235	1136	1019	884	—	—	—				
4100	1396	1220	1121	1005	—	—	—	—				
4200	1382	1205	1106	992	—	—	—	—				
4300	1369	1191	1092	979	—	—	—	—				
4400	1356	1177	1078	966	—	—	—	—				
4500	1343	1163	1065	954	—	—	—	—				
4600	1330	1149	1052	942	—	—	—	—				
4700	1318	1136	1040	930	—	—	—	—				
4800	1305	1123	1028	919	—	—	—	—				
4900	1293	1110	1016	908	—	—	—	—				
5000	1281	1098	1005	898	—	—	—	—				
5100	1269	1086	994	—	—	—	—	—				
5200	1258	1075	983	—	—	—	—	—				
5300	1246	1064	972	—	—	—	—	—				
5400	1235	1053	962	—	—	—	—	—				
5500	1223	1042	952	—	—	—	—	—				
5600	1212	1032	943	—	—	—	—	—				
5700	1201	1022	933									
5800	1191	1012	924									
5900	1180	1002	915									
6000	1170	993	906									
6100	1160	984	—									
6200	1150	975	—									
6300	1140	966	—									
6400	1130	958	—									
6500	1120	950	—									
6600	1111	941	—									
6700	1102	933	—									
6800	1093	925	—									
6900	1084	917	—									
7000	1076	910	—									
7100	1068	—	—									
7200	1059	—	—									
7300	1051	—	—									
7400	1043	—	—									
7500	1036	—	—									
7600	1028	—	—									
7700	1021	—	—									
7800	1013	—	—									
7900	1006	—	—									
8000	999	—	—									

5 *a.*

Table showing the Values of w. and d. employed in calculating the preceding Table.

Gun	w.	d.	d²÷w.	Gun	w.	d.	d²÷w.
	lbs.	ins.			lbs.	ins.	
15-in.	452·35	14·885	·4898	18-pr.	17·75	5·099	1·4648
150-pr.	163·50	10·400	·6615	12-pr.	12·25	4·523	1·6696
100-pr.	102·00	8·900	·7766	9-pr.	9·13	4·100	1·8422
68-pr.	66·20	7·925	·9487	6-pr.	6·00	3·568	2·1218
32-pr.	31·38	6·177	1·2161	3-pr.	3·00	2·823	2·6564
24-pr.	23·55	5·612	1·3373				

5 *b.*

Table showing the Work done by each pound of the Charge on Elongated Rifled Shot.

(From 'Reports on Experiments made with the Bashforth Chronograph,' p. 51.)

Gun Cal.	Shot	Charge	Work done by each lb. of Charge	Gun Cal.	Shot	Charge	Work done by each lb. of Charge	Gun Cal.	Shot	Charge	Work done by each lb. of Charge
ins.	lbs.	lbs.	Foot lbs.	ins.	lbs.	lbs.	Foot lbs.	ins.	lbs.	lbs.	Foot lbs.
3	12	2·0	142,911	5	47·68	7·945	170,534	7	61·156	20·383	—
,,	,,	1·5	135,687	,,	,,	5·961	192,071	,,	,,	15·285	171,934
,,	,,	1·0	117,061	,,	,,	4·969	199,242	,,	,,	10·191	176,885
,,	9	2·0	133,904	,,	,,	3·973	200,834	,,	,,	5·098	146,697
,,	,,	1·5	129,687	5	23·84	7·945	147,921	9	250	41·668	158,381
,,	,,	1·0	110,230	,,	,,	5·961	177,268	,,	,,	36·461	169,779
,,	6	2·0	125,062	,,	,,	3·973	187,032	,,	,,	31·250	182,090
,,	,,	1·75	131,951	,,	,,	2·980	170,964	,,	,,	26·262	187,278
,,	,,	1·5	121,363	,,	,,	1·949	159,875	,,	,,	20·832	179,109
,,	,,	1·0	102,106	7	123·125	20·383	175,273	,,	125	15·625	151,933
				,,	,,	15·285	187,292	,,	,,	10·414	140,590
				,,	,,	10·191	190,692				

The following Tables show the Velocities, Time of Flight, and Energy of Ogival-headed Elongated Service Shot at intervals of 100 *feet, supposing the Shot to move in a straight line, subject only to the Resistance of the Air.*

Distance	6 11·6-inch Gun w=700 lbs.; d=11·52-in. $d^2 \div w=·1896$			7 11·6-inch Gun w=600 lbs.; d=11·52-in. $d^2 \div w=·2212$			8 10-inch Gun w=400 lbs.; d=9·92-in. $d^2 \div w=·2460$			9 9-inch Gun w=250 lbs.; d=8·92-in. $d^2 \div w=·3183.$		
Feet	v.	t.	E.	v.	t.	E.	v.	t.	E	v.	t.	E.
0	1700	0″·000	14028	1700	0″·000	12027	1700	0″·000	8016	1700	0″·000	5010
100	1695	0·059	13953	1695	0·059	11951	1694	0·059	7961	1692	0·059	4964
200	1691	0·118	13878	1689	0·118	11875	1688	0·118	7906	1685	0·118	4919
300	1686	0·177	13803	1684	0·177	11800	1682	0·177	7851	1677	0·178	4875
400	1682	0·236	13729	1679	0·236	11726	1677	0·237	7796	1670	0·238	4831
500	1677	0·296	13655	1674	0·296	11653	1671	0·297	7742	1662	0·298	4788
600	1673	0·356	13582	1668	0·356	11580	1665	0·357	7688	1655	0·358	4745
700	1668	0·416	13509	1663	0·416	11507	1659	0·417	7635	1647	0·419	4703
800	1664	0·476	13437	1658	0·476	11435	1653	0·477	7582	1640	0·480	4661
900	1659	0·536	13365	1653	0·536	11364	1648	0·538	7530	1633	0·541	4620
1000	1655	0·596	13293	1648	0·597	11294	1642	0·599	7478	1625	0·602	4578
1100	1651	0·656	13222	1642	0·658	11224	1636	0·660	7427	1618	0·664	4537
1200	1646	0·717	13152	1637	0·719	11155	1631	0·722	7375	1611	0·726	4496
1300	1642	0·778	13083	1632	0·780	11086	1625	0·783	7324	1603	0·788	4456
1400	1637	0·839	13014	1627	0·841	11017	1619	0·845	7273	1596	0·850	4416
1500	1633	0·900	12945	1622	0·903	10949	1614	0·906	7222	1589	0·913	4376
1600	1629	0·961	12876	1617	0·965	10881	1608	0·968	7171	1582	0·976	4336
1700	1625	1·023	12807	1612	1·027	10813	1602	1·030	7121	1575	1·039	4297
1800	1620	1·085	12738	1607	1·089	10745	1597	1·093	7071	1567	1·103	4258
1900	1616	1·147	12669	1602	1·151	10678	1591	1·156	7022	1560	1·167	4219
2000	1611	1·209	12600	1597	1·214	10611	1586	1·219	6973	1553	1·231	4181
2100	1607	1·271	12532	1592	1·277	10544	1580	1·282	6924	1546	1·296	4143
2200	1603	1·333	12465	1587	1·340	10478	1575	1·345	6875	1539	1·361	4105
2300	1598	1·396	12398	1582	1·403	10412	1569	1·409	6827	1532	1·426	4068
2400	1594	1·459	12331	1577	1·466	10346	1563	1·473	6779	1525	1·491	4031
2500	1590	1·522	12265	1572	1·530	10280	1558	1·537	6731	1518	1·557	3994
2600	1585	1·585	12199	1567	1·594	10215	1552	1·601	6683	1511	1·623	3957
2700	1581	1·648	12134	1562	1·658	10150	1547	1·666	6636	1504	1·689	3921
2800	1577	1·711	12068	1557	1·722	10085	1541	1·731	6589	1497	1·756	3884
2900	1573	1·775	12002	1552	1·786	10021	1536	1·796	6543	1490	1·823	3848
3000	1568	1·839	11937	1547	1·851	9957	1531	1·861	6497	1483	1·890	3812
3100	1564	1·903	11871	1542	1·916	9893	1525	1·926	6451	1476	1·957	3777
3200	1560	1·967	11806	1537	1·981	9830	1520	1·992	6405	1469	2·025	3742
3300	1555	2·031	11741	1532	2·046	9767	1514	2·058	6359	1462	2·093	3707
3400	1551	2·095	11677	1527	2·111	9705	1509	2·124	6313	1455	2·162	3672
3500	1547	2·159	11613	1522	2·177	9643	1503	2·191	6268	1449	2·231	3638
3600	1543	2·224	11550	1518	2·243	9581	1498	2·258	6223	1442	2·300	3604
3700	1538	2·289	11487	1513	2·309	9520	1493	2·325	6179	1435	2·370	3571
3800	1534	2·354	11425	1508	2·375	9459	1487	2·392	6135	1429	2·440	3538
3900	1530	2·419	11363	1503	2·441	9398	1482	2·459	6091	1422	2·510	3505
4000	1526	2·484	11301	1498	2·508	9338	1477	2·526	6048	1416	2·580	3473
4100	1522	2·550	11239	1493	2·575	9278	1471	2·594	6004	1409	2·651	3441
4200	1518	2·616	11177	1488	2·642	9218	1466	2·662	5961	1402	2·722	3409
4300	1513	2·682	11115	1484	2·709	9159	1461	2·730	5918	1396	2·793	3378
4400	1509	2·748	11053	1479	2·776	9100	1455	2·799	5875	1389	2·865	3347
4500	1505	2·814	10992	1474	2·844	9041	1450	2·868	5833	1383	2·937	3316
4600	1501	2·881	10931	1469	2·912	8982	1445	2·937	5791	1377	3·010	3286
4700	1497	2·948	10871	1464	2·980	8923	1440	3·006	5749	1371	3·083	3256
4800	1492	3·015	10811	1460	3·048	8864	1435	3·075	5708	1364	3·156	3226
4900	1488	3·082	10752	1455	3·117	8807	1430	3·145	5667	1358	3·229	3196
5000	1484	3·149	10694	1450	3·186	8750	1425	3·215	5627	1352	3·303	3167

Distance	**6** (*cont.*) **11·6-inch Gun** w=700 lbs.; d=11·52-in. d²÷w=·1896			**7** (*cont.*) **11·6-inch Gun** w=600 lbs.; d=11·52-in. d²÷w=·2212			**8** (*cont.*) **10-inch Gun** w=400 lbs.; d=9·92-in. d²÷w=·2460			**9** (*cont.*) **9-inch Gun** w=250 lbs.; d=8·92-in. d²÷w=·3183		
Feet	v.	t.	E.	v.	t.	E.	v.	t.	E.	v.	t.	E.
5100	1480	3″·216	10635	1446	3″·255	8694	1419	3″·285	5587	1346	3″·377	3138
5200	1476	3·284	10577	1441	3·324	8638	1414	3·356	5547	1339	3·452	3110
5300	1472	3·352	10518	1436	3·393	8582	1409	3·427	5508	1333	3·527	3082
5400	1468	3·420	10459	1432	3·463	8527	1404	3·498	5469	1327	3·602	3054
5500	1464	3·488	10400	1427	3·533	8472	1399	3·569	5430	1321	3·678	3027
5600	1460	3·556	10342	1422	3·603	8417	1394	3·641	5391	1315	3·754	3000
5700	1456	3·625	10285	1418	3·673	8362	1389	3·713	5352	1310	3·830	2973
5800	1452	3·694	10228	1413	3·744	8308	1384	3·785	5314	1304	3·907	2946
5900	1448	3·763	10171	1409	3·815	8254	1379	3·857	5276	1298	3·984	2920
6000	1444	3·832	10115	1404	3·886	8201	1374	3·930	5239	1292	4·061	2894
6100	1440	3·901	10059	1400	3·957	8148	1370	4·003	5202	1286	4·138	2869
6200	1436	3·971	10003	1395	4·029	8096	1365	4·076	5165	1281	4·216	2844
6300	1432	4·041	9948	1391	4·101	8045	1360	4·149	5128	1275	4·294	2819
6400	1428	4·111	9894	1386	4·173	7994	1355	4·223	5092	1270	4·373	2794
6500	1424	4·181	9840	1382	4·245	7943	1350	4·297	5056	1264	4·452	2769
6600	1420	4·251	9786	1377	4·318	7892	1345	4·371	5021	1258	4·531	2745
6700	1416	4·322	9732	1373	4·391	7841	1341	4·445	4986	1253	4·611	2721
6800	1412	4·393	9678	1369	4·464	7791	1336	4·520	4951	1248	4·691	2698
6900	1408	4·464	9624	1364	4·537	7741	1331	4·595	4916	1242	4·771	2675
7000	1404	4·535	9571	1360	4·610	7692	1327	4·670	4882	1237	4·852	2652
7100	1400	4·606	9518	1355	4·684	7643	1322	4·746	4848	1232	4·933	2629
7200	1397	4·678	9466	1351	4·758	7595	1318	4·822	4814	1226	5·014	2607
7300	1393	4·750	9414	1347	4·832	7547	1313	4·898	4781	1221	5·096	2585
7400	1389	4·822	9362	1343	4·906	7499	1308	4·974	4748	1216	5·178	2563
7500	1385	4·894	9311	1338	4·981	7452	1304	5·051	4715	1211	5·260	2542
7600	1381	4·966	9260	1334	5·056	7405	1299	5·128	4682	1206	5·343	2521
7700	1378	5·038	9209	1330	5·131	7359	1295	5·205	4650	1201	5·426	2500
7800	1374	5·110	9159	1326	5·206	7313	1290	5·282	4618	1196	5·510	2479
7900	1370	5·183	9109	1322	5·282	7267	1286	5·360	4587	1191	5·594	2458
8000	1366	5·256	9059	1317	5·358	7221	1282	5·438	4556	1186	5·678	2438
8100	1363	5·329	9010	1313	5·434	7176	1277	5·516	4525	1181	5·762	2418
8200	1359	5·403	8961	1309	5·510	7131	1273	5·594	4494	1176	5.847	2399
8300	1355	5·477	8912	1305	5·587	7087	1269	5·673	4464	1172	5·932	2380
8400	1351	5·551	8864	1301	5·664	7043	1264	5·752	4434	1167	6·018	2361
8500	1348	5·625	8816	1297	5·741	6999	1260	5·831	4404	1162	6·104	2342
8600	1344	5·699	8768	1293	5·818	6956	1256	5·911	4375	1158	6·190	2323
8700	1340	5·774	8721	1289	5·895	6914	1252	5·991	4346	1153	6·277	2305
8800	1337	5·849	8674	1285	5·973	6872	1248	6·071	4317	1148	6·364	2287
8900	1333	5·924	8627	1281	6·051	6830	1243	6·151	4289	1144	6·451	2269
9000	1330	5·999	8580	1277	6·129	6788	1239	6·231	4261	1139	6·539	2251
9100	1326	6·074	8534	1273	6·207	6747	1235	6·312	4233	1135	6·627	2233
9200	1322	6·150	8488	1270	6·286	6706	1231	6·393	4205	1131	6·715	2216
9300	1319	6·226	8442	1266	6·365	6665	1227	6·474	4177	1126	6·803	2199
9400	1315	6·302	8397	1262	6·444	6624	1223	6·556	4149	1122	6·892	2182
9500	1312	6·379	8352	1258	6·523	6584	1219	6·638	4122	1118	6·981	2165
9600	1308	6·456	8308	1254	6·603	6545	1215	6·720	4095	1114	7·071	2149
9700	1305	6·533	8264	1250	6·683	6506	1211	6·802	4068	1109	7·161	2133
9800	1301	6·610	8220	1247	6·763	6467	1207	6·885	4042	1105	7·251	2117
9900	1298	6·687	8176	1243	6·843	6428	1203	6·968	4016	1101	7.342	2101
10000	1294	6·764	8133	1239	6·924	6390	1199	7·051	3990	1097	7·433	2085
10100	1291	6·842	8090	1237	7·005	6352	1196	7·134	3964	1093	7·524	2070

Distance	**6** (*cont.*) **11·6-inch Gun** w=700 lbs.; d=11·52-in. d²÷w=·1896			**7** (*cont.*) **11·6-inch Gun** w=600 lbs.; d=11·52-in. d²÷w=·2212			**8** (*cont.*) **10-inch Gun** w=400 lbs.; d=9·92-in. d²÷w=·2460			**9** (*cont.*) **9-inch Gun** w=250 lbs.; d=8·92-in. d²÷w=·3183		
Feet	v.	t.	E.	v.	t.	E.	v.	t.	E.	v.	t.	E.
10200	1288	6·920"	8047	1232	7·086"	6314	1192	7·218"	3939	1089	7·616"	2055
10300	1284	6·998	8005	1228	7·167	6277	1188	7·302	3914	1085	7·708	2040
10400	1281	7·076	7963	1225	7·248	6240	1184	7·387	3889	1081	7·800	2026
10500	1278	7·155	7921	1221	7·330	6203	1180	7·472	3864	1077	7·893	2012
10600	1274	7·235	7880	1217	7·412	6167	1177	7·557	3840	1073	7·986	1998
10700	1271	7·314	7839	1214	7·494	6131	1173	7·642	3816	1069	8·079	1984
10800	1268	7·393	7798	1210	7·577	6095	1169	7·728	3792	1066	8·173	1970
10900	1264	7·472	7758	1207	7·660	6059	1166	7·814	3769	1063	8·267	1957
11000	1261	7·552	7718	1203	7·743	6024	1162	7·900	3746	1059	8·361	1945
11100	1258	7·632	7678	1200	7·826	5989	1159	7·986	3723	1056	8·456	1933
11200	1254	7·712	7638	1196	7·909	5955	1155	8·073	3700	1053	8·551	1921
11300	1251	7·792	7599	1193	7·993	5921	1151	8·160	3677	1049	8·646	1909
11400	1248	7·873	7560	1190	8·077	5887	1148	8·247	3655	1046	8·741	1897
11500	1245	7·954	7521	1186	8·161	5854	1144	8·334	3633	1043	8·837	1885
11600	1242	8·035	7483	1183	8·245	5821	1141	8·422	3611	1040	8·933	1873
11700	1238	8·116	7445	1179	8·330	5788	1138	8·509	3589	1037	9·029	1862
11800	1235	8·197	7407	1176	8·415	5755	1134	8·597	3567	1033	9·126	1851
11900	1232	8·279	7369	1173	8·500	5723	1131	8·685	3546	1030	9·223	1840
12000	1229	8·361	7332	1170	8·585	5691	1127	8·773	3525	1027	9·320	1829
12100	1226	8·443	7295	1166	8·671	5659	1124	8·862	3504	1024	9·417	1819
12200	1223	8·525	7258	1163	8·757	5627	1121	8·951	3483	1022	9·515	1809
12300	1220	8·607	7221	1160	8·843	5596	1117	9·040	3463	1019	9·613	1800
12400	1217	8·689	7184	1157	8·929	5565	1114	9·130	3443	1017	9·711	1791
12500	1214	8·771	7148	1153	9·016	5534	1111	9·220	3423	1014	9·809	1782
12600	1211	8·854	7112	1150	9·103	5503	1108	9·310	3403	1012	9·908	1774
12700	1208	8·937	7077	1147	9·190	5473	1105	9·401	3383	1009	10·007	1765
12800	1205	9·020	7042	1144	9·277	5443	1101	9·492	3364	1007	10·106	1756
12900	1202	9·103	7007	1141	9·364	5413	1098	9·583	3345	1004	10·205	1748
13000	1199	9·186	6973	1138	9·452	5384	1095	9·674	3326	1002	10·305	1740
13100	1196	9·270	6939	1135	9·540	5355	1092	9·766	3307	1000	10·405	1732
13200	1193	9·354	6905	1132	9·628	5326	1089	9·857	3288	997	10·505	1724
13300	1190	9·438	6871	1128	9·717	5297	1086	9·949	3269	995	10·605	1716
13400	1187	9·522	6837	1125	9·806	5269	1083	10·041	3251	993	10·706	1708
13500	1184	9·606	6803	1122	9·895	5241	1080	10·133	3233	990	10·807	1700
13600	1181	9·690	6770	1119	9·984	5214	1077	10·225	3215	988	10·908	1692
13700	1178	9·775	6737	1117	10·073	5187	1074	10·318	3199	986	11·009	1684
13800	1175	9·860	6705	1114	10·163	5160	1071	10·411	3183	983	11·111	1676
13900	1173	9·945	6673	1111	10·253	5133	1068	10·505	3167	981	11·213	1668
14000	1170	10·030	6641	1108	10·343	5106	1066	10·599	3151	979	11·315	1660
14100	1167	10·116	6609	1105	10·433	5080	1063	10·693	3135	976	11·418	1653
14200	1164	10·202	6577	1102	10·524	5054	1061	10·787	3120	974	11·521	1646
14300	1161	10·288	6546	1099	10·615	5028	1058	10·882	3105	972	11·624	1639
14400	1159	10·374	6515	1096	10·706	5002	1056	10·977	3090	970	11·727	1632
14500	1156	10·460	6484	1094	10·798	4976	1053	11·072	3075	968	11·830	1625
14600	1153	10·547	6453	1091	10·890	4951	1050	11·167	3060	966	11·933	1618
14700	1150	10·634	6423	1088	10·982	4926	1048	11·262	3045	964	12·037	1611
14800	1148	10·721	6393	1085	11·074	4901	1045	11·358	3031	962	12·141	1604
14900	1145	10·808	6363	1083	11·166	4877	1043	11·454	3016	960	12·245	1598
15000	1142	10·895	6334	1080	11·258	4853	1040	11·550	3002	958	12·349	1592
15100	1140	10·983	6304	1077	11·351	4829	1038	11·646	2988	956	12·453	1585
15200	1137	11·071	6275	1074	11·444	4806	1036	11·742	2974	954	12·558	1578
15300	1134	11·159	6246	1072	11·537	4783	1033	11·839	2960	952	12·663	1571
15400	1132	11·247	6217	1070	11·630	4761	1031	11·935	2947	950	12·768	1565
15500	1129	11·336	6188	1067	11·724	4739	1028	12·032	2934	949	12·873	1559

Distance	**6** (*cont.*) **11·6-inch Gun** w=700 lbs.; d=11·52-in. $d^2 \div w$ = ·1896			**7** (*cont.*) **11·6-inch Gun** w=600 lbs.; d=11·52-in. $d^2 \div w$ = ·2212			**8** (*cont.*) **10-inch Gun** w=400 lbs.; d=9·92-in. $d^2 \div w$ = ·2460			**9** (*cont.*) **9-inch Gun** w=250 lbs.; d=8·92-in. $d^2 \div w$ = ·3183		
Feet	v.	t.	E.	v.	t.	E.	v.	t.	E.	v.	t.	E.
15600	1126	11″·425	6160	1065	11″·818	4717	1026	12″·129	2922	947	12·979	1552
15700	1124	11·514	6132	1063	11·912	4696	1024	12·227	2910	945	13·085	1546
15800	1121	11·603	6104	1060	12·006	4675	1022	12·325	2898	943	13·191	1540
15900	1119	11·692	6076	1058	12·100	4655	1020	12·423	2886	941	13·297	1534
16000	1116	11·781	6048	1056	12·195	4635	1018	12·521	2875	939	13·403	1528
16100	1114	11·871	6021	1053	12·290	4615	1016	12·619	2864	937	13·510	1522
16200	1111	11·961	5994	1051	12·385	4595	1014	12·718	2853	935	13·617	1516
16300	1109	12·051	5968	1049	12·480	4576	1012	12·817	2842	933	13·724	1510
16400	1106	12·141	5942	1047	12·575	4557	1011	12·916	2832	931	13·831	1504
16500	1104	12·231	5916	1044	12·671	4538	1009	13·015	2822	930	13·938	1498
16600	1102	12·322	5890	1042	12·767	4519	1007	13·114	2812	928	14·046	1492
16700	1099	12·413	5864	1040	12·863	4500	1005	13·214	2801	926	14·154	1486
16800	1097	12·504	5839	1038	12·959	4481	1003	13·314	2791	924	14·262	1480
16900	1094	12·595	5814	1036	13·056	4462	1001	13·414	2780	922	14·370	1474
17000	1092	12·686	5789	1033	13·152	4443	999	13·514	2770	921	14·479	1468
17100	1089	12·778	5764	1031	13·250	4425	998	13·614	2760	919	14·588	1463
17200	1087	12·870	5740	1029	13·347	4408	996	13·714	2750	917	14·697	1457
17300	1085	12·962	5716	1027	13·444	4391	994	13·815	2740	915	14·806	1452
17400	1082	13·054	5692	1025	13·541	4375	992	13·915	2730	914	14·915	1447
17500	1080	13·146	5668	1023	13·639	4359	990	14·016	2720	912	15·025	1441
17600	1078	13·239	5644	1021	13·737	4343	988	14·117	2710	910	15·135	1436
17700	1075	13.332	5621	1019	13·835	4327	987	14·218	2700	909	15·245	1430
17800	1073	13·426	5598	1018	13·933	4312	985	14·320	2690	907	15·355	1425
17900	1071	13·519	5576	1016	14·031	4297	983	14·421	2680	905	15·465	1420
18000	1069	13·612	5554	1014	14·130	4282	981	14·523	2670	904	15·576	1415
18100	1067	13·706	5532	1013	14·229	4267	979	14·625	2661	902	15·687	1409
18200	1065	13·800	5510	1011	14·328	4252	978	14·727	2651	900	15·798	1404
18300	1063	13·894	5488	1009	14·427	4237	976	14·829	2642	899	15·909	1399
18400	1061	13·988	5467	1008	14·526	4223	974	14·931	2633	897	16·020	1394
18500	1059	14·082	5446	1006	14·625	4209	973	15·034	2624	895	16·132	1389
18600	1057	14·177	5425	1004	14·725	4195	971	15·137	2615	894	16·243	1384
18700	1055	14·272	5404	1003	14·825	4181	970	15·240	2606	892	16·355	1379
18800	1053	14·367	5383	1001	14·925	4167	968	15·343	2598	890	16·467	1374
18900	1051	14·462	5363	999	15·025	4152	966	15·446	2589	889	16·579	1369
19000	1049	14·557	5343	998	15·125	4139	965	15·550	2581	887	16·692	1364
19100	1047	14·652	5323	996	15·225	4125	963	15·654	2573			
19200	1045	14·748	5303	994	15·326	4111	962	15·758	2564			
19300	1043	14·844	5284	993	15·427	4098	960	15·862	2556			
19400	1042	14·940	5265	991	15·528	4085	959	15·966	2548			
19500	1040	15·036	5246	989	15·629	4072	957	16·070	2540			
19600	1038	15·132	5227	988	15·730	4059	956	16·175	2532			
19700	1036	15·229	5208	986	15·831	4046	954	16·280	2524			
19800	1034	15·326	5190	984	15·932	4033	953	16·385	2516			
19900	1032	15·423	5171	983	16·033	4020	951	16·490	2508			
20000	1030	15·520	5152	981	16·135	4007	950	16·595	2500			
20100	1028	15·617	5135	980	16·237	3994	948	16·700	2493			
20200	1027	15·714	5119	978	16·339	3982	947	16·806	2485			
20300	1025	15·811	5103	977	16·441	3970	945	16·912	2477			
20400	1024	15·909	5087	975	16·543	3958	944	17·018	2469			
20500	1022	16·007	5071	974	16·646	3946	942	17·124	2462			
20600	1021	16·105	5056	972	16·749	3934	941	17·230	2454			
20700	1019	16·203	5041	971	16·852	3922	939	17·336	2447			
20800	1018	16·301	5026	970	16·955	3910	938	17·443	2439			
20900	1016	16·399	5011	968	17·058	3899	936	17·550	2431			

Distance	**6** (*cont.*) **11·6-inch Gun** w=700 lbs.; d=11·52-in.; $d^2 \div w =$ ·1896			**7** (*cont.*) **11.6-inch Gun** w=600 lbs.; d=11·52-in.; $d^2 \div w =$ ·2212			**8** (*cont.*) **10-inch Gun** w=400 lbs.; d=9·92-in.; $d^2 \div w =$ ·2460			**10**		
										Dis-tance	w=150 lbs. W. Shot, Flat Head. Mean d=6·665-in.	Ogival Head w=150 lbs.; d=7·446-in.; $d^2 \div w =$ ·3696
Feet	v.	t.	E.	v.	t.	E.	v.	t.	E.	Feet	v.	v.
21000	1015	16″·497	4997	967	17″·161	3888	935	17″·657	2424	0	1200	1200
21100	1013	16·596	4982	965	17·265	3877	933	17·764	2416	100	1194	1194
21200	1012	16·695	4968	964	17·369	3866	932	17·871	2408	200	1189	1189
21300	1010	16·794	4953	963	17·473	3855	931	17·978	2401	300	1183	1183
21400	1009	16·893	4939	961	17·577	3844	929	18·086	2394	400	1178	1177
21500	1007	16·992	4925	960	17·681	3833	928	18·193	2387	500	1172	1172
21600	1006	17·091	4911	958	17·785	3822	926	18·301	2380	600	1167	1166
21700	1005	17·191	4897	957	17·889	3811	925	18·409	2373	700	1161	1161
21800	1003	17·291	4883	956	17·994	3800	924	18·517	2366	800	1156	1156
21900	1002	17·391	4869	954	18·099	3789	922	18·626	2359	900	1151	1150
22000	1000	17·491	4856	953	18·204	3778	921	18·734	2352	1000	1145	1145
22100	999	17·591	4842	952	18·309	3767	920	18·843	2345	1100	1140	1140
22200	997	17·691	4828	950	18·414	3756	918	18·952	2339	1200	1135	1135
22300	996	17·791	4814	949	18·519	3745	917	19·061	2332	1300	1130	1129
22400	995	17·891	4801	948	18·624	3735	916	19·170	2325	1400	1125	1124
22500	993	17·992	4787	946	18·730	3724	914	19·279	2319	1500	1120	1119
22600	992	18·093	4774	945	18·836	3713	913	19·389	2312	1600	1115	1115
22700	990	18·194	4760	944	18·942	3703	912	19·499	2305	1700	1110	1110
22800	989	18·295	4747	942	19·048	3693	910	19·609	2299	1800	1105	1105
22900	988	18·396	4733	941	19·154	3683	909	19·719	2292	1900	1100	1100
23000	986	18·497	4720	940	19·260	3673	908	19·829	2285	2000	1095	1095
23100	985	18·599	4707	938	19·367	3662	906	19·939	2279	2100	1091	1091
23200	983	18·701	4694	937	19·474	3652	905	20·049	2272	2200	1086	1086
23300	982	18·803	4681	936	19·581	3642	904	20·160	2265	2300	1081	1081
23400	981	18·905	4668	934	19·688	3632	902	20·271	2259	2400	1076	1077
23500	979	19·007	4655	933	19·795	3622	901	20·382	2252	2500	1072	1072
23600	978	19·109	4642	932	19·902	3612	900	20·493	2246	2600	1067	1068
23700	977	19·211	4630	930	29·009	3602	899	20·604	2239	2700	1063	1065
23800	975	19·313	4618	929	20·116	3592	897	20·715	2233	2800	1058	1061
23900	974	19·416	4606	928	20·224	3582	896	20·827	2226	2900	1054	1057
24000	973	19·519	4594	927	20·332	3572	895	20·938	2220	3000	1049	1052
24300	969	19·828	4559	923	20·656	3543				3100	1045	1049
24600	966	20·137	4525	919	20·982	3515				3200	1041	1045
24900	962	20·449	4493	916	21·309	3488				3300	1036	1042
25200	959	20·761	4460	912	21·637	3461				3400	1032	1038
25500	955	21·075	4427	909	21·967	3434				3500	1028	1034
25800	952	21·390	4394	905	22·297	3408				3600	1024	1031
26100	948	21·705	4362	902	22·630	3381				3700	1020	1027
26400	945	22·023	4331	898	22·963	3355				3800	1015	1024
26700	941	22·341	4300	895	23·298	3329				3900	1011	1021
27000	938	22·660	4269	891	23·634	3303				4000	1007	1018
27300	935	22·981	4239	888	23·971	3278				4100	1003	1016
27600	931	23·302	4209	885	24·310	3253				4200	999	1013
27900	928	23·625	4179	881	24·649	3229				4300	995	1010
28200	925	23·949	4150	878	24·991	3206				4400	991	1007
28500	921	24·273	4121	875	25·333	3184				4500	988	1004
28800	918	24·600	4093	871	25·677	3160				4600	984	1001
29100	915	24·927	4066							4700	980	999
29400	912	25·255	4039							4800	976	996
29700	909	25·585	4013							4900	972	993
30000	906	25·915	3986							5000	968	990

Distance	11 8-inch Gun w=180 lbs.; d=7·92 in.; $d^2 \div w = \cdot 3485$			12 7-inch Gun w=115 lbs.; d=6·92-in.; $d^2 \div w = \cdot 4164$			13 6·3-inch Gun w=64 lbs.; d=6·22-in.; $d^2 \div w = \cdot 6045$			14 3·6-inch Gun w=16 lbs.; d=3·52-in.; $d^2 \div w = \cdot 7744$		
Feet	v.	t.	E.	v.	t.	E.	v.	t.	E.	v.	t.	E.
0	1700	0″·000	3607	1700	0″·000	2305	1700	0″·000	1283	1700	0″·000	321
100	1692	0·059	3572	1690	0·059	2278	1686	0·059	1261	1681	0·059	314
200	1683	0·118	3537	1680	0·118	2251	1671	0·119	1240	1663	0·119	307
300	1675	0·178	3502	1670	0·178	2224	1657	0·179	1219	1645	0·180	300
400	1667	0·238	3468	1660	0·238	2198	1643	0·239	1198	1627	0·241	294
500	1659	0·298	3434	1651	0·298	2172	1629	0·300	1178	1609	0·303	287
600	1651	0·358	3400	1641	0·359	2146	1616	0·362	1158	1591	0·365	281
700	1642	0·419	3367	1632	0·420	2121	1602	0·424	1138	1574	0·428	275
800	1634	0·480	3334	1622	0·482	2096	1588	0·487	1119	1557	0·492	269
900	1627	0·541	3300	1612	0·544	2071	1574	0·550	1100	1539	0·557	263
1000	1618	0·603	3268	1603	0·606	2047	1561	0·614	1081	1522	0·622	257
1100	1610	0·665	3236	1593	0·669	2023	1547	0·678	1062	1505	0·688	252
1200	1602	0·727	3204	1584	0·732	1999	1534	0·743	1044	1488	0·755	246
1300	1594	0·790	3172	1575	0·795	1976	1521	0·809	1025	1472	0·822	241
1400	1587	0·853	3141	1565	0·859	1953	1507	0·875	1007	1455	0·890	235
1500	1579	0·916	3110	1556	0·923	1930	1494	0·942	989	1439	0·959	230
1600	1571	0·980	3079	1547	0·987	1907	1481	1·009	972	1423	1·030	225
1700	1563	1·044	3048	1537	1·052	1884	1468	1·078	956	1407	1·101	220
1800	1555	1·108	3018	1528	1·117	1861	1455	1·147	940	1391	1·172	215
1900	1547	1·172	2988	1519	1·183	1839	1442	1·216	924	1375	1·244	210
2000	1539	1·237	2958	1510	1·249	1817	1430	1·286	908	1360	1·317	205
2100	1532	1·302	2928	1500	1·315	1795	1418	1·356	892	1345	1·391	201
2200	1524	1·367	2899	1491	1·382	1773	1405	1·427	876	1330	1·466	196
2300	1516	1·433	2870	1482	1·449	1752	1393	1·499	861	1316	1·542	192
2400	1509	1·499	2841	1474	1·517	1731	1381	1·571	846	1301	1·618	188
2500	1501	1·566	2813	1464	1·585	1710	1369	1·644	832	1287	1·695	184
2600	1493	1·633	2785	1455	1·654	1690	1357	1·717	818	1274	1·773	180
2700	1486	1·700	2757	1447	1·723	1670	1345	1·791	804	1260	1·852	176
2800	1478	1·767	2729	1438	1·792	1650	1334	1·866	790	1247	1·932	172
2900	1471	1·835	2701	1429	1·862	1630	1322	1·941	777	1234	2·013	169
3000	1463	1·903	2673	1421	1·932	1610	1311	2·017	764	1221	2·094	165
3100	1456	1·971	2646	1412	2·003	1591	1300	2·093	751	1209	2·176	162
3200	1448	2·040	2619	1403	2·074	1572	1289	2·169	738	1197	2·259	159
3300	1441	2·109	2592	1395	2·145	1553	1278	2·246	726	1185	2·343	156
3400	1434	2·179	2566	1387	2·217	1534	1268	2·324	714	1173	2·428	153
3500	1427	2·249	2540	1378	2·289	1515	1257	2·403	702	1162	2·514	150
3600	1419	2·319	2514	1370	2·362	1497	1247	2·483	690	1150	2·601	147
3700	1412	2·390	2488	1362	2·435	1479	1237	2·564	679	1139	2·688	144
3800	1405	2·461	2463	1354	2·509	1462	1227	2·645	668	1129	2·776	142
3900	1398	2·533	2438	1346	2·583	1445	1217	2·727	657	1118	2·865	139
4000	1391	2·605	2413	1338	2·658	1428	1207	2·810	647	1108	2·955	136
4100	1384	2·677	2389	1330	2·733	1411	1198	2·893	637	1098	3·046	134
4200	1377	2·749	2365	1322	2·808	1394	1188	2·977	627	1088	3·138	132
4300	1370	2·822	2341	1314	2·884	1378	1179	3·061	617	1079	3·230	130
4400	1363	2·895	2318	1306	2·960	1362	1170	3·146	608	1070	3·323	128
4500	1356	2·968	2295	1299	3·037	1346	1161	3·232	599	1062	3·417	126
4600	1349	3·042	2272	1291	3·114	1330	1152	3·319	590	1054	3·511	124
4700	1342	3·116	2249	1284	3·192	1314	1144	3·407	581	1046	3·606	122
4800	1336	3·191	2227	1277	3·270	1299	1135	3·495	572	1038	3·702	120
4900	1329	3·266	2205	1269	3·349	1284	1127	3·584	564	1031	3·799	118
5000	1323	3·342	2183	1262	3·428	1270	1119	3·673	556	1025	3·896	116

Distance	**11** (*cont.*) **8-inch Gun** w=180 lbs.; d=7·92-in.; $d^2 \div w$=·3485			**12** (*cont.*) **7-inch Gun** w=115 lbs.; d=6·92-in.; $d^2 \div w$=·4164			**13** (*cont.*) **6·3-inch Gun** w=64 lbs.; d=6·22-in.; $d^2 \div w$=·6045			**14** (*cont.*) **3·6-inch Gun** w=16 lbs.; d=3·52-in.; $d^2 \div w$=·7744		
Feet	v.	t.	E.	v.	t.	E.	v.	t.	E.	v.	t.	E.
5100	1316	3″·418	2162	1255	3″·507	1256	1111	3″·763	548	1019	3″·994	114
5200	1310	3·494	2141	1248	3·587	1242	1103	3·854	540	1013	4·092	113
5300	1303	3·571	2120	1241	3·667	1228	1095	3·946	532	1007	4·191	111
5400	1297	3·648	2099	1234	3·748	1214	1088	4·039	525	1001	4·291	110
5500	1291	3·725	2079	1227	3·829	1201	1080	4·132	518	995	4·391	109
5600	1284	3·802	2059	1220	3·911	1188	1073	4·225	511	989	4·492	108
5700	1278	3·880	2039	1213	3·993	1175	1066	4·318	505	984	4·593	107
5800	1272	3·958	2019	1207	4·076	1162	1060	4·412	499	978	4·695	106
5900	1266	4·037	2000	1200	4·159	1149	1054	4·507	493	973	4·797	105
6000	1260	4·116	1981	1194	4·243	1136	1048	4·602	487	968	4·900	104
6100	1254	4·196	1962	1187	4·327	1124	1041	4·698	481	963	5·004	103
6200	1248	4·276	1944	1181	4·411	1112	1035	4·794	475	958	5·108	102
6300	1242	4·356	1926	1175	4·496	1100	1029	4·891	470	954	5·213	101
6400	1236	4·437	1908	1168	4·581	1088	1024	4·988	465	949	5·318	100
6500	1231	4·518	1890	1162	4·667	1077	1019	5·086	460	944	5·424	99
6600	1225	4·600	1872	1156	4·753	1066	1014	5·184	456	940	5·530	98
6700	1219	4·682	1855	1150	4·840	1055	1009	5·283	452	935	5·637	97
6800	1214	4·764	1838	1144	4·927	1044	1005	5·382	448	931	5·744	96
6900	1208	4·847	1821	1138	5·015	1033	1000	5·482	444	926	5·852	95
7000	1202	4·930	1804	1133	5·103	1023	996	5·583	440	922	5·960	94
7100	1197	5·013	1788	1127	5·191	1013	991	5·684	436	917	6·069	93
7200	1192	5·097	1772	1121	5·280	1003	987	5·785	432	913	6·178	92
7300	1186	5·181	1756	1116	5·369	993	982	5·886	428	909	6·288	91
7400	1181	5·265	1740	1110	5·459	983	978	5·988	425	905	6·398	90
7500	1176	5·350	1725	1105	5·549	973	974	6·090	421	901	6·509	90
7600	1170	5·435	1710	1100	5·640	964	970	6·193	418	897	6·620	89
7700	1165	5·421	1695	1094	5·731	955	967	6·296	414	893	6·732	89
7800	1160	5·607	1680	1089	5·823	946	963	6·400	411	889	6·844	88
7900	1155	5·693	1665	1084	5·915	937	959	6·504	408	885	6·957	87
8000	1150	5·780	1651	1079	6·008	929	955	6·608	405	881	7·070	87
8100	1145	5·867	1637	1074	6·101	921	952	6·713	402	877	7·184	86
8200	1140	5·955	1623	1069	6·194	913	948	6·818	399	873	7·298	85
8300	1135	6·043	1609	1065	6·288	905	944	6·924	396	870	7·413	84
8400	1131	6·131	1595	1060	6·382	897	941	7·030	393	866	7·528	83
8500	1126	6·219	1582	1056	6·477	899	937	7·137	390	862	7·644	83
8600	1121	6·308	1569	1052	6·572	882	933	7·244	387	858	7·760	82
8700	1116	6·397	1556	1047	6·667	875	930	7·351	384	855	7·877	81
8800	1112	6·487	1543	1043	6·763	868	926	7·459	381	851	7·994	81
8900	1107	6·577	1530	1039	6·859	861	923	7·567	378	848	8·112	80
9000	1103	6·668	1518	1035	6·955	854	920	7·676	375	844	8·230	79
9100	1098	6·759	1505	1031	7·052	848	917	7·785	372			
9200	1094	6·850	1493	1027	7·149	842	913	7·894	370			
9300	1090	6·942	1481	1023	7·246	836	910	8·004	367			
9400	1085	7·034	1469	1020	7·344	830	907	8·114	365			
9500	1081	7·126	1457	1017	7·442	824	904	8·224	362			
9600	1077	7·219	1446	1014	7·540	819	900	8·335	360			
9700	1072	7·312	1435	1010	7·639	814	897	8·446	357			
9800	1069	7·405	1425	1007	7·738	809	894	8·558	355			
9900	1065	7·499	1415	1004	7·837	804	891	8·670	352			
10000	1061	7·593	1405	1001	7·937	799	888	8·782	349			
10100	1058	7·687	1395	998	8·037	794	885	8·895	347			

Distance	**11** (*cont.*) **8-inch Gun** w=180 lbs.; d=7·92-in.; d^2÷w=·3485			**12** (*cont.*) **7-inch Gun** w=115 lbs.; d=6·92-in.; d^2÷w=·4164		
Feet	v.	t.	E.	v.	t.	E.
10200	1054	7″·782	1385	995	8″·138	789
10300	1050	7·877	1375	992	8·239	784
10400	1047	7·972	1366	989	8·340	779
10500	1043	8·068	1357	986	8·441	774
10600	1040	8·164	1348	983	8·543	769
10700	1036	8·260	1339	980	8·645	765
10800	1033	8·357	1331	977	8·747	761
10900	1029	8·454	1323	973	8·850	756
11000	1026	8·552	1315	971	8·953	752
11100	1023	8·650	1307	969	9·056	748
11200	1021	8·748	1300	966	9·159	744
11300	1018	8·846	1293	963	9·263	740
11400	1015	8·944	1286	961	9·367	736
11500	1012	9·043	1279	958	9·471	732
11600	1010	9·142	1272	956	9·575	728
11700	1007	9·241	1265	953	9·680	724
11800	1004	9·340	1258	951	9·785	720
11900	1002	9·440	1252	948	9·890	717
12000	999	9·540	1246	945	9·996	713
12100	997	9·640	1239	943	10·102	709
12200	994	9·740	1232	941	10·208	705
12300	991	9·841	1226	938	10·315	701
12400	989	9·942	1219	936	10·422	697
12509	986	10·043	1213	933	10·529	694
12600	984	10·144	1207	931	10·636	691
12700	981	10·246	1201	928	10·744	687
12800	979	10·348	1195	926	10·852	684
12900	976	10·451	1190	924	10·960	680
13000	974	10·554	1184	921	11·068	677
13100	972	10·657	1179	919	11·177	673
13200	970	10·760	1173	917	11·286	670
13300	967	10·863	1168	914	11·395	667
13400	965	10.966	1162	912	11·504	663
13500	963	11·070	1157	910	11·614	660
13600	961	11·174	1152	908	11·724	657
13700	959	11·278	1147	906	11·834	654
13800	957	11·382	1142	903	11·945	651
13900	954	11·487	1137	901	12·056	647
14000	952	11·592	1132	899	12·167	644
14100	950	11·697	1127	897	12·278	641
14200	948	11·802	1122	895	12·390	638
14300	946	11·908	1117	893	12·502	635
14400	944	12·014	1112	890	12·614	632
14500	942	12·120	1107	888	12·726	629
14600	940	12·226	1102	886	12·839	626
14700	938	12·332	1098	884	12·952	624
14800	935	12·439	1093	882	13·065	621
14900	933	12·546	1088	880	13·179	618
15000	931	12·653	1083	878	13·293	615
15300	925	12·977	1069	872	13·636	606
15600	920	13·302	1055			
15900	914	13·629	1042			
16200	908	13·959	1030			
16500	903	14·290	1017			
16800	897	14·623	1005			

15 Cubic Law of Resistance			
Distance	Reports, &c., p. 15, Oct. 23, 1866	O.S.C. Minute 23,351, Sept. 21, 1867	Hélie's Law and Coefficient, 1865
Feet	v.	v.	v.
0	1500·0	1500·0	1500·0
100	1486·3	1486·4	1491·5
200	1473·0	1473.0	1483·2
300	1460·0	1459·9	1474·9
400	1447·0	1447.0	1466·7
500	1434·3	1434·3	1458·6
600	1421·9	1421·8	1450·5
700	1409·6	1409·6	1442·7
800	1397·6	1397·6	1434·9
900	1385·8	1385·8	1427·2
1000	1374·2	1374.1	1419·5
1100	1362·8	1362·7	1411·9
1200	1351·5	1351·4	1404·4
1300	1340·5	1340·4	1397·0
1400	1329·6	1329·5	1389·7
1500	1318·9	1318·8	1382·4
1600	1308·4	1308·3	1375·2
1700	1298·0	1297·9	1368·1
1800	1287·8	1287·7	1361.1
1900	1277·8	1277·6	1354·1
2000	1267·9	1267.7	1347·2
2100	1258·2	1258.0	1340.4
2200	1248·6	1248·4	1333·6
2300	1239·2	1239·0	1326·9
2400	1229·9	1229·6	1320.3
2500	1220·7	1220·5	1313·8
2600	1211·7	1211·5	1307·3
2700	1202·8	1202·6	1300·8
2800	1194·0	1193·8	1294·5
2900	1185·4	1185·2	1288·2
3000	1176·9	1176·6	1281·9
3100	1168·5	1168·3	1275·8
3200	1160·2	1160·0	1269·6
3300	1152·1	1151·8	1263·6
3400	1144·0	1143·8	1257·6
3500	1136·1	1135·8	1251·6
3600	1128·3	1128·0	1245·7
3700	1120.6	1120·3	1239·9
3800	1113·0	1112·7	1234.1
3900	1105·5	1105·2	1228·4
4000	1098·1	1097·8	1222·7
4110	1090·8	1090·5	1217·1
4200	1083·5	1083·2	1211·5
4300	1077·6	1076·1	1206·0
4400	1070·5	1069·1	1200·5
4500	1063·6	1062·2	1195·1

Distance	**16** 3·45-inch Gun w=16 lbs.; d=3·372-in.; $d^2 \div w$=·7105			**17** 3-inch B.L. Gun w=12 lbs.; d=3-in.; $d^2 \div w$=·7500			**18** 3-inch M.L. Gun w=12 lbs.; d=2·92-in.; $d^2 \div w$=·7105			**19** 3-inch M.L. Gun. w=9 lbs.; d=2·94-in.; $d^2 \div w$=·9604		
Feet	v.	t.	E.	v.	t.	E.	v.	t.	E.	v.	t.	E.
0	1700	0″·000	321	1700	0″·000	240	1700	0′·000	240	1700	0′·000	180
100	1683	0·059	314	1682	0·059	235	1683	0·059	235	1677	0·060	175
200	1666	0·119	308	1664	0·119	230	1666	0·119	230	1655	0·120	170
300	1649	0·179	302	1647	0·179	225	1649	0·179	226	1632	0·181	166
400	1633	0·240	296	1629	0·240	220	1633	0·240	221	1610	0·242	161
500	1617	0·302	290	1612	0·302	216	1617	0·302	217	1589	0·305	157
600	1601	0·364	284	1595	0·365	212	1601	0·364	213	1567	0·368	153
700	1585	0·427	278	1578	0·428	207	1585	0·427	209	1546	0·432	149
809	1569	0·490	273	1561	0·492	202	1569	0·490	205	1525	0·497	145
900	1553	0·554	267	1544	0·556	198	1553	0·554	201	1504	0·563	141
1000	1537	0·619	262	1527	0·621	194	1537	0·619	197	1483	0·630	137
1100	1521	0·685	257	1511	0·687	190	1521	0·685	193	1462	0·698	134
1200	1506	0·751	252	1494	0·753	186	1506	0·751	189	1441	0·767	130
1300	1490	0·818	246	1478	0·820	182	1490	0·818	185	1421	0·837	126
1400	1475	0·885	241	1462	0·888	178	1475	0·885	181	1401	0·908	123
1500	1460	0·953	236	1446	0·957	174	1460	0·953	178	1382	0·980	119
1600	1444	1·022	231	1430	1·027	170	1444	1·022	174	1363	1·053	116
1700	1430	1·091	226	1414	1·097	167	1430	1·091	170	1344	1·127	113
1800	1415	1·161	222	1399	1·168	163	1415	1·161	167	1326	1·202	110
1900	1400	1·232	217	1384	1·240	159	1400	1·232	163	1308	1·278	107
2000	1386	1·304	213	1369	1·313	156	1386	1·304	160	1290	1·355	104
2100	1372	1·377	209	1354	1·387	152	1372	1·377	156	1273	1·433	102
2200	1358	1·450	205	1340	1·461	149	1358	1·450	153	1257	1·512	99
2300	1344	1·524	201	1326	1·536	146	1344	1·524	150	1240	1·592	96
2400	1330	1·599	197	1312	1·612	143	1330	1·599	147	1225	1·673	94
2500	1317	1·675	193	1298	1·689	140	1317	1·675	144	1209	1·755	91
2600	1304	1·751	189	1284	1·766	137	1304	1·751	141	1194	1·838	89
2700	1291	1·828	185	1271	1·844	134	1291	1·828	138	1179	1·922	87
2800	1278	1·906	181	1258	1·923	131	1278	1·906	136	1165	2·008	85
2900	1266	1·985	178	1245	2·003	129	1266	1·985	133	1151	2·094	83
3000	1253	2·064	174	1233	2·084	127	1252	2·064	131	1138	2·182	81
3100	1241	2·144	171	1220	2·165	124	1241	2·144	128	1125	2·270	79
3200	1230	2·225	168	1208	2·247	122	1230	2·225	126	1112	2·360	77
3300	1218	2·307	165	1197	2·330	119	1218	2·307	123	1099	2·451	75
3400	1207	2·390	162	1185	2·414	117	1207	2·390	121	1087	2·542	74
3500	1196	2·473	159	1174	2·499	115	1196	2·473	119	1076	2·634	72
3600	1185	2·557	156	1163	2·585	113	1185	2·557	117	1065	2·728	71
3700	1174	2·642	153	1152	2·671	111	1174	2·642	115	1055	2·822	70
3800	1163	2·727	150	1141	2·758	109	1163	2·727	113	1045	2·917	68
3900	1153	2·813	147	1131	2·846	107	1153	2·813	111	1036	3·013	67
4000	1143	2·900	144	1120	2·935	105	1143	2·900	109	1027	3·110	66
4100	1133	2·988	142	1110	3·025	103	1133	2·988	107	1019	3·208	65
4200	1123	3·077	139	1101	3·116	101	1123	3·077	105	1011	3·307	64
4300	1114	3·166	137	1091	3·207	99	1114	3·166	103	1004	3·406	63
4400	1104	3·256	135	1082	3·299	97	1104	3·256	102	996	3·506	62
4500	1095	3·347	133	1073	3·392	96	1095	3·347	100	989	3·607	61
4600	1087	3·439	131	1065	3·486	94	1087	3·439	98	982	3·708	61
4700	1078	3·532	129	1057	3·580	93	1078	3·532	96	976	3·810	60
4800	1070	3·625	127	1049	3·675	92	1070	3·625	95	970	3·913	59
4900	1063	3·719	125	1041	3·771	90	1063	3·719	93	963	4·017	59
5000	1055	3·813	123	1034	3·867	89	1055	3·813	92	958	4·121	58

Distance	16 (*cont.*) 3·45-inch Gun w=16 lbs.; d=3.372-in.; $d^2 \div w =$ ·7105			17 (*cont.*) 3-inch B.L, Gun w=12 lbs.; d=3-in.; $d^2 \div w =$ ·7500			18 (*cont.*) 3-inch M.L. Gun w=12 lbs.; d=2·92-in.; $d^2 \div w -$ ·7105			19 (*cont.*) 3-inch M.L. Gun w=9 lbs.; d=2·94-in.; $d^2 \div w =$ ·9604		
Feet	v.	t.	E.	v.	t.	E.	v.	t.	E.	v.	t.	E.
		′			″			″			″	
5100	1048	3·908	121	1027	3·964	88	1048	3·908	91	952	4·226	57
5200	1041	4·004	120	1021	4·062	87	1041	4·004	90	946	4·331	57
5300	1034	4·101	118	1015	4·160	86	1034	4·101	89	940	4·437	56
5400	1028	4·198	117	1009	4·259	85	1028	4·198	88	935	4·544	55
5500	1022	4·296	115	1003	4·358	84	1022	4·296	87	929	4·651	55
5600	1016	4·394	114	998	4·458	83	1016	4·394	86	924	4·759	54
5700	1010	4·493	112	992	4·558	82	1010	4·493	85	919	4·868	53
5800	1005	4·592	111	987	4·659	81	1005	4·592	84	913	4·977	53
5900	999	4·692	110	981	4·761	80	999	4·692	83	908	5·087	52
6000	994	4·792	109	976	4·863	79	994	4·792	82	903	5·197	51
6100	989	4·893	108	971	4·966	79	989	4·893	81	898	5·308	51
6200	984	4·994	107	966	5·069	78	984	4·994	80	893	5·420	50
6300	979	5·096	106	962	5·173	77	979	5·096	80	888	5·532	50
6400	974	5·198	105	957	5·277	77	974	5·198	79	883	5·645	49
6500	969	5·301	104	952	5·382	76	969	5·301	78	878	5·758	49
6600	965	5·404	103	948	5·487	75	965	5·404	77	874	5·872	48
6700	960	5·508	102	943	5·593	75	960	5·508	77	869	5·987	48
6800	956	5·612	101	939	5·699	74	956	5·612	76	864	6·102	47
6900	952	5·717	100	934	5·806	73	952	5·717	75	860	6·218	47
7000	947	5·823	99	930	5·913	73	947	5·823	75	855	6·335	46
7100	943	5·929	99	926	6·021	72	943	5·929	74			
7200	939	6·035	98	922	6·129	71	939	6·035	73			
7300	935	6·142	97	917	6·238	71	935	6·142	73			
7400	931	6·249	96	913	6·347	70	931	6·249	72			
7500	927	6·357	95	909	6·457	69	927	6·357	72			
7600	923	6·465	95	905	6·567	69	923	6·465	71			
7700	919	6·574	94	901	6·678	68	919	6·574	71			
7800	915	6·683	93	898	6·789	67	915	6·683	70			
7900	911	6·792	92	894	6·901	67	911	6·792	70			
8000	907	6·902	92	890	7·013	66	907	6·902	69			
8100	903	7·013	91	886	7·126	66	903	7·013	68			
8200	900	7·124	90	882	7·239	65	900	7·124	68			
8300	896	7·235	89	879	7·353	65	896	7·235	67			
8400	892	7·347	89	875	7·467	64	892	7·347	66			
8500	889	7·459	88	871	7·581	64	889	7·459	66			
8600	885	7·572	87	867	7·696	63	885	7·572	65			
8700	881	7·685	86	864	7·811	63	881	7·685	65			
8800	878	7·799	86	860	7·927	62	878	7·799	64			
8900	874	7·913	85	857	8·044	62	874	7·913	64			
9000	871	8·028	84	853	8·161	61	871	1·028	63			

20 *A General Table for facilitating the Calculation of the Range corresponding to a given loss of Velocity of any* SPHERICAL SHOT.

Distances	0	10	20	30	40	50	60	70	80	90
feet	f.s.	f.s.	f.s.	f.s.	f.s.	f.s.	f.s.	f.s.	f.s.	f.s.
0	2100·0	2095·6	2091·3	2086·9	2082·6	2078·3	2074·0	2069·6	2065·3	2061·0
100	2056·7	2052·5	2048·2	2043·9	2039·7	2035·5	2031·2	2027·0	2022·8	2018·6
200	2014·4	2010·2	2006·0	2001·9	1997·7	1993·6	1989·4	1985·3	1981·2	1977·1
300	1973·0	1968·9	1964·8	1960·7	1956·7	1952·6	1948·6	1944·6	1940·5	1936·5
400	1932·5	1928·5	1924·5	1920·5	1916·6	1912·6	1908·7	1904·7	1900·8	1896·9
500	1893·0	1889·1	1885·2	1881·3	1877·4	1873·6	1869·7	1865·8	1862·0	1858·1
600	1854·4	1850·5	1846·7	1842·9	1839·1	1835·4	1831·6	1827·8	1824·1	1820·3
700	1816·6	1812·8	1809·1	1805·4	1801·7	1798·0	1794·3	1790·6	1786·9	1783·3
800	1779·6	1775·9	1772·3	1768·7	1765·0	1761·4	1757·8	1754·2	1750·6	1747·0
900	1743·4	1739·8	1736·3	1732·7	1729·1	1725·6	1722·1	1718·5	1715·0	1711·5
1000	1708·0	1704·5	1701·0	1697·5	1694·0	1690·5	1687·1	1683·6	1680·2	1676·7
1100	1673·3	1669·9	1666·4	1663·0	1659·6	1656·2	1652·8	1649·5	1646·1	1642·7
1200	1639·2	1636·0	1632·7	1629·3	1626·0	1622·7	1619·3	1616·0	1612·7	1609·5
1300	1606·2	1602·9	1599·6	1596·3	1593·1	1589·9	1586·6	1583·4	1580·2	1577·0
1400	1573·8	1570·6	1567·4	1564·2	1561·0	1557·9	1554·7	1551·5	1548·4	1545·3
1500	1542·1	1539·0	1535·9	1532·8	1529·7	1526·6	1523.6	1520·5	1517·4	1514·4
1600	1511·3	1508·3	1505·2	1502·2	1499·2	1496·2	1493.2	1490·2	1487·2	1484·2
1700	1481·2	1478·3	1475·3	1472·3	1469·4	1466·4	1463.5	1460·6	1457·7	1454·8
1800	1451·9	1449·0	1446·1	1443·2	1440·3	1437·5	1434·6	1431·7	1428·9	1426·1
1900	1423·2	1420·4	1417·6	1414·8	1412·0	1409·2	1406·4	1403·6	1400·8	1398·1
2000	1395·3	1392·6	1389·8	1387·1	1384·4	1381·6	1378·9	1376·2	1373·5	1370·8
2100	1368·1	1365·4	1362·8	1360·1	1357·4	1354·8	1352·1	1349·5	1346·8	1344·2
2200	1341·6	1339·0	1336·4	1333·8	1331·2	1328·6	1326·1	1323·5	1320·9	1318·4
2300	1315·8	1313·3	1310·8	1308·2	1305·7	1303·2	1300·7	1298·2	1295·7	1293·2
2400	1290·8	1288·3	1285·8	1283·4	1280·9	1278·5	1276·0	1273·6	1271·2	1268·8
2500	1266·4	1264·0	1261·6	1259·2	1256·8	1254·4	1252·1	1249·7	1247·3	1245·0
2600	1242·6	1240·3	1238·0	1235·6	1233·3	1231·0	1228·7	1226·4	1224·1	1221·9
2700	1219·6	1217·3	1215·1	1212·8	1210·5	1208·3	1206·1	1203·8	1201·6	1199·4
2800	1197·2	1195·0	1192·8	1190·6	1188·5	1186·3	1184·1	1182·0	1179·9	1177·7
2900	1175·6	1173·5	1171·4	1169·3	1167·2	1165·1	1163·0	1160·9	1158·8	1156·8
3000	1154·7	1152·7	1150·6	1148·6	1146·6	1144·6	1142·6	1140·6	1138·6	1136·6
3100	1134·6	1132·6	1130·7	1128·7	1126·8	1124·8	1122·9	1121·0	1119·1	1117·2
3200	1115·3	1113·4	1111·5	1109·6	1107·8	1105·9	1104·0	1102·2	1100·4	1098·5
3300	1096·7	1094·9	1093·1	1091·3	1089·5	1087·7	1085·9	1084·2	1082·4	1080·7
3400	1078·9	1077·2	1075·4	1073·7	1072·0	1070·3	1068·6	1066·9	1065·2	1063·6
3500	1061·9	1060·2	1058·6	1056·9	1055·3	1053·7	1052·1	1050·4	1048·8	1047·2
3600	1045·6	1044·0	1042·5	1040·9	1039·3	1037·5	1036·2	1034·7	1033·1	1031·6
3700	1030·1	1028·5	1027·0	1025·5	1024·0	1022·5	1021·0	1019·5	1018·0	1016·6
3800	1015·1	1013·6	1012·2	1010·7	1009·3	1007·8	1006·4	1005·0	1003·5	1002·1
3900	1000·7	999·3	997·9	996·5	995·1	993·7	992·3	990·9	989·5	988·2
4000	986·8	985·4	984·1	982·7	981·4	980·0	978·7	977·3	976·0	974·7
4100	973·3	972·0	970·7	969·4	968·1	966·8	965·5	964·2	962·9	961·6
4200	960·3	959·0	957·8	956·5	955·2	954·0	952·7	951·5	950·2	948·9
4300	947·7	946·4	945·2	944·0	942·8	941·5	940·3	939·1	937·8	936·6
4400	935·4	934·2	933·0	931·8	930·6	929·4	928·2	927·0	925·8	924·6
4500	923·4	922·3	921·1	919·9	918·8	917·6	916·4	915·2	914·1	912·9
4600	911·8	910·7	909·5	908·3	907·2	906·1	905·0	903·8	902·7	901·6
4700	900·4	899·3	898·2	897·1	896·0	894·9	893·8	892·7	891·6	890·5
4800	889·4	888·3	887·2	886·1	885·0	883·9	882·9	881·8	880·7	879·7
4900	878·6	877·5	876·5	875·4	874·3	873·3	872·2	871·2	870·1	869·1

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A General Table for facilitating the Calculation of the Range corresponding to a given loss of Velocity of any ELONGATED SHOT (*Ogival Head*).

Distance	0	10	20	30	40	50	60	70	80	90
feet	f.s.	f.s.	f.s.	f.s.	f.s.	f.s.	f.s.	f.s.	f.s.	f.s.
0	1700·0	1697·5	1695·1	1692·7	1690·3	1687·9	1685·5	1683.2	1680·8	1678·4
100	1676·0	1673·7	1671·3	1668·9	1666·6	1664·2	1661·9	1659·5	1657·2	1654·8
200	1652·5	1650·2	1647·9	1645·6	1643·3	1640·9	1638·6	1636·3	1634·0	1631·7
300	1629·4	1627·1	1624·8	1622·5	1620·2	1617·9	1615·6	1613·3	1611·1	1608·8
400	1606·5	1604·2	1601·9	1599·7	1597·4	1595·1	1592·8	1590·6	1588·3	1586·0
500	1583·8	1581·5	1579·2	1577·0	1574·7	1572·5	1570·2	1567·9	1565·7	1563·4
600	1561·2	1558·9	1556·7	1554·5	1552·2	1550·0	1547·8	1545·5	1543·3	1541·1
700	1538·8	1536·6	1534·4	1532·2	1530·0	1527·8	1525·6	1523·3	1521·1	1518·9
800	1516·7	1514·5	1512·3	1510·1	1507·9	1505·7	1503·5	1501·3	1499·1	1497·0
900	1494·8	1492·6	1490·4	1488·3	1486·1	1483·9	1481·8	1479·6	1477·4	1475·3
1000	1473·1	1471·0	1468·8	1466·7	1464·6	1462·4	1460·3	1458·1	1456.0	1453·9
1100	1451·8	1449·6	1447·5	1445·4	1443·3	1441·2	1439·1	1437·0	1434·9	1432·8
1200	1430·7	1428·6	1426·5	1424·4	1422·3	1420·3	1418·2	1416·1	1414·1	1412·0
1300	1409·9	1407·9	1405·8	1403·8	1401·7	1399·7	1397·7	1395·6	1393·6	1391·6
1400	1389·6	1387·5	1385·5	1383·5	1381·5	1379·5	1377·5	1375·5	1373·5	1371·5
1500	1369·5	1367·6	1365.6	1363·6	1361·7	1359·7	1357·7	1355·8	1353·8	1351·9
1600	1349·9	1348·0	1346·1	1344·1	1342·2	1340·3	1338·4	1336·5	1334·6	1332·7
1700	1330·8	1328·9	1327·0	1325·1	1323·2	1321·3	1319·5	1317·6	1315·7	1313·9
1800	1312·0	1310·2	1308·3	1306·5	1304·6	1302·8	1301·0	1299·2	1297·3	1295·5
1900	1293·7	1291·9	1290·1	1288·3	1286·5	1284·7	1282·9	1281·2	1279·4	1277·6
2000	1275·9	1274·1	1272·3	1270·6	1268·8	1267·1	1265·3	1263·6	1261·9	1260·1
2100	1258·4	1256·7	1255·0	1253·3	1251·6	1249·9	1248·2	1246·5	1244·8	1243·1
2200	1241·5	1239·8	1238·1	1236·4	1234·8	1233·1	1231·5	1229·8	1228·2	1226·5
2300	1224·9	1223·3	1221·6	1220·0	1218·4	1216·8	1215·2	1213·6	1212·0	1210·4
2400	1208·8	1207·2	1205·6	1204·0	1202·4	1200·9	1199·3	1197·7	1196·2	1194·6
2500	1193·1	1191·5	1190·0	1188·4	1186·9	1185·4	1183·8	1182·3	1180·8	1179·3
2600	1177·8	1176·3	1174·8	1173·3	1171·8	1170·3	1168·8	1167·3	1165·8	1164·3
2700	1162·9	1161·4	1159·9	1158·5	1157·0	1155·6	1154·1	1152·7	1151·3	1149·8
2800	1148·4	1147·0	1145·6	1144·1	1142·7	1141·3	1139·9	1138·5	1137·1	1135·7
2900	1134·3	1133·0	1131·6	1130·2	1128·8	1127·5	1126·1	1124·7	1123·4	1122·0
3000	1120·7	1119·3	1118·0	1116·7	1115·3	1114·0	1112·7	1111·4	1110·1	1108·7
3100	1107·4	1106·1	1104·8	1103·5	1102·2	1101·0	1099·7	1098·4	1097·1	1095·8
3200	1094·6	1093·3	1092·1	1090·8	1089·6	1088·3	1087·1	1085·8	1084·6	1083·4
3300	1082·2	1081·0	1079·8	1078·5	1077·3	1076·1	1074·9	1073·8	1072·6	1071·5
3400	1070·3	1069·2	1068·0	1066·8	1065·7	1064·6	1063·5	1062·4	1061·3	1060·2
3500	1059·1	1058·0	1056·9	1055·8	1054·7	1053·7	1052·7	1051·7	1050·6	1049·6
3600	1048·6	1047·6	1046·6	1045·5	1044·5	1043·6	1042·6	1041·6	1040·7	1039·7
3700	1038·8	1037·8	1036·9	1035·9	1035·0	1034·1	1033·2	1032·3	1031·4	1030·5
3800	1029·6	1028·7	1027·8	1027·0	1026·1	1025·2	1024·3	1023·5	1022·6	1021·8
3900	1021·0	1020·1	1019·2	1018·4	1017·6	1016·8	1015·9	1015·1	1014·3	1013·5
4000	1012·7	1011·9	1011·1	1010. 3	1009·6	1008·8	1008·0	1007·2	1006·4	1005·6
4100	1004·8	1004·1	1003·3	1002·6	1001·8	1001·1	1000·3	999·6	998·8	998·1
4200	997·3	996·6	995·8	995·1	994·3	993·6	992·9	992·2	991·5	990·8
4300	990·1	989·3	988·6	987·9	987·3	986·5	985·8	985·1	984·4	983·7
4400	983·0	982·3	981·6	981·0	980·3	979·6	979·0	978·3	977·6	976·8
4500	976·2	975·5	974·8	974·2	973·5	972·9	972·2	971·5	970·9	970·2
4600	969·6	969·0	968·3	967·7	967·0	966·4	965·7	965·1	964·4	963·8
4700	963·1	962·5	961·9	961·3	960·6	960·0	959·3	958·7	958·1	957·5
4800	956·8	956·2	955·6	954·9	954·4	953·7	953·1	952·5	951·9	951·3
5100	938·7	938·1	937·6	936·9	936·4	935·8	935·2	934·7	934·1	933·4
5400	921·7	921·1	920·6	920·0	919·5	918·9	918·3	917·8	917·2	916·7
5700	905·4	904·8	904·3	903·8	903·3	902·7	902·2	901·7	901·1	900·7

DEVELOPMENT OF ARTILLERY MISSILES

DURING 1870.

BY

CAPTAIN C. O. BROWNE, R.A.,

CAPTAIN INSTRUCTOR, ROYAL LABORATORY.

A Paper read at the R.A. Institution, Woolwich, January 31, 1871, to supplement the Paper on Rifled Shells and Fuzes read by Capt. C. O. Browne, March 8, 1870.

COLONEL W. J. SMYTHE, R.A., presided, and Captain A. D. BURNABY, Secretary of the Royal Artillery Institution, introduced the lecturer and his subject to the meeting.

Captain C. O. BROWNE then read the following paper:—

I propose to-day to place before you typical specimens of all the projectiles and fuzes connected with our rifled equipments now in the service. Those that have come into the service *during the last year* or seem likely to be adopted, I propose to *describe briefly*, explaining as far as I can the general character and design of each without entering into unnecessary detail. The remainder I merely mean to *enumerate;* in fact I only attempt to supplement the summary I gave last March, by taking a short review of any new features assumed by our equipments, besides discussing a few questions of special interest, with the hope that an opportunity may be afforded of hearing the opinions of officers who have not leisure to bring their views forward in a formal manner, and this the more because I am going to touch on matters of which my own knowledge is most imperfect.

On the table are specimens of each class of service projectile, so that I may say in a manner that all the skill and science of every branch of the regiment culminates in effectively striking the *personnel* or *matériel* of an enemy with one or another of the projectiles now before us.

To begin with the heavy ordnance.

In the equipment of the Woolwich guns there is little change, so that the guns stand—13″, 12″, 10″, 9″, 8″, and 7″ (besides the experimental 11·6″ gun). These guns have for their complete equipment—

Common shell,
Boxer shrapnel shell,
Palliser shell,
Palliser shot,
Case shot,
(the 7-inch only firing double shell).

Their fuzes are placed opposite to them. The common and double shell are generally fired with the Pettman G.S. fuze for sea service, but as I noticed last year it is most important to recollect that this fuze (which is excellent for sea service) will not act on *graze* and is therefore *useless* for *land service*, for on *direct impact* the *time* fuzes are driven in so as to explode the shells; hence while only occasionally used at sea, the sole fuzes issued for land service are the 9 and 20 seconds Boxer M.L.O. time fuzes.

The common shells, though at present unchanged in any way, are likely to have their explosive power greatly increased by the introduction of

Picric Powder.

This is the first substance partaking of the nature of a detonating composition that has offered a reasonable prospect of safety against premature explosion when used as a bursting charge for a shell, and while it is very stable in its chemical character, it possesses in common with fulminates very much greater explosive force than gunpowder (probably about double the force). I need not attempt a discussion of the chemical composition of this substance, which has been worked out by Mr. Abel in his department and recommended by him in a form which seems to be free from the defects generally belonging to compositions of a similar character hitherto used by the French and other governments.

The products of explosion are the same generally as those of guncotton—viz. carbonic acid, nitrogen gas, and water, without the generation of the volatile sulphates and sulphides which mainly contribute to the formation of the dense smoke accompanying the explosion of gunpowder. Picric powder would generally have less smoke than gunpowder, but this is no recommendation for the purposes for which it is likely to be adopted.

Palliser and Steel Projectiles.

Passing next to Palliser projectiles, I may notice the introduction of serge bags now inserted in the shells to prevent friction of powder against iron in case of the coating of lacquer in the interior being imperfect, and also in case of the presence of any iron particles cut from the wrought-iron bush in the operation of tapping, and adhering to the lacquer. The operation of lacquering these shells is specially difficult, because the shells must not be re-heated after they once cool, and it is difficult to catch them in the process of cooling at the precise temperature which favours the adhesion of the service red lacquer. To avoid the presence of iron in any form, a cold lacquer will be applied to these shells for the future, and as an additional precaution the bag will be used.

A more interesting question is that of the relative powers of our service chilled projectiles and rival shot of the same class. Good steel projectiles have been made, but some of the processes of manufacture are very tedious, and in the present state of development of the art the work is apt to fail: thus they are not only outrageously expensive, but also difficult of rapid production on a large scale, and besides there is no promise of superiority to justify any special efforts in this direction at present. Beautiful chilled projectiles have been supplied from Finspon in Sweden. The processes of manufacture are not fully known to us probably. The iron is softer than ours, the shot bear the marks of a cutting tool all over them. I believe that projectiles quite as good or even better can now be manufactured in the Royal Laboratory at about half the price charged for the Swedish shot as delivered. I do not say that all our service projectiles have been so good. As perhaps most officers present are aware, there have been manufacturing difficulties which have led to the condemnation of considerable numbers of projectiles; but I believe these are now overcome, and I feel sure that we may place great confidence in the mechanical talent and ability of all the hands to whom the work of our manufacture is entrusted. As to our future issues, the Ridsdale iron supplied from Elswick seems to promise even better results than the iron we have employed up to this time.

I should like for a few moments to consider the action of shot on impact against armour. The powers of a projectile are generally estimated—

1st. By the actual penetration in the plate.

2nd. By its own behaviour; that is whether it stands up well to its work or breaks away.

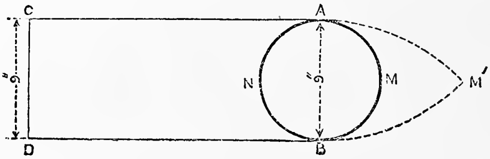
The first mentioned test is plain and fair where calibres and charges are the same. The second indication is less distinct; the supposition is that when a shot shivers, the fragments commonly carry away in them a certain part of the work stored up in the projectile, which part clearly becomes unprofitable, except in the case of *complete penetration*. It is to be noticed however that the *target* is the *agent* by which the shot is broken, and the actual work of fracture is *bonâ fide reaction of work impressed on the target* as truly as the setting up a shot; in fact a shot may be so fractured that before the fragments separate from the head, they have lent nearly all their striking power to the work: only while in this case we may say that we cannot quite estimate how little work was carried off in an unprofitable form, in the case of a shot which remains entire we are sure that none at all has been so wasted. May I call your attention to the 9-inch Finspon Palliser shot before you, which penetrated 14 ins. into solid iron plate and bounded back several feet, slightly set up and cracked but intact. In the case of complete penetration, when of course the penetrative powers are not taxed to the full, it is rather an advantage for a shot to break as it comes through.

Perhaps while on the subject of penetration of armour, it may not be wasting our time to consider a few statements concerning flight and penetration which have been made by those who have specially studied these questions.

Lieut. Sladen on Resistance of the Air.

Lieut. Sladen, after taking part in Professor Bashforth's investigations as to the resistance of the air, by means of the professor's chronograph, remarks that, in addition to the pressure on the head there is a powerful retarding force in the shape of *minus* pressure or suction, from the partial vacuum formed behind the base of any projectile moving rapidly. To this suction must be attributed a fact brought out by these investigations—viz. that the actual retarding pressure on a spherical 9-inch shot *AMBN* in fig. moving at a velocity of 1130 ft. per second is 555 lbs., while that on an elongated 9-inch shot with a hemispherical head *AMBDC* moving at the same velocity is only 487 lbs. But the anterior portions *AMB* being identical, the decrease of pressure of 68 lbs. on the elongated shot must be due to the air closing in more easily behind it. I now speak of the question of *actual resistance*, which must not be confounded with the greater *power of overcoming resistance* possessed by the elongated shot as compared with the spherical, which may generally be about 3 to 1.

Further, the service *ogival-headed* 9-inch shot *AM'BDC* meets with 98 lbs. less pressure on it than a hemispherical-headed one. So that the advantages in keeping up velocity possessed by the service form of shot as compared with a spherical one are more than would at first appear; for while the pressure of air against the latter is 555 lbs., it is only 389 against the former, and to meet that pressure there is three times the weight and momentum.

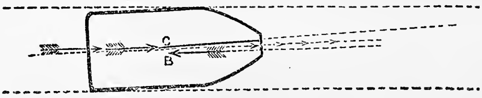


General Maievsky on the Flight of Projectiles.

The investigations of General Maievsky, as to the forces acting on projectiles in flight and penetration, are such that they form a study of great magnitude, involving peculiar applications of the highest mathematics. It would be idle to attempt to take up the pursuit of this subject without making it a regular course of study. A few of Maievsky's results quoted by Mr. Mallet in his papers in the "Engineer," as well as notes on the subject of penetration, as discussed by Mr. Mallet, may be found valuable although briefly given in general terms.

1st. As to the irregular spiral path described by rifled projectiles in flight:—

General Maievsky supposes the projectile to be proceeding on a path not absolutely coincident with its axis, and shows that the point where



the resultant of the resistance on the anterior part of the projectile intersects its axis (which he terms the "centre of resistance"), not being exactly opposite to the centre of gravity, the force of projection and that of resistance act so as to form a couple *BC* which tends to deflect the head of the shot. This being opposed by the centrifugal force due to rotation and the effect varying continually, the axis of the projectile constantly describes in space a form approaching a cone, the path of its centre of gravity being a helix or spiral.

General Maievsky arrives at the conclusion that the helix becomes wider and wider as the projectile proceeds further and further on its path.

Facts seem to contradict this, and though General Maievsky gives reasons in support of his conclusions, it seems likely that the conditions of the question are affected by the velocity of translation (and hence the disturbing cause—viz. the resistance of the air) decreasing much more rapidly than the velocity of rotation.

The small diminution of the velocity of rotation, as compared with that of translation, is a fact that has been frequently overlooked, and the strong reasons there are for believing that the flight of the projectile increases in steadiness suggest the doubt whether General Maievsky has sufficiently considered these disproportionate rates of decrease in his investigations.

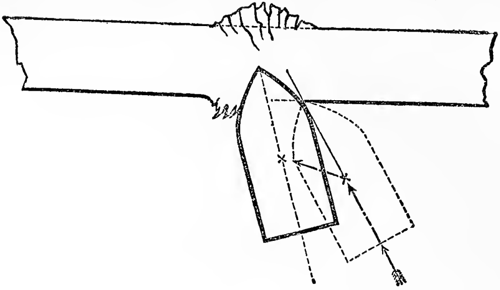
Mr. Mallet on Partial Penetration of Armour.

Mr. Mallet in his paper discusses the actual effects which are produced by various forms of projectiles in piercing armour, on the supposition that it is "a homogeneous plate of parallel thickness of a malleable material," which is *not completely penetrated* by a rigid projectile.

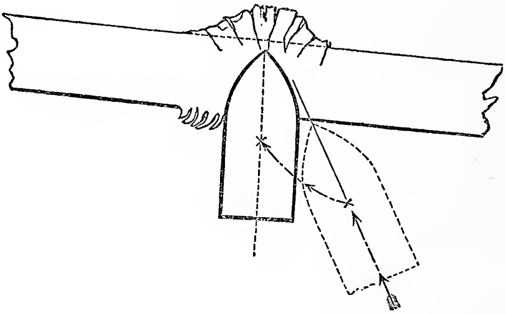
The greatest resistance is made by tough and moderately soft wrought-iron, but even this behaves as a more or less brittle body whenever the velocity of impact reaches about 560 ft. per second. The entrance of projectiles into armour, Mr. Mallet considers then as accompanied by a certain amount of direct fracture and a certain amount of lateral displacement, the metal behaving to some extent as a plastic and flexible body. The ogival form of head is specially adapted to perform this work effectually.

Probably the direct punching of the flat-headed shot compares better with the wedging open of the ogival head if the plates are *very hard.*

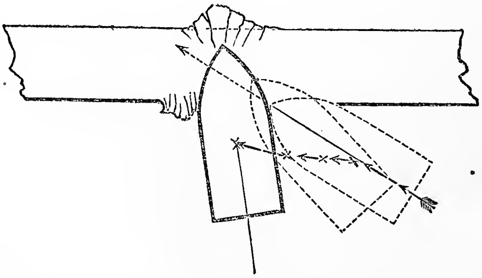
The cylindro-ogival shot, if the angle of incidence be greater than that made with the axis of the shot by a tangent to the curve of the head at the point, digs its point in at once and "the centre of gravity of the shot at the same time goes forward, turns round more readily at first than the flat-ended shot upon an equatorial axis, and slides in the direction of a line making an angle, more or less, towards the internal side of the face struck. The forward part of the shot thus cuts out and partly pushes before it, normally to the face towards which it slides, the plastically distorted part of the iron, and bulges or not the opposite face in an *umbo,* whose conditions are such as referred to in fig. below."



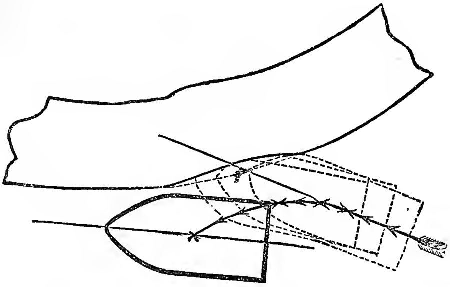
Mr. Mallet, however, considers that the shot of this form soon becomes *encastré* at its point as regards rotation in the plane of the figure, so that further rotation is prevented by the support at the left side of the head, and also near the point on the right side, the shot finally assuming the position shown in fig. following.



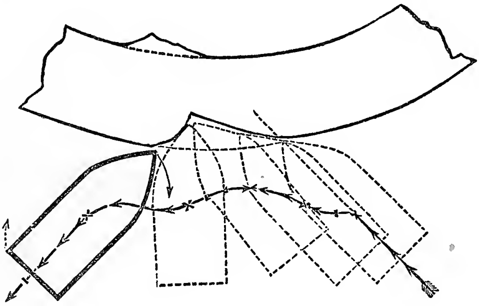
Mr. Mallet further considers that friction may even cause a shot of ogival form to turn, catch its point and penetrate when impinging on a target at an angle of incidence slightly less than that of a tangent to the ogival curve at the axis.



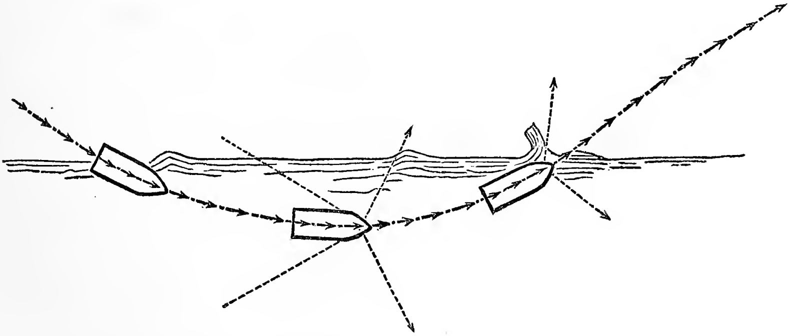
Passing on to the question of still more oblique impact as against convex plates, Mr. Mallet shows that the ogival-pointed shot may glance off *point first,* when there is not enough plastic distortion to hold the point,



and *base first* when the point is caught but not held.



Lastly, Mr. Mallet notices the conditions which cause a shot to ricochet on water (in spite of the slight tendency there is to turn downwards before the head becomes immersed, owing to the inequality of the resistances on the front of it), the coefficient of resistance being much less on the upper side.



Comparing the wave *AA* to that caused by an earthquake (*vide* the

"Engineer," 1867, January 4th, 11th, 18th, and 25th), I would ask you to observe the beauty of the effect of the *inelastic* medium water on the lower side pressing against the bottom and superincumbent mass, and on the upper side lifted in a wave, as shown in fig.

I conclude the ricochet will be repeated until the *difference* of the pressures caused by the resistance of the water against the lower half and upper half of the anterior surface of the projectile, which is a function of its velocity, becomes less than the vertical downward component of the shot.

To return to armour, it may be observed that the power of turning in instead of glancing off *point first* when striking on armour at an oblique angle increases with the radius of the circle with which the ogival head is described, inasmuch as the limiting angle of penetration is approximate to that made by the tangent to the ogival curve at the apex with the axis of the projectile, *i.e.*, the limiting angle of penetration with ogivals of various radii may be said to be approximately as follows :—

For 1 diameter	60°
" 1¼ "	53° 8′
" 1½ "	48° 12′

Captain Noble on Complete Penetration of Armour Plates.

In a report on the experiments relative to the penetration of armour plates by steel shot, printed in 1866, Captain W. H. Noble, R.A., discusses the means that exist of comparing the thickness of armour up to 4½ ins. of plate, pierced by various projectiles, and also of calculating the probable effect that may be expected from any projectile. He shows that the formula $\frac{WV^2}{2g}$ which he expresses in "foot tons," gives the "work" done by the shot on striking very correctly, whether of a light projectile with a high velocity, or a heavy one with a low velocity; further, he considers that penetration is in inverse proportion to the circumference of the shot.

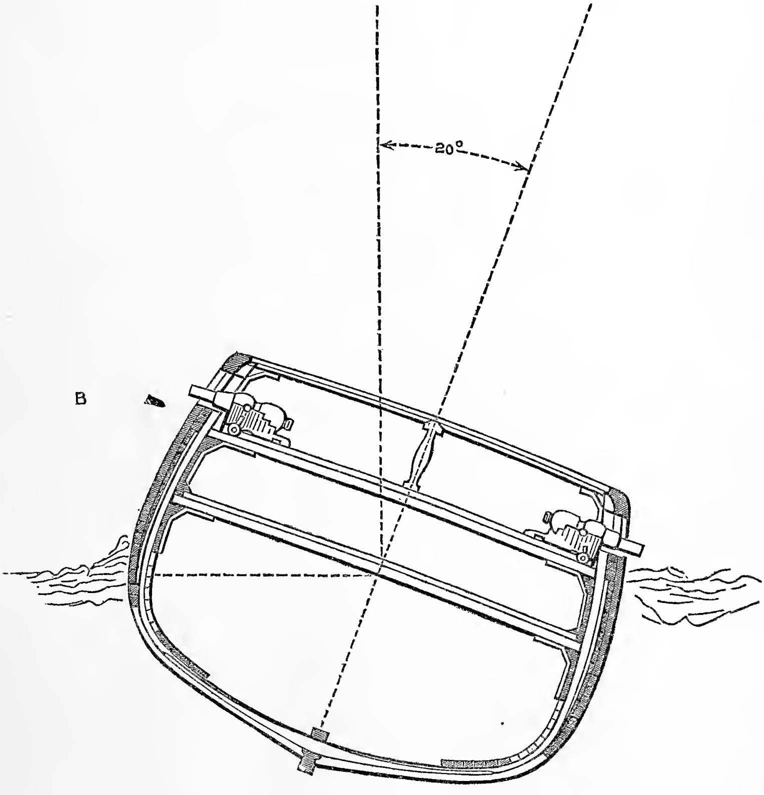
It must be observed that the calculation only applies to the question of complete perforation, when the plate may be supposed to be sheared along the line corresponding to the circumference of the projectile. This would be most nearly correct in the case of flat-headed shot.

To conclude with something more practical; Captain Noble considers, speaking roughly, that at 200 yds., 7-inch, 8-inch, and 9-inch projectiles may be expected to penetrate armour plates whose thickness does not exceed their respective diameters by more than 1 in.; *i.e.*, the 7-inch may pierce 8-inch armour, the 8-inch may pierce 9-inch armour, and the 9-inch shot, armour 10 ins. thick. The powers of projectiles of larger calibre are less thoroughly tried, but they appear to correspond generally to those of the smaller ones.

Following naturally on such matters comes the question as to the manner in which fire may be directed on a vessel in action with best effect.

Now here I am entering on the discussion of a subject which I do not understand. May we hope that some officer who has mastered it may give us his opinion? It is desirable that we should all know something about firing at ships—work which we, as well as the navy, might have to perform on service.

The old-fashioned method of fighting pursued by English ships (as far as I comprehend it) was by some means to get to windward of the enemy, and then engage hotly; the range in old days having been so short as to lead to the introduction of carronades, and afterwards having been extended (chiefly during our American war). Fighting from the windward side was I believe the same thing as getting that mysterious desideratum, the "weather gauge" of the enemy; it gave the power of closing to better advantage, and also, fighting as vessels then did under canvas, it frequently gave the opportunity of hitting a ship heeling over, "between wind and water," and making shot-holes which might prove dangerous leaks, especially when she changed her tack. (The fig. shows a cross section of the "Favourite"* at an angle of 20°, the side



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[*] Taken from "Fairbairn on Iron Ship-Building."

below *B* is between wind and water). I should think this can hardly be better illustrated than by Mr. Froude's account of the effect of our fire on the great ships of the Spanish Armada:—

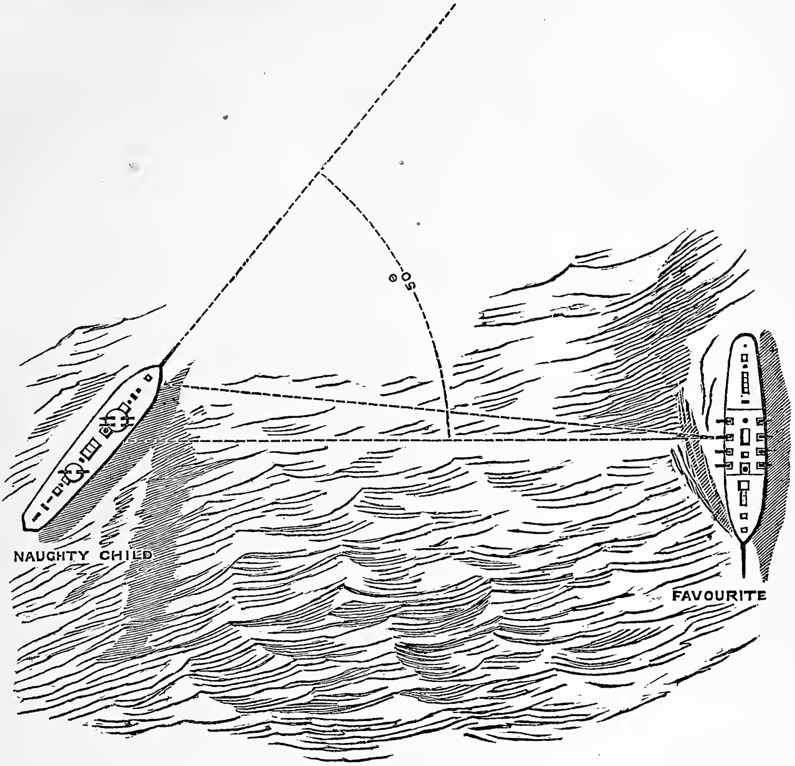
> "Being always to leeward and the wind blowing hard, the hulls of the galleons as they heeled over were exposed below the water-line. The massive timbers which were to have furnished so secure a shelter, added only to the effect of the shot. The middle decks were turned into slaughter-houses, and in one ship blood was seen streaming from the lee scuppers. Their guns were most of them dismounted, or knocked in pieces, and their chief work was to save themselves from sinking by nailing sheets of lead over the shot-holes."—Froude, Vol. VI. p. 481.

This plan of attack has done good service, but I believe its day has passed away, and that for more than one reason.

In endeavouring to learn the "soft places" of armour-plated vessels generally from the study of Mr. Reed's works on naval architecture, it is discouraging to find that the "vital parts," so to speak, are specially protected, and it seems peculiarly unlikely, unless the circumstances were very favourable, that one would succeed in seriously injuring a heavily-plated vessel along her water-line, about her engines, or even in her rudder or screw. The question then suggests itself as to the possibility of attacking a ship from the *leeward* side, and so obtaining an opportunity of striking her deck, which appears to be really a weak place; but this is met by the fact that vessels no longer fight under canvas, so that there is no *constant heel* on them, but all that remains is the *quick roll* of a vessel in a rough sea. Any chance so afforded would be offered alike by both ships, and I was informed by one of the gunnery lieutenants of the "Excellent" (Lieut. Dowding) that very little opportunity is so given. In fact on this matter I can add but little to the answer which was given me by an American naval captain whom I questioned as to where he considered one should endeavour to strike an armour-clad—"You must hit her where you can!"

When I say little is to be added to this, I would remark that a vessel in most positions presents some part of her armour nearly at right angles to one's fire, even when other portions may be at a considerable inclination. Failing a more definite object, would it not be well to aim at this part, whether near bows, stern, or midships?

So it occurs to the mind that a vessel in action might with advantage engage so as to fire her guns at an oblique angle with her keel (as shown in fig. below in the position of the "Naughty Child.") Further, she might change her position so as to turn away a damaged part of her armour; only in a rough sea it may be harder to take good aim when thus engaging obliquely, because the *line* as well as the *elevation* would alter with the roll of the ship. In the fig. below it may be seen that while the "Favourite" receives all the fire of the "Naughty Child" direct on her sides, the latter is so placed than unless the "Favourite" strikes her near her bows the shot are received at an angle of 50°, so that penetration seems out of the question; and it may be observed how little, comparatively speaking, a vessel will appear to be foreshortened



when thus turned to the glancing angle of service projectiles. Here however I am getting beyond my province, so I will now come to our siege and field equipments, considering the former to consist of 64 and 40-pr. B.L. guns, and the latter of 20, 12, and 9-pr. B.L. and 9-pr. M.L. guns. The 7-inch B.L. is rather hard to classify; I need not however notice it beyond mentioning that it fires the same projectiles as the 64-pr. Besides these there is a 16-pr. proposed as a heavy field gun, and there is also our 7-pr. mountain equipment, all firing—

Common shell,	Segment shell,
Boxer shrapnel shell,	Case shot,

except the 9 and 7-pr. M.L., which have no segment shell, and the 20-pr., which for some reason has as yet no shrapnel. The 40 and 20-pr. still have solid shot also, and the 7-pr. a double shell.

The time fuzes for service generally are the 5 secs. and 9 secs. M.L.O. fuzes for the muzzle-loaders, except the 7-pr., which has a special gauge fuze hole and set of fuzes which I trust are shortly to be abolished.* The

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* Abolition since ordered to be carried out.

5, 9, and 20 secs. B.L.R.O. fuzes are used for the breech-loaders. As to percussion fuzes for B.L. field service, the one that has come in and is now issued is the original pattern of Armstrong fuze with the phosphorus composition replaced by cap composition, which in the form of a cap as proposed by Colonel Milward, is much more reliable than its predecessors. This is of the pattern which is dropped into the B.L. segment and common shell, being used beneath the screw plug; the *E* and *F* time fuzes being called in from land service equipments but not from the navy, so that the segment and common shell for boat service are fired as formerly with time and percussion fuzes, but for land service with percussion fuzes and screw plugs. But this arrangement sometimes leaves a little play so as to allow the fuze to rattle; to obviate this, therefore (which might cause premature explosion), a lead disc is served out to field batteries to press home into the bottom of each segment shell, the burster being replaced in the shell over it. The use of time and percussion fuzes *together* in segment shells I believe is a mistake, and it has led to misconception. It may be seen by anyone who cares to analyse results that all the success of shells so fired has been due to those which were burst by the *percussion* fuzes, in fact for good effect segment shell should be burst within a very few yards of the object. No time fuze can be set accurately enough to effect this, and hence it commonly either spoils the effect by opening the shell too soon, or else simply plays the part of a plug.

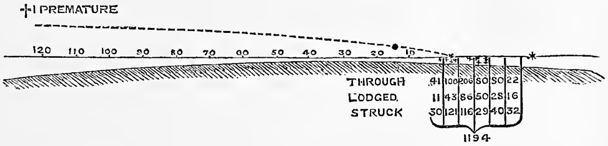
A screw pattern of "cap" percussion fuze is likely to come in for field service shells, with the general service gauge fuze hole, which I shall notice presently.

The segment and common shell remain unchanged, except that the sockets in the common shell have been found too weak, and are being replaced by sockets of a stronger pattern. Shrapnel shell of the pattern used at Dartmoor and elsewhere experimentally have been since introduced into the service equipments.

Again we are brought face to face with the question of what shell to use in the field, considering the results obtained at Aldershot and those of the gigantic trials in actual service in the French and Prussian war. It is impossible to ignore the great results achieved by the Prussian artillery fire, but what conclusion do they justify? If we take the Prussian view of the matter, apparently to the adoption of common shells with percussion fuzes for the chief projectiles used in the field; so that whereas last year after Dartmoor the decision had still to be made between segment and shrapnel, we this year have competing with them, common shell fired with percussion fuzes.

It is well, then, first to see on what grounds the common shell, which *we* have found to be so inferior in effect on the *personnel* of an enemy, is to be preferred, and chiefly what results have been obtained with it. The most striking I believe were those produced at Sedan, where we read of appalling havoc; that the dead lay in heaps, and that the ground was covered with men blown into "masses of flesh and rags." This result was no doubt produced by common shells fired with percussion fuzes; in fact it is needless to quote the Prussian report on this matter, for nothing else would effect this result. Some officers here may remember a heap of Russian dead precisely in this condition close to the salient of the Redan at the fall of Sebastopol, who no doubt had been mangled by common shells burst close to them (a common shell with a *time fuze* occasionally but not frequently acting in this way). Colonel Enderly Gordon informs me that at Inkerman a soldier near him was blown into the air, and fell such a mass of flesh and blue cloth that he was unable to pronounce whether the man was a Turk or a gunner.

Then comes the question, is it necessary to blow an enemy into flesh and rags? Is it even desirable? The moral effect is no doubt considerable on those who are *close* to a man so mutilated, and moral effect is something; but common sense tells us that each human body so torn asunder represents a large share of the power of a shell, and the choice consequently seems to lie between killing or wounding perhaps a dozen men with bullets, and blowing one or two into fragments. It will no doubt be urged that the *number* destroyed by the Prussians in the time was very great; but to this may be answered that the circumstances were exceptional, and when the conditions on active service, as in this case, at all approach those of ordinary practice firing, the slaughter must always be frightful. The range at Sedan probably varied little during the day, the ground was hard, the men were in close formation, the fire was converging. We might discharge any kind of projectile into masses of men penned up in a corner, with great confidence in being able to kill large numbers.



May I again show you the diagram which represents the fifteen best rounds of segment fired at Dartmoor at targets representing a regiment in column partly concealed behind the crest of a hill? 1194 hits were produced! At this rate, each field battery would annihilate an entire infantry regiment in about a minute and a half; but continue the fire at half that rate, and the bare conception of each field battery killing or wounding 20,000 men per hour, is enough to show us that it is only necessary on service to approach the conditions of practice with segment or shrapnel, to cause results such as we may well hope we may never see. I suppose we can hardly look forward to a time when we shall disable an enemy so skilfully that we come to look on it as an awkward mistake when we kill men, but still there seems something savage in revelling in the idea of not only disabling men but also blowing them into fragments. The natural feeling of dislike to mutilate our fellow-creatures may seem to savour more of sentiment than real humanity, but still I think humanity is in favour of striking men rapidly with shrapnel bullets rather than blowing them to pieces slowly and tediously with common shell, especially as in the latter case it is possible that the battle may last longer; but at all events, looking at the result as "work done," the former appears decidedly to be in the more profitable shape.

The Prussian common shells and percussion fuzes are I believe not doing so well this winter, and it is not wonderful; even ploughed fields may become hard in the sun, but battles may be fought, like Waterloo, under circumstances which would render it very doubtful if percussion fuzes would act at all. If we are to imitate the Prussians, let it be in the way in which they form their own conclusions, and when well founded, hold to them in spite of the opinions of other nations (as for example in their adoption of the needle gun), rather than in the servile copy of what *we* have proved to be bad.

Since writing the above, Captain Majendie has informed me of the news that the Prussians are dissatisfied with their common shells and percussion fuzes, and are endeavouring to get a supply of shrapnel and time fuzes. This, however, can hardly be said to affect our decision in this matter, for we have worked this question out for ourselves in a way that may be relied on. Supposing then that the choice lies between the segment with its wide-spread and telling action on graze or impact, and the shrapnel with its close cone of dispersion and great penetration, so admirably suited to time fuzes; are we to take both, or which of the two? This is still a matter open to speculation and opinion, but I hope there may yet be found a satisfactory solution. The wide spread is desirable for action on impact or graze, the close cone for bursting in the air. Can the same shell be made to act in both ways? It hardly appears probable that the segment could be made to open with the close prolonged action of the shrapnel in the air, but is it not evident that the immediate wide dispersion so desirable on graze might be given to the shrapnel by simply inserting a second bursting charge in the socket beneath the percussion fuze, which, with it, would be removed when a time fuze was to be used, so that the design and action of the shell in its own way would not be interfered with. I proposed this before the Aldershot trial took place, and some time since Mr. Forest brought it forward, using a tin burster to contain the powder, and it has given good results.

It appears also that the advantage of great speed in action may be obtained by carrying the shell with a percussion fuze and bursting charge in a tin burster beneath it. This is fired as quickly as a shot, for it is only necessary for the man bringing it up to the gun to pull out the safety pin, which in the form of fuze now brought forward by Colonel Milward is clear above the apex of the shell.

Should an officer consider he can fire time fuzes with advantage, the screw percussion fuze and burster may be nearly as quickly removed as a screw plug.

Does it not appear that we might under these circumstances depend mainly on Boxer shrapnel supported with case shot and a few common shell; and thus, while fully owning what the segment has taught us, make the shrapnel perform duty for it in the way just described?

As to case shot, there is a much better pattern likely to come in for the 9-pr., containing lead and antimony balls packed in clay and sand, which seems to travel well and give remarkably good results.

I believe Colonel Wray has chiefly worked out this question, with some suggestions of Mr. Widgery, a foreman in the Royal Laboratory.

Mitrailleuses.

It is impossible here to do more than notice the probable powers of the mitrailleuse in general and the part it plays in the field. In order to do this we must know the ammunition it is to fire. Should it be decided to employ with it the same ammunition as the infantry, its powers become very limited, and its place easily defined; its extended use with *heavier ammunition* need not now be discussed, for it appears that the authorities have decided on the lighter nature for our service. We may say then, since it is obviously unsuitable for firing at skirmishers, and cannot injure *matériel*, that its work must be limited to firing on *masses of men within rifle range.* When will it have the opportunity of doing this? Chiefly we may suppose in the defence of bridges, breaches, and whenever it can be masked and brought to bear suddenly on bodies of men, or when it can be specially protected by cover: for it clearly cannot be expected to work generally with skirmishers in an open field, for its men or horses would be killed, its limited range making it impossible for it to work from artillery positions.

Thus I think it will appear:

1st., that the mitrailleuse is decidedly adapted for defence rather than attack, speaking generally.

And 2ndly, that it is specially adapted for a closed country rather than an open one.

Hence it is an arm that England, of all nations, should adopt; we may expect before long to find it taken up by the volunteer corps.

The fire of mitrailleuses compares best with that of guns at long case or short shrapnel ranges (say between 200 and 700 yds.)

The skilful disposition of mitrailleuses is a kindred science with (but must not be supposed to be the same as) the handling of field artillery.

Rockets.

If time permitted, much that is interesting might be said about rockets; just at present they are not in a satisfactory condition. Sir W. Congreve introduced them for incendiary purposes, but shell rockets have been condemned and carcass rockets have dropped out of the service almost unperceived, yet these were Sir William's special favourites.

It surely cannot be thought satisfactory to use rockets which, if fired at much beyond half the full range of the old Congreve, fall dead with no more incendiary power and nothing like the striking force of a shot. Again, though Hale's principle is good, the accuracy is now nothing to boast of; and here I may notice a very curious fact as to ranges of Hale's rockets fired in different winds. Captain Majendie advised me to classify results according to the direction of the wind, and in doing so it appears that the average range of Hale's rockets during the year

1870, fired with the wind blowing across the range from right to left, is half again what it is when the wind is blowing from left to right. This may be a coincidence, but if so it is a very remarkable one, for not only is it arrived at by the comparison of a large number of rounds, but the maximum and minimum as well as the mean range obtained in each wind conform to the apparent rule. Mr. Forest informs me he should have expected this result, or at all events a tendency to it, from the direction of the rocket's rotation; and certainly when it is remembered that the velocity of rotation is very rapid and that of translation comparatively slow, it seems quite reasonable to suppose that the greater pressure of air against the side turning rapidly *upwards* tends to make the rocket as it were roll itself downwards; but the matter needs investigation. It is, I am glad to say, proposed to introduce carcass rockets again, so as to restore to the rocket its incendiary power.

I might notice that there have been manufacturing difficulties which have caused large numbers of the war and life-saving rockets issued to the service to fail. Such difficulties are it is hoped now overcome, and the old store is being replaced by rockets of stronger and sounder make.

I believe our rocket system is capable of great improvement. Let no one suppose that we have solved the problem of how to discharge rockets satisfactorily. My own private opinion on this matter is that we have been beating about without a sufficiently definite object. We have adopted troughs for our land service machines. Now, since a rocket discharges itself feebly from a trough as compared with a tube, it must be supposed that the recommendations of a trough are simplicity and non-liability to foul. As to simplicity, although one trough may discharge more than one size of rocket, for the rockets we have decided to retain in the service—viz. the 24-pr. and 9-pr. for land service, and the 24-pr. for sea service—we have two sizes of trough and one tube; it would be difficult to have *more;* and as to fouling, it is quite a question whether even a foul tube would discharge a rocket in a worse manner than a clean trough. In Abyssinia a tube was used which was sponged and acted excellently.

Then the method of giving elevation is absolutely false, both for the land and sea service machines. Its recommendation appears to be simplicity. Is it to be wondered at that Mr. Hale should have protested against the trough and present method of treating his rockets, which Major Geary aptly terms looking on them as "some sort of dangerous wild beast?"

Do I greatly exaggerate if I say that the most successful performance expected with the service rocket appears to be to discharge it without bursting charge, without incendiary power, without a fair force of propulsion, with much less range than the old Congreve, without any particular aim, and with a false elevation? In fact we are reminded of the sailor at Sebastopol who fired a shot from a gun, sunk in a pit, at 45° elevation, and who, as it went far beyond his ken, complacently remarked that it had gone "somewhere into Rooshia."

I will close the subject of war rockets by mentioning that the navy (so Lieut. Dowding informs me) have sometimes obtained enormous range and power by closing the rear of a rocket tube. This seems reasonable but decidedly dangerous; but it might I think be interesting to try how the 9-pr. Hale rocket propels itself out of a gun—the 12-pr. B.L. at a high angle might be very suitable. The rocket should have some quick match fagoted in its vent, and then might be entered in the gun and the latter fired by a friction tube in the vent-piece in the usual way (no cartridge of course being used). It must however be clearly borne in mind that this can never be more than a possible expedient, for if rockets were habitually discharged from guns instead of light tubes, &c., the chief advantage that led to their introduction would be sacrificed, to say nothing of the injury that might be caused to the rifling of the gun.

Life-Saving Rockets.

The science of communicating with ships in distress is a very interesting one, and there must be something very satisfactory in having to employ science to save life, but I am only calling your attention to-day to the curious conditions of flight of the rocket. The stick is placed on one side, hence the centre of gravity and centre of resistance are not opposite to each other, and we have Maievsky's question of spiral flight again, the arrow-like action of the stick being the steadying power corresponding to the rotation of the projectile, and tending to keep the point to the front; but the flight would be very bad and unsteady were it not for the pull of the line which the rocket carries; indeed it would fly so badly as to be nearly worthless. I believe more use might be made of the pull of the line, and possibly the rocket might carry without either stick or rotation by its means, and so it might be fired in a more advantageous way than at present.

One thing should be specially noticed—viz. the great importance of taking advantage of any momentary lull to get the rocket off in a true direction, for the pull of the line soon acquires great force and tends to draw the axis of the rocket into the line of flight it has up to that time taken; thus it causes the rocket's gas to propel it into the *prolongation* of the same line; hence the importance of its *commencing* on the true direction.

I have now touched on a great many points, and have certainly done justice to none. It might have been more satisfactory to myself to have spent the time on one subject, but I think that it must be more generally *useful* to notice the features of our equipment as a whole than to deal more fully with one or two questions, although the latter proceeding might be the more interesting one.

At the conclusion of the reading, which was much applauded—

Colonel SMYTHE invited discussion, saying that Captain Browne would be happy to answer any questions which might be put to him.

Colonel PHILLPOTTS, R.H.A., asked how long the serge bags for holding the bursting charges in shells had been introduced?

Captain Browne replied that they were first adopted some months ago.

Captain E. H. Cameron, R.A., said the lecturer had quoted from Captain Noble as to the penetration of an ogival-headed shot into armour being estimated at one inch in excess of its diameter. He wished to enquire if that law applied to chilled shot only?

Captain Browne answered that it applied to chilled shot or steel, which was nearly as good.

Major Campbell, R.A., said he had not exactly understood the lecturer's remarks as to the objections against time fuzes.

Captain Browne said the principal objection to time fuzes with segment shell was that they could not be set so accurately as to make sure of that shell being effective; and the chances were a hundred to one that the round was spoilt. If they could set the fuze so that it exploded the segment shell at 10 yds. from the object, the effect would be good, but if 50 yds. in advance or 50 yds. beyond it would be bad; and the fuze was much more likely to operate 50 yds. away than close to the target. In fact, in firing time fuzes, every alternate shell would probably burst 50 yds. in front, and every other shell would go through the target like a mere shot. In the Dartmoor trials, officers were perfectly aware of this peculiarity, their intelligence being actually in advance of their morals—(a laugh)—for they purposely set their time fuzes long, so as to give the shells their percussion action against the target. They fired in fact with percussion fuzes, while the shell had the credit of acting with time fuzes.

Major Campbell.—Then you would reject the time fuze altogether?

Captain Browne.—With *segment shell.*

Captain Majendie, R.A., Assistant Superintendent Royal Laboratory, said it might interest some officers to know that the experiments to test the relative advantages of segment and shrapnel shells, used with percussion fuzes in the manner described by Captain Browne, would take place next day at Shoeburyness. It was, he considered, an experiment of very great importance; for, as Captain Browne had justly said, there was a greater necessity for getting rid of their surplus material and simplifying their equipment, than there was of new inventions. As to the merits of the two systems, his own opinion was that the shrapnel shell, fitted with a fuze which burst on graze, was so little inferior in effect to the segment burst in the same way, that he very much questioned whether, for the sake of such a slight difference, which would hardly be sensible at all on service, they ought to maintain the two shells. (Hear, hear.) He knew there were officers who could see no objection to having two, three, or any number of different kinds of projectiles with the gun, but he held complication and multiplicity of projectiles to be a valid and practical objection, and he hoped the results of these experiments would show that the shrapnel shell, with a percussion fuze, was practically able to answer all the purposes of the segment, while as a time shell the shrapnel was admitted to be very superior. Another thing might be said of the shrapnel: that although its want of quick scattering effect might be disadvantageous when burst very close to an object, if it burst 50 yds. in front of the object, that action was rather an advantage than otherwise; but with the segment shell, if it burst 50 yds. in front, the round was almost thrown away. These, however, were points still under discussion, and soon to be put to the test. Some objectors argued that segment shells were better than shrapnel against *matériel*—an advantage which he could certainly not appreciate. What *matériel* did they mean? They would surely not fire either one or the other shell against a house; and if they did, one would be of just as much or as little use as the other. It was said that the segment was better for cutting away the branches of *abattis*, but it was not the segments with which the shell was charged, which only cut the twigs, by which an effective destruction was caused, but the body of the shell itself which cut away the big branches; and the same could be said of stockades—one shell would do for such a purpose as well as the other.

In analysing that objection, he was therefore unable to know what *matériel* was meant. Did it mean gun carriages? If so, they could be cut up by the body of either projectile; but there was no such real, substantial, or considerable advantage on the side of the segment shell as would warrant its retention as a separate projectile. (Applause).

Captain **Strange**, R.A., said that in spite of the opprobrium cast upon inventors or anyone who introduced anything new, he would ask Captain Browne whether he did not think it was desirable to have a percussion fuze for the siege ordnance; and, again, whether they had a good reliable percussion fuze which would act on newly turned earth? He knew they had the Pettman fuze, both for land and sea service, but that required the resistance of 8 ins. of oak to make it act, and as they were not likely to have wooden ships to fight against, nor wooden fortifications, he did not see much virtue in a test like that. (Applause).

Captain **Browne** replied that beyond doubt the seige equipment was in a peculiar position. He would especially notice that there was no fuze adapted for graze with heavy projectiles, but he considered that the *C* percussion screw fuze, if introduced, would answer for large as well as small shells. Another peculiarity which he observed in the siege equipment was, that they used a *segment* shell with a *time fuze* or a *Pettman general service percussion fuze*. Now, the time fuze they could only set at ranges 135 yds. apart, which would be quite unsuitable for the action of segment shell. They had no fuze to act on graze with such a shell, and the only use he could see for it was to drive troops out of a building. The wood fuzes and the Pettman percussion fuzes would sometimes go off on impact against earth, but he did not know whether they would be effectual against *newly turned* earth; so that there might be a want in that respect at present, as well as in the matter of action on graze. Both wants he believed would be met by the screw percussion fuze, if introduced.

Captain **Strange** added, that in firing at batteries armed with unserviceable guns, as they did at Shoeburyness, they found that the ordinary Boxer wood time fuze was driven in on striking a gun or platform, and acted as a percussion fuze, but would not explode on the newly turned earth of the exterior slope of the battery; and earthwork was mostly what we would have to fire at.

Captain **Majendie** said that Mr. Pettman had anticipated the want spoken of by Captain Strange, by a plan for rendering his land service fuze more sensitive, and the suggestion had been officially put forward by Mr. Pettman. As to the proof of the Pettman land service fuze, he might say that they did not now fire them at oak butts, but at sand bags, and that the result was quite satisfactory. It must be admitted, however, that they would not burst on graze, and in that respect they were capable of improvement. But if a very sensitive percussion fuze to burst on graze were required with our heavy guns, the *C* cap percussion fuze, with its outer case screwed to fit the general service fuze hole, would no doubt answer all our requirements.

Major **Geary**, R.A., said: One sentiment of the lecturer's he cordially re-echoed —viz. that we should so rely upon our own ingenuity as not hurriedly to adopt every novelty exhibited by foreign powers. It was to be regretted that this feeling of confidence was not more general. Those who had read the newspaper correspondents' accounts of the battle of Sedan, and notably that of Dr. Russell, would remember how graphically the effect of the Prussian shells had been described—blowing men to atoms, &c., &c. From thence the deduction had been made that this country should introduce a similar projectile. It had, however, transpired since, that the Prussians had had recourse to this shell with a percussion fuze simply from their want of segment shell or of shrapnel shell with time fuzes—a deficiency they are now strenuously endeavouring to make good. With the tables before them of the practice carried on at Dartmoor, together with the estimate made by Captain Browne as to the number of men which a battery might be expected to put *hors de combat* in an hour, he apprehended that no more destructive effects against troops could be desired; so that for that purpose a larger shell than the 12-pr. now in the service would appear to be unnecessary. He admitted that it might be desirable in the attack of an entrenched position; but could not guns of position, whether 16, 20, or even 40-prs., be brought up during the time occupied necessarily by the general in reconnoitring and making his dispositions for the attack? As England was already, as regards shells, in a superior position to any foreign power, he deprecated more heavily arming the ordinary field batteries for the sake of a larger shell. At a recent lecture delivered in this Institution by Lieut. Jones, many officers had been somewhat alarmed to hear that the proposed 16-pr. would bring into the field only 100 rounds per gun; and it appeared that in repelling the last sortie from Paris, the Prussians had twice sent to the rear the caissons of their field batteries to be replenished. Being on their own ground, as it were, this had not much signified; but he put it to the meeting, how great would have been the inconvenience under any other circumstances, or to use an Americanism, in the case of a free fight. He submitted that the adoption of a larger shell for field batteries, involving as it did a heavier gun and a reduced complement of ammunition, was a matter demanding very grave consideration.

Lieut. JONES, R.A., said that Major Geary had referred to his lecture on Field Artillery, and seemed to think that if 100 rounds was all that could be conveniently carried with the 16-pr. gun, it would be far too little. Why he (Lieut. Jones) advocated the larger shell was, because he considered that at long ranges it would be far superior to the smaller one, and that, consequently, fewer rounds would do more work. (Hear, hear.) Practically he believed it would overthrow the smaller and less powerful artillery; for though the latter might carry a larger number of rounds, it would never have the opportunity of letting them off.

Lieut. SLADEN, R.A., said he proposed in a lecture about a fortnight hence to go fully into the question of equipment, in the hope that it might be properly ventilated, and decided once for all what weight of projectile could be carried in the limbers of a field battery; and (having due regard to mobility) the heavier that projectile was the better. (Applause).

The discussion being ended,

Colonel SMYTHE returned thanks in the name of the officers present to Captain Browne for his interesting and instructive lecture, and the proceedings terminated.

THE DETERMINATION
OF
THE EXPLOSIVE FORCE OF GUNPOWDER.

A PAPER READ AT THE R.A. INSTITUTION, WOOLWICH, MARCH 15, 1871,

BY

CAPTAIN J. P. MORGAN, R.A.

COLONEL W. J. SMYTHE, R.A., F.R.S., IN THE CHAIR.

THIS subject has been investigated by some very able men, both theoretically and practically; but though the facts thus elicited are very valuable, the conclusions which have been derived from them are not sufficiently harmonious to warrant us in believing that the question has been completely solved.

I. WHAT HAS BEEN DONE.

1. *Theoretically.*

The explosive force of gunpowder may be calculated from the products of combustion, on the assumption that certain laws hold good, such as that the tension of a gas varies with its density and also with its temperature. It must, however, be borne in mind that these laws have been verified only within certain limits of pressure and temperature, and, therefore, when we come to such very great pressures and temperatures as are met with in the explosion of gunpowder, any conclusions founded on them must be received with caution until the results have been confirmed by experiment.

Robins, about the middle of last century, endeavoured to calculate the force of gunpowder from the amount of elastic fluid produced. He found that the gaseous products would occupy 244 times the bulk of the powder, at the temperature and pressure of the atmosphere. If this amount of gas were confined in a space of the same size as that occupied by the powder, the pressure would be 244 atmospheres, without making any allowance for the enormously increased temperature at the moment of combustion. By heating a piece of musket barrel to "the extremest degree of red hot iron"—his assumed temperature of exploded gunpowder—and cooling it in water with certain precautions, he found that the heated air it contained contracted to one-fourth of its bulk, and concluded that the increase of heat increased the elastic force of the gases fourfold. Thus the 244 volumes of gas at the temperature referred to would possess an elastic force of 1000 atmospheres, or 6·7 tons per square inch.

Gay-Lussac obtained 450 volumes of gas, and, estimating the temperature at 1000° C., deduced a pressure of 2137 atmospheres (14·3 tons).

Piobert accepted Gay-Lussac's determination of the quantity of gas produced, but estimated the temperature at 2400° C., and thus deduced a pressure of between 4000 and 5000 atmospheres for the permanent gases alone. Counting the other products, which at this temperature he considered would be in a state of vapour at a high tension, he estimated the total pressure at 9600 atmospheres (64 tons).

With regard to the solid products, he says:—*

"There thus exist two very distinct periods during the continuance of the phenomenon of explosion; the first during which the products are in the state of elastic fluids, the tension of the vapours adding themselves to those of the permanent gases; and the second period during which the permanent gases alone act, the vapours being condensed, and forming those residues of combustion termed 'crasse,' and which deposit themselves on the sides of the chamber in which the powder is shut up, because these products have not been able to escape during the time they were in the gaseous state.

"The explosion of powder may thus present great anomalies in the effects produced from one point of action to another, when the elastic fluids act only during the first period, which is that of greatest effort, and this should be taken into consideration every time the circumstances of firing do not remain identically the same; also the force of powder measured during this period has given rise to a great many valuations very different from one another. When, on the contrary, the force of the powder is measured after these effects, during the second period, it is estimated at much less than it is in reality, because in this case no account is taken of the tension of the vapours which no longer exist."

Bunsen and Schischkoff obtained 193·1 volumes of gas, the production of which was attended by the development of 619·5 units of heat, and from this, taken in conjunction with the known capacities for heat of the products, they concluded that the temperature of the flame of powder, exploded in a closed space so that the gases cannot freely expand, is 3340° C. With regard to the residue, they say:—†

"Although a slight volatilisation cannot be denied, it may be shown from the calculation of the temperature of the flame that the tension caused thereby cannot amount to one atmosphere. The temperature of the flame of hydrogen burning in air is 3259° C. A fragment of powder residue fused on a thin platinum wire was gradually volatilised in a jet of hydrogen burning in air, but it never reached ebullition, and hence the tension of its vapour could never have attained one atmosphere."

They conclude that the pressure can never reach 4500 atmospheres (30 tons).

Mr. Abel‡ remarks:—

"The conclusions to which Bunsen and Schischkoff have been led by their elaborate investigation of the products of decomposition of gunpowder are, in the

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* "Traité d'Artillerie théorique et pratique."

† "Occasional Papers, R.A. Institution," p. 310.

‡ Chemist to the War Department.

most important respects, so greatly at variance with the views hitherto adopted respecting the general nature of the chemical changes involved in the explosion of gunpowder, and consequently, with reference to the several conditions which influence the degree of force exerted by the explosion, that all who are interested in the considerations embraced in the research of these chemists, will be inclined to scrutinise closely the means by which they have arrived at their results before accepting them as likely to represent correctly the effects obtained by the employment of gunpowder in practice."

Their errors lie in their supposing that the products they obtained are the same as exist in the gun during the time of maximum effect. The solid residue, which forms about two-thirds of the total charge, is mainly carbonate and sulphate of potash. Mr. Bloxam* informs me that, from the appearance of this residue after deposition, he is decidedly of opinion that it has been deposited from the gaseous state. Further on we shall see that Rumford's experiments support this view. We are therefore at liberty to assume with Piobert that there are two actions, one during the time of greatest heat and pressure, and one afterwards. We may even go further than Piobert, and suppose that the solid products are not only in the gaseous state, but to a certain extent decomposed by the high temperature, in accordance with a chemical law, of which there are numerous examples, such as the decomposition of carbonic acid into carbonic oxide and oxygen at a high temperature, or of water into hydrogen and oxygen by the heat of the electric spark.

Keeping these considerations in view, I have prepared a formula which appears to be a very reasonable one. In the opinion of Professor Bloxam, to whom I have submitted it, we know so little of the effects of such extremely high temperatures upon the substances remaining after the explosion of powder, that the supposition is as allowable as any other. It is this:—

English powder, with one-quarter per cent. less nitre, gives an exact chemical formula which we may suppose to decompose thus:—

$$6\,(KO,NO_5) + 20\,C + 5\,S = 20\,CO + 5\,SO_2 + 6\,KO + 6\,N.$$

The method of calculating the amount of gas produced, with the temperature and resulting pressure, is as follows:—

Constituents.	Units of heat evolved.	Products.	Volumes of 23·3 cub. in.	Weight in grains.	Specific heat.	Units of heat required to raise 1° C.
20 C	297720	20 CO	40	280	·174	48·72
5 S	176000	5 SO_2	10	160	·11	17·6
6 (KO,NO_5) ...	...	6 N	12	84	·174	14·616
		6 KO		282	·174 ?	49·068
	473720		62	806		130

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* Professor of Chemistry, King's College, London, Advanced Class of Artillery Officers, &c., &c.

Thus 806 grains of powder produce 62 volumes or 1444·6 cubic inches of gas at 0° C., and 1 atmosphere pressure; and, consequently, 1 cubic inch, or 240 grains, will produce 430 cubic inches of gas at the same temperature and pressure. The temperature of the products occupying 430 times the powder space will be $\frac{473720}{130} = 3644°$ C., and the pressure, supposing the solid potash to occupy one-third and the gases two-thirds of the powder space, will be $= \frac{3}{2} \times 430\ (1 + \cdot 00366 \times 3644) = 9250$ atmospheres, or 62 tons per square inch.

Exception may be taken that no heat is here allowed for the decomposition of the nitre, nor for the latent heat of the gases evolved from it. But I may observe that, in all compounds containing nitrogen, the elements are very readily decomposed, and in some cases, such as nitrous oxide, heat is actually evolved by the separation of the atoms. The units of heat were obtained by Bunsen and Schischkoff with the gases expanded and much latent heat absorbed; but, in passing from the liquid to the gaseous state under great pressure, the law has been established that no latent heat is absorbed, and *vice versâ*. We may therefore consider the temperature arrived at as not very different from that which exists at the moment of explosion, for any absorption of heat by decomposition would probably be more than counterbalanced by the heat which would be evolved if we were to reduce the 430 volumes to $\frac{2}{3}$ of a volume.

It is possible that the temperature may even be higher, and the pressure deduced is by no means the limit which might be attained, but is rather to be considered a minimum than a maximum, seeing that the products may be in a still further state of decomposition than has been assumed; for it is well known that at a high temperature carbon will reduce potassa; the tendency also of potassium to pass into vapour is well known. It is possible therefore that in the presence of carbonic oxide, and at such a temperature, the elasticity of the two vapours of potassium and oxygen may be sufficient to cause decomposition, and thus we should have all the products in the state of vapour with a corresponding augmentation of pressure.

This is not at all unlikely, for in the cases of gun-cotton and nitroglycerine, the products of decomposition are much more dissociated by being exploded in a confined space than when burned in the air. In their case the products, being carbonic acid, carbonic oxide, nitrogen, and aqueous vapour, have no tendency to reunite, and can be recovered in the very state in which they were at the time of maximum pressure; but, in the case of gunpowder, one of the products is potassium or potassa, whose strong basic attraction causes recombination, so that none of the other products, nitrogen only excepted, can remain free until it is satiated.

These considerations show, almost with absolute certainty, that the products obtained by the combustion of powder are not the same as exist in the gun during the time of greatest action; and we thus get rid of a difficulty which would tend to prevent our accepting the high pressures which we shall see are obtained by experiment.

Another consideration in favour of a possible high pressure is the limit to which the laws applicable to gases can be carried. At some point the liquid form would be assumed; and, though with low temperatures the increment of pressure diminishes as the liquid form is approached, the same does not appear to hold good as the temperature is increased. Carbonic acid gas, so far as is known, cannot be liquefied above 80° F. With high temperatures the pressure may increase very greatly when the density is great. It may even approach the law of water pressure, which we know increases enormously with a small diminution of bulk. Thus even theoretically, the pressure may attain an amount which it would be impossible for us to restrain with all the appliances at our command.

It is necessary that we should have clear ideas on this point, as we shall see it is the slowness and regularity of the combustion of gunpowder that are the elements which make it possible to utilise its enormous pressure and keep it under control; and, to be of any practical use to us, even were we to know exactly what are the products of combustion, we must also know

The Rate of Combustion.

Robins made a very ingenious experiment to determine whether the explosion of gunpowder was instantaneous or not. He says :—*

> "If part only of the powder is fired, and that successively, then, by laying a larger weight before the charge (suppose two or three bullets instead of one) a greater quantity of powder will necessarily be fired, since a heavier weight would be a longer time in passing through the barrel. Whence it would follow that two or three bullets would be impelled with a much greater force than one only. But the contrary of this appears by experiment; for, firing two and three bullets laid contiguous to each other with the same charge respectively, I have found that their velocities were not much different from the reciprocal of their sub-duplicates of matter."

Though Robins, in accordance with his deductions of a small initial pressure, might have been prepared to accept the result he here states, yet others, who knew that his estimate was much too low, could not accept his conclusion, seeing that, if gunpowder were burnt in its own space, no possible gun could withstand its explosive effects. It is to be remembered, however, that Robins made all his experiments with small-arms, where the nature of the powder used would make the actual facts of the case approximate so closely to his deductions as to defy detection by the rude method he employed. Any windage would allow a greater escape of gas as the number of bullets increased, and, though the pressure might be greater at the commencement of the bullet's motion, such a loss would give rise to a diminished pressure afterwards. Sir W. Armstrong mentions another circumstance in connection with this :—†

> "By using a slower burning powder, less heat and pressure are evolved at first, and the waste of heat in the stage of initial pressure being less, more heat remains for expansive action. Hence the slower burning powder is weaker at first but stronger afterwards, and, although the total quantity of gas be only the same, and the pressure not so great at any point, yet the aggregate pressure throughout the bore may equal that of the more energetic and more dangerous powder."

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* "Ency. Brit." Gunnery.

† Address, as President of the Institution of Mechanical Engineers, Newcastle Meeting, 1869.

It is not surprising that Robins should have failed to detect all the points of a most difficult question on which long experience alone has succeeded in shedding but even yet a faint light. The wonder is that, living in the time he did, he should have discovered so much. When he took up the question, gunnery was not a science, but was very much in the state in which Newton found astronomy. The subject had to some extent been treated in a rude practical way, and wild speculations had been made as to the nature of the forces at play, but the matter had never once been scientifically approached. The fact, too, that all his results, obtained with the aid of small-arms, have in the main been found to extend to the biggest guns without the discovery of any new law, must always make Robins occupy the first place in the estimation of every artilleryman.

The question of the instantaneous explosion of gunpowder is one of extreme importance; for, independently of the increase of the actual amount of pressure which it would cause in a gun, it has another bearing on the subject of almost equal importance. In a paper read here last year, I have given a rigid mathematical demonstration which shows that a sudden pressure has twice the destructive action on a gun that the same pressure would have if slowly applied. Mr. Mallet* also has illustrated this point very clearly, by showing that a weight would bend a support twice as much when suddenly applied as it would when slowly applied. Anyone can test it with a spring balance.

Long experience has shown that it lies in our power to vary the rate of combustion of gunpowder, and in this gunpowder differs very much from gun-cotton. In gun-cotton the instability which renders explosion possible is brought about by chemical action, so that atom finds atom in closest proximity ready for immediate recombination if only sufficient temperature be attained. In gunpowder, on the contrary, the instability is produced by mechanical mixture, and, on a minute scale, the particles of charcoal are burned like coals in a fire. With gunpowder in its rude state, the difficulty was to get the particles close enough together to make the combustion sufficiently rapid, and it was not till the importance of thorough incorporation was understood that any real progress was made in rendering it a destructive agent. Even with thorough incorporation, it was necessary to provide for the rapid ignition of the various particles, for the combustion could not travel with sufficient rapidity through the entire mass. To make the action energetic enough, it was necessary, as it were, to light the fire in a great many places. Granulation effects this by allowing the flame from one point of ignition to spread throughout the charge and ignite all the grains very nearly simultaneously. It also has the good effect of preventing any separation of the ingredients when once thoroughly incorporated. Thus the action depends on the rapidity of ignition of the grains, and the rate of combustion of each grain. The rapidity of ignition of the grains depends on the size of the spaces between the grains, and the rapidity of combustion on the smallness of the grains themselves; but as these are opposed to one another, we can readily see that with some size of grain which is most favourable to both requirements the combustion of the whole charge will be the most rapid. Small grains will burn rapidly, but the spaces between them being

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* "Construction of Artillery."

also small, the ignition will not be so rapid. Large grains will burn slowly, but will admit of rapid ignition. The shape of the grain is another element to be considered, but one of still more importance is the density; for, if the grain be porous, the flame will not only pass between the grains, but also penetrate into their mass. We shall obtain the most rapid combustion, therefore, by combining a certain size and shape of grain with a certain density of grain; and, if we wish to moderate the rate of combustion, we must not only increase the size of the grain, but also increase its density, especially in large guns, where the pressure is very great.

The objects to be attained in regulating the size and density of the grains are, the greatest possible velocity of projectile combined with the least strain on the gun. These cannot be obtained by one set of conditions for all natures of ordnance. A small projectile moves quickly, and relieves the strain in a still greater ratio. A heavy projectile not only moves slowly, but even a considerable motion does not relieve the strain in a proportionate manner, because the column of powder is longer in a large than a small gun. With small-arms consequently we must use fine grain powder, but large grain powder with heavy guns. Owing to the effect heat and pressure have in accelerating the combustion, we cannot determine *à priori* what size or density of grain will suit any particular gun. This, and as a consequence the actual pressure in the gun itself, can only be determined

2. *Practically.*

Rumford was the first who attempted to obtain the pressure of gunpowder by actual experiment. Not being able to find any material strong enough to confine it when exploded in its own space, he measured the pressure when exploded in closed spaces bearing various relations to the bulk of the charge, and had it been possible to combine this method with a knowledge of the rate of combustion, he would have completely solved the question. The plan he adopted was to make a small, short, strong gun, the muzzle of which he confined with a heavy weight, varying the charges and so regulating the weight that the force of explosion was just sufficient to lift it.

In this way he obtained the various pressures, and made a calculation of what the pressure would be if the charge were exploded in its own space. No vent or escape of any kind was allowed. The charge was fired by means of a red-hot ball, which communicated the heat through the walls which contained a long narrow chamber at the base of the charge. Fig. 1 shows the method used; the enclosing weight was placed on the top, and is not shown.

The bore was $\frac{1}{4}$ inch diameter at the top, and the actual capacity of the whole gun was $25\frac{1}{2}$ grains.

The following table gives the pressures obtained with a varying quantity of powder in grains. The first column gives the actual pressures, the second the pressures calculated according to what appeared to be a law. Sometimes the weight was lifted with an explosion like that of a gun, at others it was not raised at all. The result was taken when it was just lifted with a very small escape of gas.*

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* Philosophical Transactions of the Royal Society of London, 1797.

Charge in grains.	Ratio of charge to space.	Pressure in tons per square inch.	
		Measured.	Calculated.
1	·039	0·5	0·5
2	·078	1·2	1·1
3	·117	1·5	1·8
4	·156	2·5	2·6
5	·195	3·7	3·6
6	·234	4·6	4·8
7	·273	5·4	6·2
8	·312	7·8	7·8
9	·351	10·3	9·8
10	·390	12·6	12·1
11	·429	14·8	14·9
12	·468	17·1	18·1
13	·507	21·9	22·0
14	·546	26·7	26·5
15	·585	31·5	31·9
16	·624	47·3	38·2
17	·663		45·6
18	·702	73·2	54·3
19	·741		64·5
20	·780		76·5
25½	1·		194·5

The curve in Fig. 2 shows the calculated pressures. They agree very well with the measured pressures up to 15 grains. The pressures afterwards are calculated without taking into account the higher pressures, which appeared to manifest themselves as the cannon began to fail. If these higher pressures were taken into account, Rumford considered that 100,000 atmospheres, or nearly 700 tons, would not be too great an estimate of the force of powder exploded in its own space.* Piobert, however, considers that the higher pressures were probably due to the yielding of the metal at the top as it began to fail.

Observing that when the space is three times that of the charge the pressure is, in round numbers, 10 tons; when it is twice, 20 tons; once and a half, 40 tons; and once and a quarter, 80 tons; a very simple empirical formula, applicable to guns, may be given, founded on the supposition that

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* Some experiments have been made on this point by Captain Noble, of Elswick, who has fired by electricity as much as ¾ lb. of powder confined in cylinders of steel tempered in oil. The cylinders, which were 2 ins. internal diameter and 1½ calibres thick, usually expanded ·002″ or ·003″, and one as much as ·02″ external diameter. To produce this effect would, I consider, require an internal pressure of at least 100 tons per square inch; for the outside, where the tension would necessarily be least, would not yield permanently with a less strain than 30 tons, while the internal portions, being more expanded, would be under a greater strain. Some "crusher gauges" were placed inside, and from them, I believe, Captain Noble deduced a maximum pressure of 40 tons. I do not know, however, what reliance is to be placed on their indications under such extreme pressures as they must have been subjected to; nor can I reconcile their indications with the expanding of the cylinders, which is more in harmony with Rumford's results.

the pressure varies inversely as the amount of extra space which is added to that of the charge consumed:—

If P = pressure in tons,
l = length of charge,
y = proportion of charge consumed,
x = distance moved by the shot,

$$P = \frac{20y}{\frac{x}{l} + 1 - y}.$$

> "What was very remarkable in all the experiments in which the generated elastic vapour was completely confined, was the small amount of expansive force which the vapour appeared to possess after it had been suffered to remain a few minutes, or even only a few seconds, confined in the barrel; for, in raising the weight by means of its lever, and suffering this vapour to escape, instead of escaping with a loud report it rushed out with a hissing noise hardly so loud or so sharp as the report of a common air-gun, and its effects against the leathern stopper by which it assisted in raising the weight were so very feeble as not to be sensible. On examining the barrel, however, this diminution of force in the generated elastic fluid was easily explained; for what was undoubtedly in the moment of explosion in the form of an elastic fluid, was now found transformed into a solid body, as hard as a stone.
>
> "That this hard substance, found in the barrel after an explosion in which the generated elastic fluid had been completely confined, was actually in a fluid or elastic state in the moment of explosion, is evident from hence, that in all those cases in which the weight was raised and the stopper blown out of the bore, nothing was found remaining in the barrel. It was very remarkable that this hard substance was not found distributed about in all parts of the barrel indifferently, but more of it was always found near the middle of the length of the bore than at either of its extremities; and the upper part of the vent-tube in particular was always found quite filled with it. It should seem from hence that it attached itself to those parts of the barrel which were soonest cooled; and hence the reason, most probably, why none of it was ever found in the lower part of the vent-tube, where it was kept hot by the red-hot ball by which the powder was set on fire."*

A better plan than that adopted by Rumford for measuring the actual pressure cannot be conceived. We have considered the nature of a suddenly applied pressure in doubling the strain on yielding material, but a suddenly applied pressure in this case would make no difference, for the absolute weight keeping the powder enclosed would not yield to any pressure less than itself, and so would show the same result whether the pressure were suddenly or slowly applied.

There is, however, another kind of pressure to be considered. It was investigated by Robins in the following manner. By firing a musket charged with a light wad against a pendulum, he considered the velocity of forced gunpowder to be 7000 f.s. He says:—

> "From these determinations may be deduced the force of petards, since the action depends entirely on the impulse of the flame, and it appears that a quantity

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* Philosophical Transactions of the Royal Society of London, 1797.

of powder, properly placed in such a machine, may produce as violent an effect as a bullet twice its weight moving with a velocity of 1400 or 1500 ft. per second."*

In order to discover what effect this action had on the velocity of the bullet, Robins placed 12 pennyweights of powder at the bottom of a musket and a bullet 11¼ ins. from the bottom of the bore, and found that the velocity imparted was 1400 ft. per second instead of a calculated velocity of 1200 f.s. without the action in question. When the same quantity of power was scattered through the whole space, the velocity was only 1100 f.s.

By placing a bullet 16 ins. in front of the charge in a "good Tower musket," he found that "the part of the barrel just behind the bullet was swelled out to double its diameter, like a blown bladder, and two large pieces 2 ins. long were burst out of it."

We have every reason to believe that the action here referred to does exist, and also that it is local and does not extend throughout all the space in which the pressure of the powder acts. Under these circumstances, the thinner the confining surface at the point of action the more injurious would be the effects produced. With a thick wall, as in a gun, the action would be more distributed, and, though it might indent the surface of the bore as by a blow, it might not succeed in endangering the structure of the gun. For the same reason it is more than likely that any action of the sort would not appreciably interfere with Rumford's results, as well on account of the great mass on which he received the pressure as on account of the fact that a small motion of the weight had to take place before any gas could escape.

It will be observed, however, that though Rumford's experiments are most valuable in showing the extraordinary force of fired gunpowder and its pressure when occupying various spaces; yet, because they leave out of account the rate of combustion, on which mainly depends the amount of relief given by the motion of a shot in a gun, they do not help us practically. We consequently find that succeeding experimenters have turned their attention to some method of determining the explosive force of powder which includes this most important element.

Rodman is the next whose experiments we must consider. He endeavoured to measure the pressure in the bore from the recoil of the gun, swung as a pendulum, by causing it to trace a curve on a revolving cylinder. As, however, the whole space of recoil was less than an inch, nothing more than a general outline of the pressure could be obtained. He says:—†

"The curves described show that the gun and shot had acquired one-half of their final velocity in about one-fourth of the time required for the shot to pass from its seat to the muzzle of the gun; therefore the mean pressure in the bore of the gun, during the first fourth of that time, must have deen double that for the whole time, or = 18,132 lbs. (8 tons) per square inch. They further show that the shot and pendulum had acquired one-fourth of their final velocity in about one-sixteenth part of the whole time aforesaid, and that the mean pressure during the first sixteenth part of that time was = 36,264 lbs. (16·2 tons). And the pressure will be still greater during the lower rates of velocity, amounting to probably 50,000 lbs. (22·3 tons) per inch; and this estimate is for a statical

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* "Ency. Brit." Gunnery.

† "Experiments on Metals for Cannon and Cannon Powder." Rodman.

pressure, the strain due to which, as will be shown further forward in this report, must be considerably less than the actual strain, the rate of application of the force affecting the strain to which it subjects the resisting body so far as even to double it in the extreme case, or when the application of the force becomes instantaneous."

He conducted a much more elaborate and valuable series of experiments to ascertain in the very bore itself what was the actual pressure at each point. In order the better to judge of the value of his deductions, it is necessary to give a short account of some preliminary experiments which were made with hollow cylinders to test their strength.

Major Wade gives the hydrostatic pressures necessary to burst cast-iron hollow cylinders cut from the chase of a 6-pr. gun, of one-quarter and one-half calibres thickness, compared with the tensile strength of the iron.*

Tenacity.		Tons per square inch.	Proportion.
By direct tensile force		14·8	1
By water pressure	Thickness equal to half a radius	11·1	0·742
	Thickness equal to radius	8·9	0·602

These pressures agree so well with what might be expected from the law of decrease of proportionate strength as the thickness increases, that I have no hesitation in accepting them as correct. The law of decrease only holds strictly as far as the elastic limits up to which the extension is uniform; beyond the elastic limits the extension increases more rapidly than the strain. Thus there is a slight increase of the proportion of strength given when the thickness was one-half calibre, which by calculation would otherwise be equal to half the tensile strength of the metal.

Rodman tested similar cylinders with gunpowder. The cylinders, like the last, had the column of metal in the walls of the same length as the bore on which the pressure acted. The length was 12 ins., and the calibre 2 ins. The thickness of metal was varied. The following table shows the actual pressures measured when these cylinders were burst by powder exploded in the interior. Alongside the actual pressures is given a set of pressures calculated according to the law which regulates the strength of hollow cylinders, and made to agree with the instance in which the thickness of metal was one-half calibre in Rodman's experiment, the particular thickness being chosen because it required two charges to burst it, and may therefore be considered as just burst, and no more. (See Fig. 3.)

I have given Major Wade's hydrostatic bursting pressures for comparison.

Thickness of metal.	Mean bursting pressure by experiment.	Computed bursting pressure.	Hydrostatic bursting pressure.
	tons.	tons.	tons.
0·5 in.	16·9	11·4	5·5
1·0 〃	17·1	17·1	8·9
1·5 〃	28·3	20·6	—
2·0 〃	35·8	22·8	—
2·5 〃	41·2	24·4	—
3·0 〃	41·8	25·7	—
Tenacity	12·0	—	—

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* Reports of Experiments on Metals for Cannon, by Officers of the Ordnance Department U.S. Army.

It will be noticed that even in the most favourable case for comparison, viz., that in which the cylinder was just burst, the pressure obtained by gunpowder was about double the hydrostatic pressure. This is a very serious discrepancy, and is sufficient to cast a doubt on the accuracy of his method of measuring the pressure, which was by fixing a "pressure gauge" in the gun at various distances along the bore. The pressure was inferred from the distance an indenting tool was pressed into a wrought-iron or copper specimen, the force necessary for any particular indentation having first been obtained by statical pressure.

Fig. 4 shows this gauge.

Rodman tried the effect of varying the charge and shot in a gun. He fired a 43 lb. round shot with charges varying from 3 to 12 lbs., and found that the pressure varied very accurately as the charge; he also fired from the same gun, with a fixed charge of 5 lbs., shot varying from 35 to 85 lbs., and again found that the pressure varied with the shot. He says :—*

> "The nearest approximation to any regular law of variation of pressure due to variation of charge and projectile, discoverable in the results obtained from the series, with a constant weight of projectile and variable weight of charge, and that with a constant weight of charge and variable weight of projectile is, that with a constant diameter the pressure increases directly as the product of the weight of the charge by that of the projectile."

This law is much severer than that of Rumford, and, unless we account for it by his method of measurement being inaccurate, we must do so by concluding that the rate of combustion increased with the charge and projectile on account of the greater heat and pressure developed.

He next tried varying the bore, with the following results :—

> "Table showing the velocity of shot in feet per second, and pressure of gas per square inch (in tons) due to equal columns of powder behind equal columns of metal, when fired in guns of different diameters of bore, each result being a mean of ten fires.

Diameter of bore.	Windage.	Weight of charge.	Weight of shot.	Velocity, f.s.	Pressure at different distances from bottom of bore.						
					At bottom.	At 14″.	At 28″.	At 42″.	At 56″.	At 70″.	At 84″.
ins.	ins.	lbs.	lbs.								
7	·07	5·13	74·44	904	16·3	7·1	3·7	2·9	3·1	3·6	3·0
9	·09	8·48	124·42	888	30·0	9·4	7·9	6·7	13·1	9·4	10·2
11	·11	12·67	186·03	927	38·7	13·1	12·4	10·0	12·7	15·1	11·2

> "The points most worthy of note in these results are the very marked increase in the pressure of gas as the diameter of bore increases, and that the indications of pressure are greater at 56, 70, and 84 ins. than at 42 ins., especially in the 9-inch and 11-inch guns."

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* "Experiments, &c."

The former, Rodman accounts for by the greater heat developed in a large than in a small charge. The small bore, too, abstracts a greater proportion of heat by means of the walls of the gun, and also allows a greater proportion of gas to escape by means of the vent. The increase of pressure towards the muzzle he believes "to be due to the more violent and sudden contraction in the thin than in the thick part of the gun. . . . For in the thick part of the gun the pressure is much less rapidly developed, and subsides much more gradually, the contained gas forming an elastic cushion, which would, if the bore were long enough, allow this part of the gun to return from its strained to its free condition, without any vibration at all: while in the model used in these experiments the pressure is almost instantaneously developed and as suddenly subsides in the chase of the gun, so that while the indenting piston is on its way outward, it is suddenly met by the returning specimen, which is drawn in along with the housing by the contraction of the gun, with such violence as to amount in effect to a smart blow of the indenting tool against the specimen. Close examination shows a number of marks or cuts of the indenting tool on the specimen in this part of the gun, caused by the tool not striking in the same place at each vibration of the gun."

If this explanation be the true one, it may account for the unsatisfactory results given by his gauge as to absolute pressures. That it does not give the absolute pressures is manifest, for in the 11-inch gun we find the pressure per square inch throughout the bore more than double that of the 7-inch, and yet the resulting velocities remain the same, or nearly so. It is possible that it may represent the destructive action on the gun, and may be accounted for by a sudden pressure which sets up vibration in the powder-chamber to be continued throughout the bore, the greater intensity towards the muzzle being due to the same cause which makes the waves of the sea more violent as they come into shallow water.* That, however, the destructive action on the walls is the same in amount as that indicated by the gauges cannot be relied on, because the action shown by the gauges is the result of the compound vibration of both walls and indenting tool.

He also tried the effects of varying the size of the grain of powder with the following results:—

"Table showing the velocities of shot and the pressure of gas, due to equal charges of powder, of the same composition, and differing only in size of grain—each result being the mean of five fires—with the 11-inch gun, the same shot being used in all the fires.

Diameter of grain.	Weight of charge.	Weight of shot.	Initial velocity.	Pressure of gas in tons.		
				At bottom.	At 14″.	At 28″.
ins.	lbs.	lbs.	f.s.			
·6	12·67	186·3	933	9·5	4·6	3·6
·5	"	"	932	9·5	5·0	3·3
·4	"	"	881	11·4	4·8	3·2
·3	"	"	890	15·8	4·8	3·0
·3†	"	"	912	29·4	6·6	3·7

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* I have heard Professor Rankine give the explanation in a lecture on waves, at Newcastle-on-Tyne.

† Powder of 1859, but not so hard pressed as that of 1860.

This is one of the most important points Rodman has drawn attention to, for in this way the maximum pressure can be reduced, and yet the initial velocity maintained.

As, however, there is a danger of carrying even this advantage to an extreme, I shall premise another set of experiments made by Rodman, which will serve to illustrate the point I refer to.

He tried statical pressure through the medium of soft wax in cylinders bored out like a gun on a small scale (see Fig. 5). Various lengths of the bore were filled with the wax and the bursting pressures obtained. The calibre was 1·128 ins., and the thickness of metal one calibre. The following are the results:—

Length pressed.	Mean bursting pressure.	Length pressed.	Mean bursting pressure.
ins.	tons.	ins.	tons.
6	24·0	7	27·1
5	26·8	2	33·0
4	32·0	2	29·4
3	34·8	2	40·3
2	39·1	2·6	42·0

Rodman considers that these pressures are high, owing to the want of perfect fluidity in the wax. They serve, however, to show a law which is represented in Fig. 6, where the horizontal and vertical co-ordinates of the curve represent the lengths of bore and bursting pressures respectively. The benefit to be derived from the operation of this law may be shortly stated thus: with two calibres the circumferential strength is increased by one-half, while beyond five calibres no advantage is gained by it. It will be noticed, that if the powder burn very slowly, the shot will move during the first and most important part of its course under a much smaller pressure than the gun is capable of sustaining, with a corresponding loss of velocity.

The maximum pressure should be obtained as soon as possible, and should not be allowed to subside too rapidly, but should be continued as nearly as possible in accordance with the curve given above. The maximum pressure ought not, however, to be obtained so rapidly as to partake of the nature of a sudden pressure, *i.e.*, it should not be obtained so rapidly as not to give the metal of the gun time to expand before it has reached its maximum. The law above given has also a very important bearing on the size of the bore of the gun; for, in addition to giving a smaller pressure per square inch, a larger bore will not throw the pressure so far forward with the same charge of powder.

Committee on Explosives.

Somewhat tardily in our own country this Committee has been appointed to consider, amongst other things, the question of most pressing importance before proceeding with the manufacture of very heavy guns, viz., to find a powder which, in the monster ordnance we are about to construct, will give the greatest initial velocity of projectile with the least strain on the gun.

In our heavy service guns, when R.L.G. powder is used, we find the initial velocities decreasing with the size of the gun; thus—

Nature of gun.........	7-inch,	8-inch,	9-inch,	10-inch,	600-pr.
Initial velocity.........	1458,	1363,	1336,	1298,	1180.

This result is entirely due to the use, with these guns, of powder suitable only for smaller natures; for, if the guns are of the same construction and equally perfect manufacture, they will stand the same strains, and if the strains be the same throughout corresponding lengths of bore the initial velocities ought to be identical.

It is true no doubt that in heavy guns the manufacture slightly deteriorates and the length in calibres has to be decreased; but these are reasons, if we wish to retain the velocity and at the same time not overstrain the gun, for making the law of pressure conform more instead of less closely to the strength of the gun as the various lengths of bore come under the influence of pressure. Any departure from this will result either in a loss of initial velocity, or cause an undue strain on the gun at some particular point.

Perfection would be attained by having a special powder suitable for each nature of gun, but practically this cannot well be carried out. It is of all the more importance therefore that we should be provided with the fullest information on the subject, that we may be able to decide on some single powder suitable to all heavy guns, or on two or more sorts, the mixture of which will best answer the purposes required.

To a great extent the Committee have, in their investigations, followed in the footsteps of Rodman, *i.e.*, they have endeavoured to obtain the pressures as they actually occur in the bore; and, like him, they have adopted two methods of doing so.

Instead of his "pressure gauge" they use a "crusher gauge," a representation of which is given in Fig. 7; and, instead of estimating the pressure from the velocity of recoil of the gun, they do so from the velocity of the shot in the bore.

For this last purpose they make use of a "chronoscope," invented by Captain Andrew Noble, late R.A., of Elswick. It notes the moments of passing various points in the bore by electric sparks which arise from the shot in its course causing projecting tools to shear wires in succession, as shown in Fig. 8.

Their experiments have been confined to four kinds of powder, viz., R.L.G., prismatic, pellet, and a new sort called pebble. The following results have been obtained with the 8-inch gun by the chronoscope:—*

Nature of powder.	Charge.	Initial velocity.	Maximum pressure.
	lbs.	f.s.	tons.
R.L.G.	30	1324	29·8
Russian prismatic	32	1366	20·5
Service pellet	30	1338	17·4
Pebble No. 5. Density 1·78	35	1374	15·4

The pressure curves during the initial stages of the shot's motion are given in Fig. 9.

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* Preliminary Report, Committee on Explosives.

By the empirical formula I have derived from Rumford's experiments put in the form of—

$$y = \frac{P}{20 + P}\left(\frac{x}{l} + 1\right)$$

I deduce the respective proportions of each of those powders which are consumed at the time of the maximum pressure to be: R.L.G. 60 per cent., prismatic 57 per cent., and pebble 43 per cent.

The comparison of the prismatic and pebble curves is most suggestive; for though the prismatic charge is only 32 lbs. while the pebble is 35, and though the prismatic begins to burn more slowly than the pebble, yet not only does the prismatic very nearly maintain its velocity, but actually shows a greater pressure than the pebble, and that too at a point further forward in the gun.

It does not follow from this that at any point as regards time more prismatic than pebble is consumed, as will be evident by a reference to the time curves given in Fig. 10; but, as regards space moved by the shot, it does. It may to a great extent be due to the shape of the grain, which allows of greater acceleration of combustion. The fact that at the time it occurs the shot is moving less rapidly may also have something to do with it. But it is not to be left out of consideration that it may be due to another cause; for the low initial pressure would be favourable to ignition, and thus in the case of the prismatic, the whole charge may become more thoroughly ignited than in the case of the pebble, and though the combustion be less rapid at first, it may proceed with greater intensity afterwards. The greater velocity and less pressure of the pellet as compared with the R.L.G. may be similarly accounted for.

That there is room for an increased acceleration of combustion, is evident from the moderate amount of powder consumed at the time of the maximum. This supposition would also appear to explain the unaccountable fact of unconsumed grains being blown out of the gun when large charges are used, for the truth of which I can vouch. It is probable that the violent commotion set up in the chamber on first ignition of the charge is such that, more especially in long charges, portions are driven to the extremities and become so packed together by the enormous pressure, as to prevent thorough ignition of some of the grains.*

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* In the discussion which follows, Professor Abel explains that the unburnt grains, when expelled from the gun, are in a state of combustion, and are afterwards extinguished by the expansion of the gas. This fact is in accordance with the view put forward in the text, on the supposition that the ignition of some of the grains is delayed in the manner suggested. An experiment will be familiar to many, especially to those who have attended Professor Bloxam's lectures at the Royal Military Academy. A charge of 5 grs. F.G. is put in a miniature cannon with a projectile consisting of a cylinder of press cake 1″ × ·25″. The latter seems to leave the muzzle of the gun unignited, and may be caught in a box; but if a paper target be placed over the box to show where the projectile hits, it not uncommonly happens that the press cake ignites in going through the paper screen, perhaps from the heat resulting from the arrest of its motion, since it must have a very high temperature when it leaves the gun, and requires little more to raise it to the igniting point. The size of the grain is not the only cause of unburnt grains being blown out, for the same effect is produced with R.L.G. when large charges are used. It is probable that, in some cases, the passage of the flame is either prevented, or at least so filtered and cooled down in passing through

I am aware that it is usual to consider that the amount of powder consumed depends on the burning of each grain from the surface towards the centre, and that most of these curves might be explained in this way.

Sir William Armstrong we have seen explains the anomaly of the pellet maintaining its velocity against R.L.G., by the loss of heat which the latter sustains during the initial stage of combustion. There are, however, as we shall see, other points not so easily explained on the theory usually adopted. Whatever be the cause, the pebble is undoubtedly a better curve than the prismatic, and shows some advantages in addition to its less maximum; for the maximum pressure of the pebble takes place before that of the prismatic, and also there is less appearance of suddenness in the former than in the latter. The prismatic gets up the pressure very slowly at first, but, when about to reach the maximum, it takes a sudden rise, which may possibly be rapid enough to produce partially the effect of a sudden pressure. Its maximum is 20·5 tons; but suppose the pressure rises slowly up to 12 tons, and then suddenly becomes 20, we should have a pressure of 20 tons met by a resistance of 12, 13, 14,—20 tons in succession, during which time the walls of the gun have acquired a velocity outwards, requiring a resistance of 20, 21, 22—28 tons in succession to bring them to rest. The walls would again vibrate back to 12 tons, and out to 28 tons, increasing the injurious effects on the gun.

With the 10-inch gun,

"The principal average results, in various series of six rounds each, are shown in the following abstract, the pressure given being the highest as indicated by the crusher gauge.*

Nature of powder.	Density.	Charge.	Velocity.	Pressure.	Remarks.
		lbs.	f.s.		
R.L.G.	1·742	60	1318	51	
	1·733	60	1321	48	
	1·67	60	1313	53	
Pellet	1·677	64	1364	25	
Prismatic Russian	1·66	61	1335	19	
		68	1425	29	One round.
Prismatic Ritter	1·66	61	1349	21½	
		70	1416	24	One round.
Pebble	1·732	70	1474	29	Uniform grain.
	1·782	70	1432	21	
	1·732	60	1359	21	One round.
	1·782	60	1298	15	One round.

We here see the remarkable fertility of the subject, the initial velocity being increased by more than 150 f.s. when pebble powder is used, while the strain is very much reduced. The great importance of density is also

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the spaces between the grains, that the portions at the extremities are not ignited at the same time as the bulk of the charge. On the other hand, should the extremities become ignited before the maximum jamming action takes place, then the crushing up of the grains will make their combustion very much more rapid. The uncertainty of this action may thus account for the very irregular results which are obtained, both as regards pressure and velocity, when large charges are used.

* Memorandum, 12th July, 1870, Committee on Explosives.

shown, leading us to believe that this is one of the most important points to be taken into consideration in the manufacture of powder for very heavy guns.

With slow burning powders, the Committee state, the indications of pressure given by the "crushers" have been found to correspond very closely with those deduced from the chronoscope;* but this is not the case with quick burning powders, nor even with slow burning powders when fired in large charges in very heavy guns. From Rodman's experience with his pressure gauge, we cannot doubt that the crusher is not in all cases to be relied on. It seems to indicate intense local pressures which are greater as the point of their action is more distant from the point of ignition of the charge, greater at the extremities of the chamber than at the point of ignition in the middle, and greater when the crusher is at a distance from the bore than when close to the bore, amounting in some cases to double the pressure deduced from the "chronoscope," or even more. As an instance, the Committee state that, with R.L.G. in an 8-inch gun, when the "crusher" was close to the bore, the pressure indicated was 22½ tons, but when at a distance, it was 40 tons per square inch.

The occurrence of these pressures would appear, in the estimation of the Committee, to correspond with the notion already mentioned as having been investigated by Robins, of the gas first formed being suddenly arrested when at a high velocity and converted as by a blow into pressure. But when the crushers are put in a second time, little or no further setting up takes place, as would be the case if the action were due to a blow produced by the mass of gas in motion. Under such a supposition the intense pressures would take place before the general maximum is attained, and it is difficult to conceive that the necessarily small mass of gas is sufficient to produce the results manifested.

It is more reasonable to suppose that they occur at the moment when the general maximum exists, and may be superadded to it. In addition, it appears both from Rodman's experiments and those of the Committee, that when once the action is set up, it is continued throughout the bore, which would not be the case were it due to the velocities of the gases first ignited. This continuance of the action is also unfavourable to the supposition that it is due to an intense general pressure of the amount indicated, which, as shown by Rodman, would gradually subside as the gas expanded and produce no further vibration. It might, however, be explained were the general pressure of the nature of water pressure, which would suddenly subside with a very small motion of the shot, and so produce vibration by sudden cessation; and in support of this view it may be said there is a marvellous harmony in the fact that Rumford, Rodman, and the Committee all find these pressures manifesting themselves somewhere about 30 tons.

The apparently local nature of the pressures might be accounted for by the relief which would be given at those points where the gas could escape, such as the vent and the base of the shot. The vibration, however, would equally be set up by a moderate general pressure if it were suddenly applied,

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* This can only refer to the chronoscopic pressures at and after the maximum. During the ascending branch of the curve the crushers can only show the maximum pressure.

and which, acting on the "crusher" and walls of the gun would, in the first instance, produce effects on each varying with their masses, the spaces described, and the resistances, and afterwards set up an action which would be most felt by the "crushers," because they would partake both of their own motion and that of the walls of the gun.

There is yet another supposition which would account for these pressures.

If the charge when ignited burn uniformly, the grains nearest the point of ignition will naturally be in a more advanced state of combustion than those further away.

A great pressure and temperature will arise, causing increased combustion, which will be most felt where the greatest amount of powder remains to be consumed, and where it may be supposed to be a mass of half-burnt grains crushed to dust by the pressure proceeding from the point of ignition—a condition most favourable for intensely rapid combustion. Thus sudden local pressures would be manifested at these points and be continued through the chamber by a sort of wave motion, which, passing backwards and forwards, would manifest the greatest effects where the direction of its motion was changed, viz., at the base of the shot and at the bottom of the bore. The facts that indentations are found in the bore at the base of the shot, and also that so much trouble has been found in preserving the bottom of the bores from the action of the powder, appear to favour this view. The continued action throughout the bore also accords with it. On this supposition the pressure would be often repeated, but the whole of the chamber would not be under its influence at the same time, and the structure of the gun would not be so injuriously affected as the more limited surfaces of the crushers.

These anomalous pressures would thus appear to be due to one or other of two causes—either a wave motion in the gas originated somewhat in the manner described, or a vibration or wave motion in the walls of the gun, set up either by a very intense water pressure, or by a less intense gaseous pressure suddenly applied.

I have long been favourable to the notion that the wave motion exists in the gas; but a consideration of the enormous pressure of which gunpowder is capable, and the exceeding rapidity with which it is augmented, make me doubtful if the action be not due to vibration in the walls of the gun, and of a very dangerous character. The practical point is to decide between these two views, and to determine whether the destructive action in the gun is comparable to the indications of the crushers.

These questions, though very necessary, are of such extreme delicacy that the chronoscope must fail to detect them, owing to the fact that it does not note the motion of the projectile continuously throughout the bore, but only from point to point; so that a pressure of great intensity but very short duration, may occur between two points of observation which cannot be separated from the general law of pressure, but must be absorbed in it, causing a modification.

The action in question we may assume to be originated during the initial stages of the shot's motion, where the wires of the chronoscope are 2 ins. apart. The maximum pressure is attained even with the slowest burning powder before the third wire is cut, so that only two spaces of time are measured at this important point. If we take into consideration that the pressures may vary very irregularly and very greatly during this part of the action, it will be seen that the difficulty of tracing it must be very great.

The difficulty of determining the pressure by the chronoscope, during the initial stages, is still further increased by the fact that the shot has to move some distance before shearing the first wire, and that no record of time can be obtained between the first moving of the shot and the shearing of the first wire. Any error in assuming the space through which the shot has moved or the velocity it has acquired when passing the first wire, must affect the calculation of the pressure afterwards, up to the point at least where the maximum occurs.

In addition, any uncertain action of the cutters or deflexion of the sparks, might be sufficient to throw it out, and would not readily be detected because the velocity would be the same at any point, provided the area below the curve of pressure were the same up to that point. There would, however, be a difference in the total time; but, as has been noticed, the chronoscope does not note the time from the first starting of the shot, where the difference mainly arises.

It will be seen by reference to the pressure curves with the 8-inch gun, how closely the pebble curve would approximate to that of the prismatic, were the density increased so as to make the combustion slower at the commencement, and if this increase of density had also the effect of making the ignition more perfect, and the combustion afterwards more rapid. Density is considered by some as the most, if not the only important element to be considered in the manufacture of powder for very heavy guns.

From a consideration of the various principles I have brought forward, I was quite prepared for the manifestation of some very high pressures in the proof of the 35-ton gun. I am indebted to Colonel Miller* for the following particulars of pressures obtained by crushers in the base of the shot:—

Charge …………………	75	100	110	120	130 lbs.
Pressure …………………	17	25·4	31·8	46·3	63·7 tons.
Velocity …………………	1163	1237	1303	1364	1348 f.s.
Length of cartridge ……	22	27½	30	32½	35 ins.

As the crushers in the base of the shot do not usually correspond in their indications with those of any crusher in the gun, a crusher plug was substituted for the vent and the charge fired by electricity. The following results were obtained when the powder was the service pebble, and the tube in the service position of vent:—

Charge.	Velocity.	Vent crusher.	Shot crusher.
120	1300	28·6	40·4
120	1357	20	21·7

Colonel Miller considers from these indications that a powder which will give in charges up to 80 or 90 lbs. a pressure evenly distributed over the powder chamber, is liable to give severe local pressures in such charges as were used with the 35-ton gun. Now the point yet to be determined is how far we can afford to disregard these pressures; for unless we can dis-

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* One of the Committee on Explosives.

regard them, the gun, although undoubtedly the most powerful gun in the world, must either fail to accomplish its intended object, or a new powder must be provided. We may, indeed, advantageously increase the calibre so as to reduce the columns of powder and shot; but alterations of this description with such a very heavy gun entail considerable expense, and may perhaps be avoided by a systematic series of experiments beforehand to determine not only the best sort of powder to be used, but also the weight and calibre of the gun to be adopted.

II. What remains to be done.

What remains to be done, is therefore to determine with greater certainty the law of pressure during the first part of the shot's motion through the bore, in order that it may be made to approximate as closely as possible to the law of strength of the gun, without running any risk from sudden pressure or anomalous pressures of whatever description. No method of accomplishing this has as yet met with entire success. Rodman's velocimeter failed for want of delicacy. The chronoscope of Captain Noble cannot be relied on for the reasons given. Another attempt was made by General Mayevski, of the Russian artillery, who attached to the base of the shot a rod which he passed through a hole in the breech of the gun. As the shot moved, the end of this rod was made to break two electric currents at varied distances with different rounds. It seems strange that he did not make it trace a curve on a revolving cylinder, for he would thus at least have obtained what is most required, viz., a tracing for a very short space from the very starting point of the shot. The connecting rod, however, broke, and his results are of no practical importance.*

Particular care must be given to determine, as far as possible, the nature of the anomalous pressures so often referred to, so as to know whether they are due to length of cartridge and position of point of ignition, or to some chemical or physical law. If the former, they may probably be prevented; but if the latter, they may be expected to manifest themselves on the attainment and in continuation of some definite pressure, and will have to be avoided.

The experiments, however, will not be complete if they merely tell us what is best adapted to any existing service gun. By a comparison of the results obtained with varied powders, bores, charges, and projectiles, some laws must be established which will enable us to determine beforehand what powder, calibre, charge, and projectile will be best adapted to any contemplated new gun; for if, when we make a new gun, we have not only to alter the bore, but also the powder, we shall land ourselves in an expenditure of money which will very soon ring the knell of our future monster artillery, and the ships will beat us in the race.

The precise nature of the powder to be adopted is not by any means to be considered as definitely settled. The pebble powder which has been recommended by the Committee has given satisfactory results only as far as

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* "Mémoire sur les experiences faites a l'establissement de M. Krupp a Essen, au mois de Novembre 1867, pour determiner les pressures des gaz de la poudre dans l'ame des bouches a feu," par M. Mayevski, Général Major, Membre du Comité de l'Artillerie Russe, 1869.

the 600-pr., and there is reason to believe that with the 700-pr. a new description will be required. It is not improbable that it will be found necessary to adopt two sorts of different densities, one of which shall be suitable for the smallest of our heavy guns, and the other for the heaviest. Mixtures in different proportions, it may be conceived, will meet the requirements of the intermediate natures. From past experience we should take a lesson not to rush on too hastily in an old groove, making large quantities of a powder which, though well adapted to present requirements, may soon become obsolete as the art of gun-making advances; for if we do, we may again find ourselves with plenty of powder, but with very little of the precise nature we require.

III. How to do it.

The importance of determining the questions I have briefly sketched out will readily be recognised, but the question may be asked, How are we to do it when so many have failed? We must benefit by the experience of those who have gone before us, and, if possible, improve on it, taking care to avoid their failures. Rodman had a clear idea of how a systematic series of experiments ought to be carried out when he varied the length of charge, column of shot, and diameter of bore. It is because Mr. Bashforth followed a similar principle when he carried out his experiments with varied bores, charges, and projectiles, to determine the resistance of the air, that he has met with such marked success. Had Rodman's pressure-gauges been as accurate and as sensitive to determine pressures as Mr. Bashforth's instrument was to determine time, we should not have had much more to do than accept his conclusions. But Rodman failed for want of an instrument to carry out his ideas. He has, however, shown us what is to be done. Let us but carry out his notions on the plan laid down by him, and we shall obtain results which will well repay a little trouble and some expense.

It would be necessary to have experimental guns of the strongest possible form of construction, and of varied calibres—say 3, 5, 7, 9, and, possibly, 11 ins.

Pebble powder being most likely to give satisfactory results, should first be tried. Density, also, appearing to be the most important element, should first be investigated. Two densities of this powder might be used, 1·74 and 1·84. Commencing with density 1·74, it should be fired first from the 3-inch gun, with varied charges and projectiles, noting the increase of pressure for each increase of charge and each increase of projectile, and taking care to note any manifestation of anomalous pressure.

The same powder should then be tried, in the same manner, with the 5-inch gun, and the pressures noted, with the view to find out whether they increased with the lengths of charge and projectile in the same way as in the 3-inch gun, or at a more rapid rate.

The same should be done with the 7-inch gun, to see if the pressures were the same, or increased at a still more rapid rate, and so on with the 9-inch and 11-inch guns if necessary.

Density 1·84 should be tried in a similar manner, and in all probability will show that the pressures are less under similar circumstances, and that longer columns of powder and shot can be fired with this powder than with density 1·74.

Any other density can be tried, if necessary, in order more satisfactorily to elucidate the allowability of increase in column of powder and projectile with increase of density.

If equal columns of powder and projectile in all the guns give similar pressures, then the size of gun for any particular density of powder will be given by the length of the columns; but if not, a modification must be made according to the influence of the size of the bore on the pressure. In the latter case much light will be thrown on the relative values of big and small bores, especially if taken in connection with the known laws of the resistance of the air and the penetration of armour plates.

In this manner we shall not only be able to say what the pressure is with varied charges, calibres, and densities of powder, but we shall be able, from the laws which may be established, to calculate with tolerable accuracy what will be the pressures with larger charges and bigger guns, and what density of powder is suitable for each.

Lastly, having fixed certain densities which are to be manufactured, and what guns they are suitable for, we may, if thought advisable, make some experiments to determine what mixture of these densities would give better results with intermediate guns.

This method of proceeding is founded on the supposition that density will not fail us, but it may not be all that we require. If it fail us, other methods of regulating and moderating the combustion of gunpowder might be tried.

It is possible that with our heaviest guns we may have not only to search for the very best description of powder, but also for the very best description of gun. We can obtain some very good practical information to guide us in fixing what is the maximum pressure which it is safe to use; for, by firing the battering charges of our service guns in these experimental guns, we can note the pressure given, and adopt that as the maximum, which must not be exceeded in any new gun of similar construction.*

I am indebted to Mr. Bashforth† for the suggestion that a gun with a movable breech, on the plan proposed by me a year ago, would be the best means of carrying out these experiments. I may observe that of late I have very much improved its construction, my object being to allow the breech to move right away, so as not to disturb the elevation. In this way there would be no shock on the carriage, and, with a 15-inch gun firing at 15° elevation, the strain would be reduced from 1000 tons to 100 tons at most. This enormous reduction of strain would make it exceedingly well adapted to the small gun-boats now being constructed to carry heavy guns on platforms, which can be raised or lowered at will, on the plan invented by Mr. Rendel, of the firm of Sir W. G. Armstrong & Co. Fig. 11 shews an elevation of the gun. The breech is run home on the guide bars, and thus the hollow part of the curve is bridged over.‡

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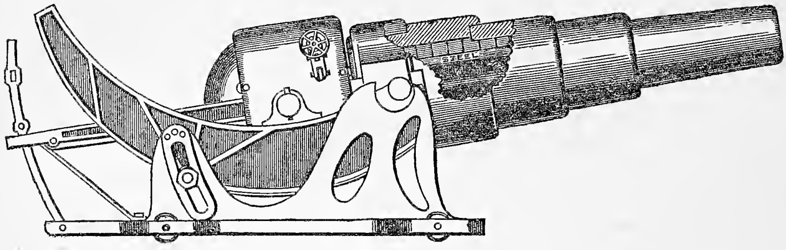
* Some very valuable information could also be obtained during these experiments by firing through the Bashforth chronograph, which would show the amount of steadiness given to varied lengths of projectile with varied velocities.

† Professor of Applied Mathematics to the Advanced Class of Artillery Officers.

‡ A small model 1 in. to a foot has been made for me at Elswick and fired. The shot was 11 ozs. and charge 2 ozs. of powder. The action was perfect. A leather gas check entirely prevented the escape of gas at the breech, and could be used over again.

Fig. 11.



For the general law of pressure throughout the bore the gun could be used in the form shown, for the slipping away of the breech without resistance would give an accurate measure of the pressure which impelled it. It would have four times the delicacy of Rodman's velocimeter, because the space it would move would be more than 3 ins. while the shot traversed the bore. It would have this great advantage over Captain Noble's chronoscope, that the tracing which could be obtained from it on a revolving cylinder would be a continuous curve from the very starting of the shot, and not merely indicated by several points. It would also show the effect of lead-coating and rifling on the pressure.

But the great advantage to be gained by this method would be the possibility of determining exactly the nature of the anomalous pressures. The breech could be reduced in weight to any amount necessary to give the desired sensitiveness, and the pressure could without difficulty be distinctly traced during the first stages of the shot's motion. For this purpose it might be necessary to use a short gun, so as not to get up an extreme velocity. It would even be possible to have breech and projectile of the same weight, and each double the weight of an ordinary shot, and the conditions of pressure would remain very much the same, because the two would move in opposite directions, each with a velocity equal to half that of an ordinary shot. And if the gun were not too long, a record could be obtained from both projectiles. This would be a means of detecting even successive impulses of wave motion, if any such existed in the elastic fluid. It is probable, however, that such extreme delicacy would not be necessary, but that the law of pressure would be so traced during the initial stages as to give us all the information we desire.

But if it were desirable to test enormous pressures, so as to trace Rumford's law as far as possible, this method could be adopted; for, by using a very short column of powder, and two very long columns of shot, the pressure would be very high, but, by virtue of Rodman's law of increase of strength with diminution of length of chamber, our very strong guns would withstand the explosion, and we should be able to go far above Rumford's pressures.

There is yet another use to which such a gun could be applied, and which would be of very great advantage as confirming the results obtained in the way first indicated. For this suggestion I am again indebted to Mr. Bashforth. We have seen how very satisfactory Rumford's method of measuring the pressures was, as far as he was able to go, because it takes account only of absolute pressure, and not of sudden pressure or wave motion.

There is a difficulty in applying Rumford's method to an ordinary gun, because the recoil of the gun would prevent the arrangement of the heavy weight on the top of the stopper; but in a gun with a movable breech this difficulty would not occur, because the barrel does not recoil.

If these two methods of measuring the pressure coincide, as I am confident they must, not only on my own mature consideration, but also because they meet the approval of so able and successful an experimenter as Mr. Bashforth, the results might be safely relied on, and laws would be established which would allow of extension, so as to tell with certainty what would be the probable fate of any proposed new gun; and in future we should be able to justify our preference for big or small bores, not by the opinion of any individual, however eminent, but by the invariable laws of science, deduced from experiment. No doubt such experiments would require a considerable expenditure of public money, but if we go on with big guns, as go on with big guns we must, they will result in a gigantic economy; and, if these investigations were combined with what we already know, and what yet remains to be determined in the other branches of gunnery, our English artillery would, as heretofore, maintain its position as the first in the world.

At the close of the lecture—

Colonel W. J. SMYTHE invited gentlemen present to make any remarks they thought fit on the subject, or to ask Captain Morgan any questions.

Captain C. ORDE BROWNE, R.A., Captain Instructor Royal Laboratory, asked for an explanation of the mode in which Captain Morgan proposed to register what he understood as local pressure by a movement of the breech. He thought the breech would fail to indicate any sudden local pressure, or slight variations in pressure, from the momentum it must necessarily possess; and hence in registering such pressure he thought there was a great advantage in having something stationary, although he admitted the advantage of obtaining a continuous trace of a curve over registered points; but perhaps he had not understood the lecturer.

Captain MORGAN said the local pressure was due to the wave-like motion of the gases, and by his plan he thought these waves could be detected, if the breech was light enough, as clearly as if they were successive blows.

Captain BROWNE expressed a doubt whether any *decrease* in the pressure could be truly ascertained by that means.

Captain MORGAN said a decrease of pressure would give a less increment of velocity. The variation in velocity of the recoil of the breech would be more or less according as the pressure was greater or smaller.

Captain W. H. NOBLE, R.A., asked what Captain Morgan meant by the indications of the crusher gauge being affected by the vibration of the gun.

Captain MORGAN stated that the explanation was not his, but was Rodman's.

Captain NOBLE did not consider the explanation satisfactory. He could understand the effect of a vibration in the gas, but he could not see how the vibration of the metal of the gun could sensibly affect the dimensions of the copper cylinder upon which the amount of pressure depended.

Captain MORGAN said the effect upon the crusher did not depend entirely upon the pressure. The result was a compound of pressure and vibration. The crusher moved backwards and forwards in its casing from the effect of the vibration of the walls of the gun. The crusher would thus to some extent act as a hammer.

Professor ABEL, the Chemist of the War Department, said so many points had been raised in the very interesting lecture they had heard, that he scarcely knew which to speak of first. Everyone present must be struck with the remarkable progress which had been made in the investigation of this subject within a very recent period; but, although very much information had been gained, he hoped and believed that further researches would elicit still more valuable results. Captain Morgan had laid before them many interesting facts and ideas on the subject which could not be controverted, but on several points which he had touched upon opinions varied. With regard, for instance, to the unexploded powder which is sometimes thrown out of the gun, he (Mr. Abel) believed that beyond doubt the particles had been in a state of ignition, and, indeed, were burning at the instant of their projection from the gun, but that the sudden expansion of gas had the effect of extinguishing them. The condition of the surfaces of these particles indicated that the most inflammable portions of the masses had been burning, and the fragments of pellet powder especially afforded convincing evidence of having been burning and of its extinguishment being accidental. He thought they could not avoid the conclusion that during the explosion of a charge each particle of powder remained isolated from the others, through the agency of the gases evolved from their surfaces. The theory adopted by the lecturer that the particles composing the two extremities of a charge became jammed up in a solid mass, did not therefore appear to him (Mr. Abel) to be one which he could accept; in fact, experiment appeared, as far as it had been carried, to demonstrate the opposite. He would not enter into a controversy concerning the precise effects to be ascribed to the density of gunpowder, simply remarking that there were abundant proofs that the properties of gunpowder might to a considerable extent be regulated by variation of density. There was another variable property of gunpowder which had perhaps not attracted the attention it deserved—perhaps because it was so difficult of comparison in different powders—and that was the property of hardness. Some powders were very hard though their density was low; and as hardness, apart from density, no doubt exercised an important influence on the rate of burning of a powder, it was highly desirable, if possible, that reliable means should be devised for registering this quality. The production of a powder thoroughly suitable for the large guns of the present day was unquestionably a difficult problem. There was no doubt that theoretically they ought to have a distinct powder for each kind of gun; but that being obviously impracticable, they must endeavour so to regulate and balance the various properties of the powder as to obtain, with as little sacrifice of power as possible in the smaller of the guns, a powder which can be safely used in the heaviest charges. His name had been mentioned by the lecturer as objecting to deductions founded on the experiments of Bunsen and Schischkoff; he would therefore wish to state that his objections were specially directed against the mode of operation pursued in their investigations. He considered the method of experimenting to be fallacious, firstly, because they did not explode gunpowder under pressure, when collecting the products; and secondly, because some of the products were submitted to treatment which must involve secondary changes before they were examined, and hence one might expect to obtain analytical results which would not fairly represent the original products of explosion. The experiments which were now being made in reference to the character of the decomposition of gunpowder by Captain A. Noble, were likely to furnish very important results. Captain Noble, in conducting his investigations, was exploding charges of considerable amount in strong vessels either absolutely or nearly closed, and was thereby likely to arrive at results approximating much more closely to those of actual practice than any which hitherto had been obtained. The physical and chemical results attending the explosion of gunpowder constituted a

Fig 1.

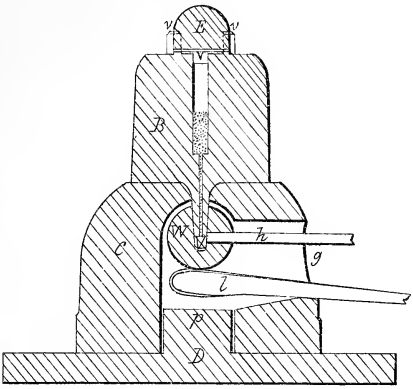


Fig 2.

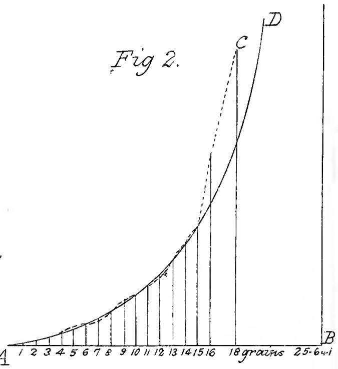


Fig 3

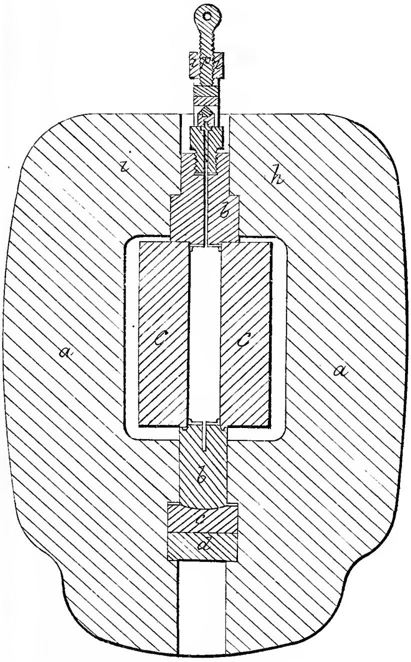


Fig 5.

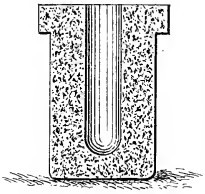
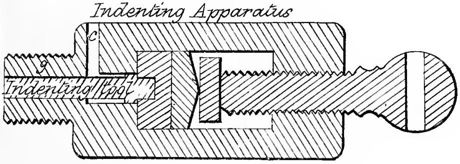


Fig 4.

Indenting Apparatus



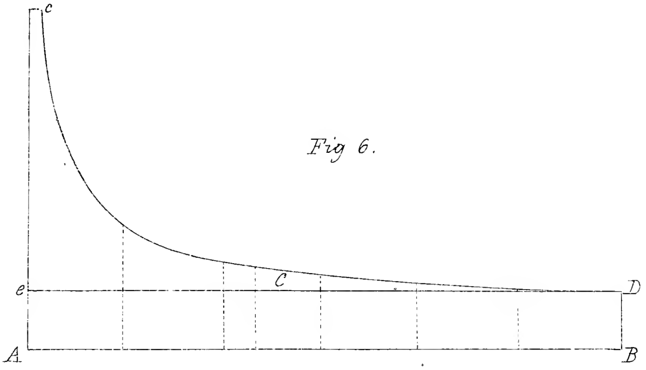


Fig 6.

Fig 7.

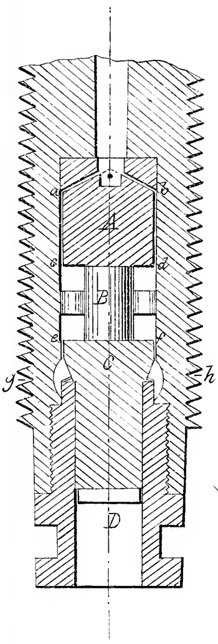


Fig 8.

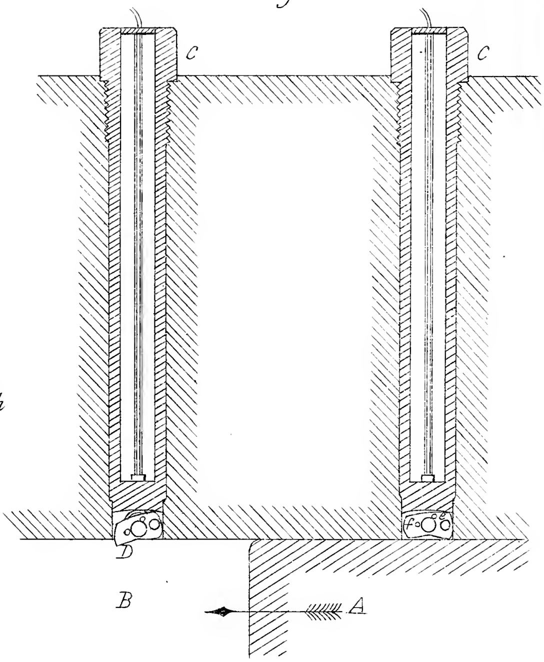


Fig 9.

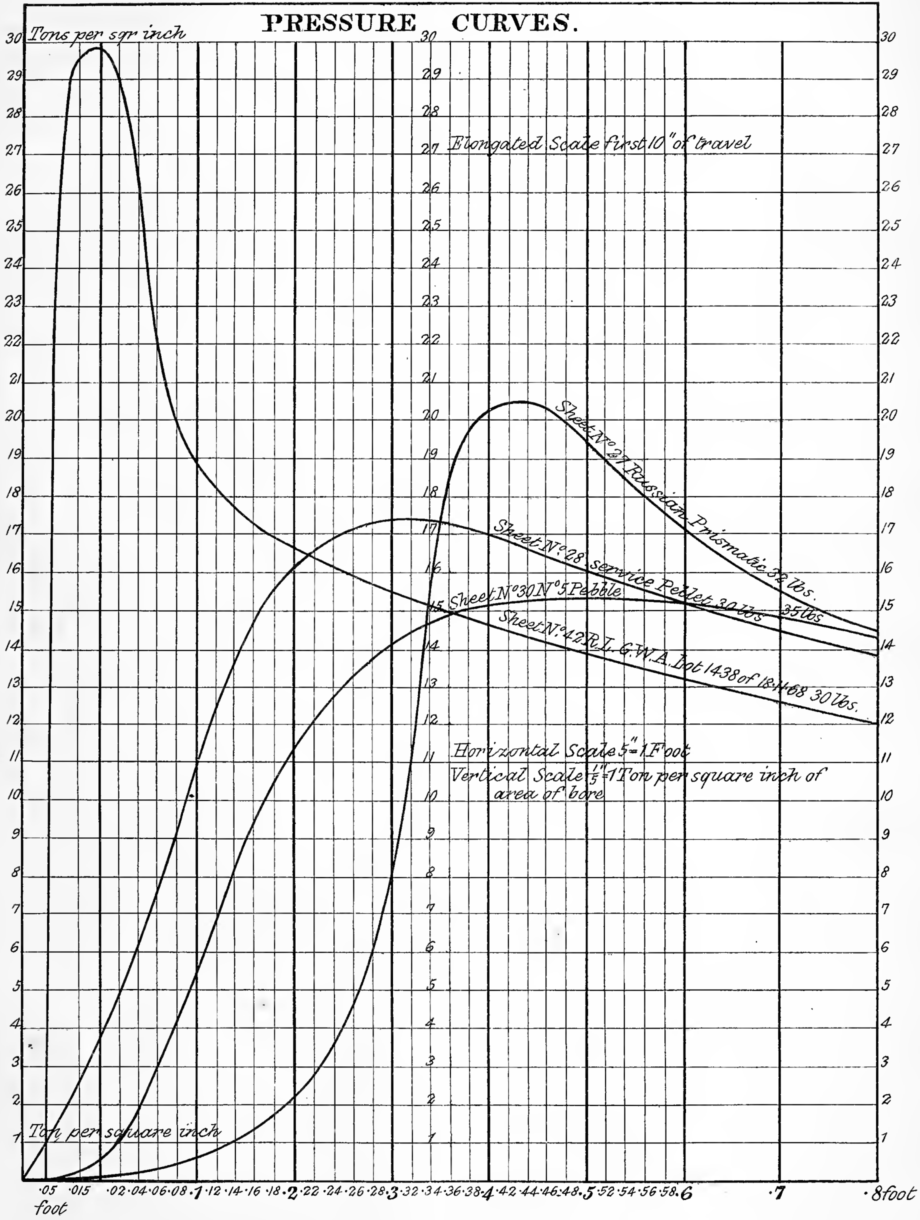
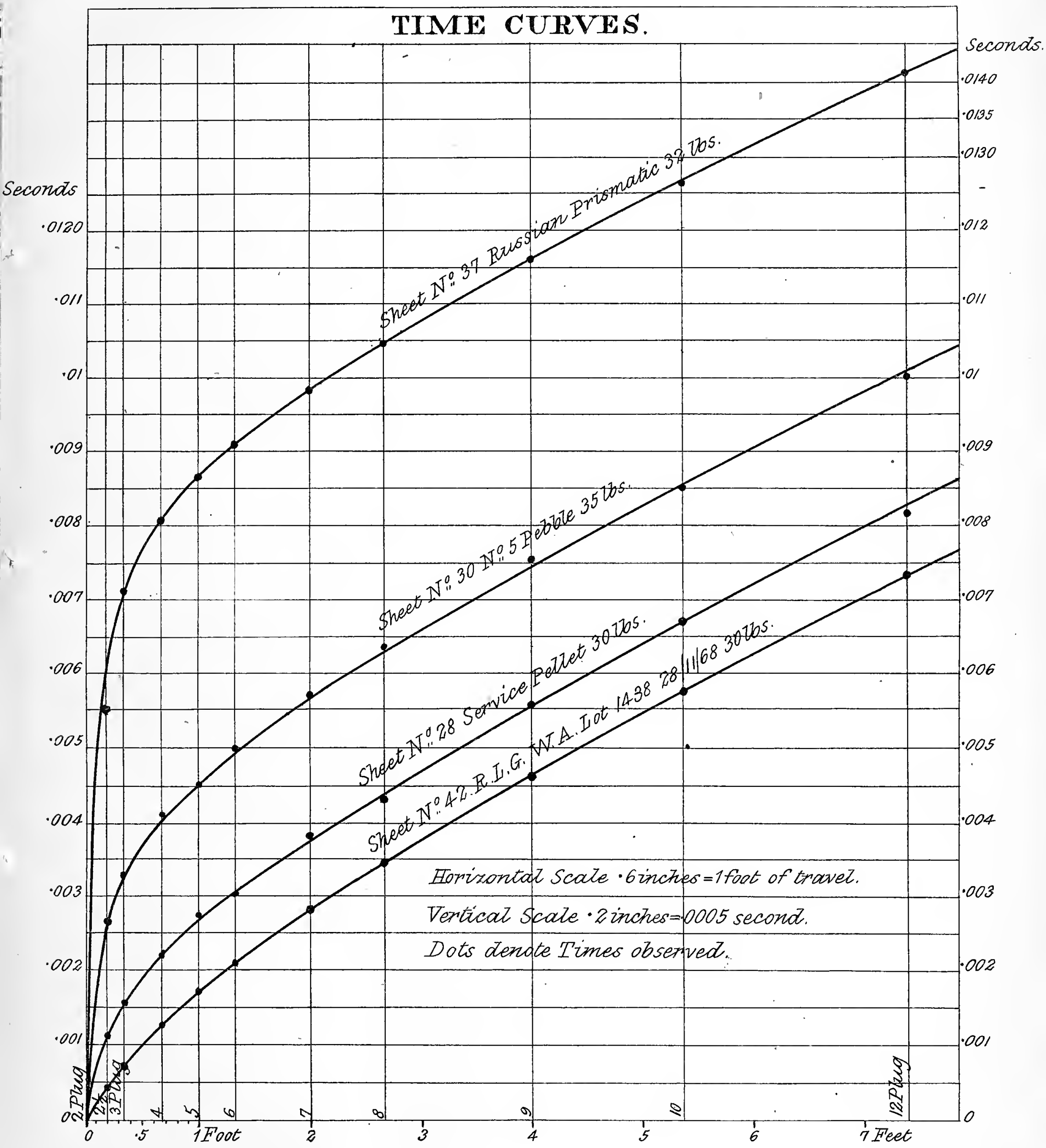

PRESSURE CURVES.
Tons per sqr inch
Elongated Scale first 10" of travel
Sheet No 37 Russian Prismatic 32 lbs.
35 lbs
Sheet No 28 service Pellet 30 lbs
Sheet No 30 No 5 Pebble
Sheet No 42 R.L.G.W.A. Lot 1438 of 18-11-68 30 lbs.
Horizontal Scale 5"=1 Foot
Vertical Scale 1/5"=1 Ton per square inch of area of bore
Ton per square inch
30 29 28 27 26 25 24 23 22 21 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1
·05 ·015 ·02 ·04 ·06 ·08 ·1 ·12 ·14 ·16 ·18 ·2 ·22 ·24 ·26 ·28 ·3 ·32 ·34 ·36 ·38 ·4 ·42 ·44 ·46 ·48 ·5 ·52 ·54 ·56 ·58 ·6 ·7 ·8 foot
foot

Fig 10.



Horizontal Scale ·6 inches = 1 foot of travel.

Vertical Scale ·2 inches = ·0005 second.

Dots denote Times observed.

most fruitful subject of investigation, worthy of engrossing the attention not only of artillerymen, but also of purely scientific investigators.

Colonel SMYTHE, in expressing the thanks of the meeting to Captain Morgan, said that nothing was more remarkable than the way in which the properties of gunpowder were now considered as compared with what had been the case up to a recent period. The forces generated by fired gunpowder under different conditions had been discovered to be so complex as to require the most delicate instruments for their determination. Captain Morgan had shown that there was yet much to be done, both experimentally and instrumentally, and probably an instrument constructed on the principle of his proposed large gun would be the best for settling the question of pressure. It was very gratifying to find a subject of such great artillery importance taken up by an officer of Captain Morgan's high mathematical ability, and he (Colonel Smythe) had no doubt that before long the properties of the forces of gunpowder, so far as they were of practical import, would be ascertained and usefully applied. (Applause.)

BREACHING BY INDIRECT FIRE.

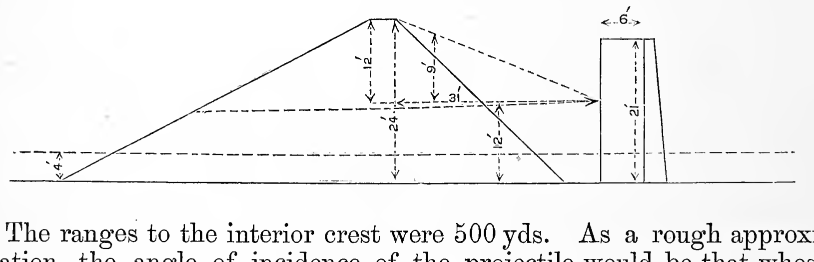
BY

COLONEL H. H. MAXWELL, R.A.

SUPERINTENDENT, COSSIPORE GUN FOUNDRY.

The first instance on record, to my knowledge, of breaching by high-angle fire is that at Woolwich in the years 1822 to 1824,* when experiments were carried on under the then Master-General of the Ordnance, the Duke of Wellington, to determine whether it was possible to breach walls protected by earthen counterguards, as proposed by Carnot in his "System of Defence," by firing over the crest of such counterguards. The inner edge of the top of the counterguard was 31 ft. from the face of the wall; the height of the crest of the counterguard was 24 ft., and the point intended to be struck was 12 ft. above the level of the ground.

Fig. 1.



The ranges to the interior crest were 500 yds. As a rough approximation, the angle of incidence of the projectile would be that whose tangent is $\frac{12}{31}$, or 21° 10′. Supposing the muzzle of the piece were 4 ft. above the level, calculating by the Russian formula hereafter given, the angle would be 21° 26′. On the 5th August, 1824, a year after the completion of the wall, eight 68-pr. carronades, in battery 500 yds. from the crest of the counterguard, three 8-inch and three 10-inch howitzers at a distance of 400 yds.—in all fourteen pieces—fired 100 rounds each in about six hours, the howitzers firing live shells filled with powder and the carronades solid shot. The 8-inch and 10-inch

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* See "Aide-Memoire to the Military Sciences," article Fortification, Permanent. Appendix A, p. 62.

howitzers fired with charges of $\frac{1}{5\,5}$th and $\frac{1}{5\,8}$th of the weight of their projectiles respectively, the 24-pr. gun with a charge of $\frac{1}{4\,3}$rd, and the 68-pr. carronade with one of $\frac{1}{8\,4}$th and $\frac{1}{6\,8}$th. A practicable breach 14 ft. in width was made by their fire, and the buttresses were much injured.

On the 6th August the firing recommenced from eight 68-pr. carronades at 500 yds., two 8-inch iron howitzers and four 10-inch howitzers at 400 yds. Fifty rounds per piece were fired in two hours, when the breach was examined and found to be complete in every respect, and the buttresses to be in a ruinous state.

There is no rifled piece in existence, which fires with a small charge with accuracy, capable of dropping its shell at such an angle from a range so short as 500 yds.; but the Russian 12-prs. (32 lb. common shell) could attain this angle at ranges of from 1120 to 1266 yds.; and the same might be effected by their larger pieces from greater ranges. This case—that of a wall covered by a counterguard at a distance of only 31 ft.—is an extreme one; no instance of Carnot's system, as far as I am aware, having been actually constructed. The distance between the wall to be breached and the covering mass in ordinary fortifications is usually very much greater than 31 ft.

At the siege of Strasburg by the Prussians in 1870, a breach was made in one of the bastions of the enceinte from a battery of four short B.L. 24-pr. guns,* firing common shells weighing 61 lbs., inclusive of a bursting charge of 4·4 lbs.; the range was about 900 yds., and the escarp breached was invisible from the battery. An eye-witness who examined the breach after the siege, describes the wall as fairly down, but the earth of the rampart and parapet so far intact that a good deal had yet to be done to render the breach practicable.

As this system of breaching is, I believe, practically unknown in England, some description of the method by which this result is attained may be of service.

The Russian "Handbook for Artillery Officers," published in 1870, and Prehn's "Schiesskunst," Berlin, 1867, give full details of this system. From these sources I purpose to describe it.

The problem resolves itself into this:—At what angle and with what charge must a certain piece be fired from a given distance, so as to send its shell just clear of the covering work which intercepts the view—whether glacis, counterguard, or counterscarp—and to strike the escarp wall at the proper height above the bottom of the ditch with the maximum velocity?

As the range, the height of the covering work, and its distance from the escarp, as well as the height of that escarp, may all vary, it is

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* This piece had just been introduced into the Prussian service for the above purpose. It is a howitzer to all intents and purposes, and worthy of imitation. The following are some of the details of the piece:—Calibre, 5·866″; length of piece, 14·4 calibres; length of bore rifled, 58·7″; number of grooves, 24; pitch of rifling, $\frac{1}{45}$; weight of piece, 29 cwt., or 53 times the weight of its projectile; maximum charge, 3·3 lbs.; load-ratio (powder to projectile), $\frac{1}{18\cdot5}$; length of shell, 14·2″; weight of shell, 61·07 lbs.; weight of bursting charge, 4·4 lbs. See "Artilleristisches Taschenbuch," Witte, Berlin, 1870.

evident that the elements of the shooting of the piece with various charges must be known, to enable the artilleryman to give an answer to this question. For this purpose a series of tables of fire for each piece is thus constructed :—

The gun is fired with its service charge at upright wooden targets at 500, 1000, and 1500 yds.; further, practice is made with such elevations as shall give ranges of about 2000, 2500, 3000, and 4000 yds., the ranges being measured on the plane. At the shorter ranges fifteen rounds are fired at each elevation, exclusive of trial shots; at the longer ranges twenty rounds are fired, as the disturbing influences acting on the projectile increase with the range. The positions of the mean points of impact are calculated, the elevations being corrected so as to bring them to what they would have been had the ranges been measured on a horizontal plane through the muzzle of the gun.

In Prussia no notice was taken of the angle through which the gun jumped on discharge; in Russia it seems to have been taken into account, the angles of elevation being corrected accordingly.

The positions of the seven mean points of impact are laid down on lattice-paper, the *angles* of elevation being taken as ordinates and the *ranges* as abscissæ; the origin being at the muzzle of the gun. A curved line is traced connecting the seven points as advantageously as possible with the origin; that is, if a continuous curve, starting from the origin, cannot pass through the seven points, it should leave as many points above it as below it. The elevations for intermediate ranges can now be read off at will.

The gun is next fired with about the lowest charge with which it will fire with accuracy. For guns intended more especially for flat shooting, the charge is found to vary from $\frac{1}{45}$th to $\frac{1}{35}$th of the weight of the shell. Finally, it is fired with two charges equidistant between the service and the lowest charges. The elevations are such as will give ranges of about 500, 1000, and 1500 yds.; fifteen rounds being fired at each elevation. If the angles of elevation and projection are found to be the same, no correction is required beyond that due to the height of the gun above the plane, as in the previous case. The points are plotted on lattice-paper as before. The elevations for intermediate ranges can be found by inspection.

The elevations for the fundamental charges are used to obtain elevations for all intermediate charges as follows :—For four fixed ranges of 500, 1000, 1500, and 2000 yds., four separate curves are struck, *elevation and charge* being taken as abscissa and ordinate. Having thus got four elevations giving fixed ranges for any charge we please between the lowest and the service charge, a curve is traced for each proposed charge, *elevation and range* being taken as ordinate and abscissa.

In the Russian tables there are fifteen or sixteen charges for each gun; the increase of charge being at first one-half what it is as the service charge is approached. Thus, on the same sheet of lattice-paper the whole of the fifteen curves are traced, and from these curves fifteen tables are made out of the shooting of each gun.

The following is a specimen of the Russian tables :—

A.

Fire of Siege and Garrison Steel 12-*pr. Common Shell.*

Charge, 2·08 lbs.

1	2	3	4	5	6		7		8
Distance.	Height of tangent sight.	Deflection sight left.	Alteration in range due to 0·1″ on the tangent sight.	Lateral translation due to 0·1″ on deflection sight.	Angle of elevation.		Angle of incidence.		Tangent of angle of incidence.
yds.	tenths of in.	tenths of in.	yds.	ft.	°	′	°	′	
59	1·3	0	45	0·5	0	12	0	13	0·0038
117	2·6	0	44	1·0	0	25	0	27	0·0079
175	4·0	0	42	1·5	0	38	0	42	0·0122
233	5·4	0	41	2·0	0	51	0	58	0·0169
292	6·8	0	40	2·5	1	5	1	14	0·0215
350	8·3	0·1	39	2·9	1	19	1	31	0·0265
408	9·8	0·1	38	3·4	1	34	1	48	0·0314
467	11·4	0·2	37	3·9	1	49	2	5	0·0364
525	13·0	0·3	36	4·4	2	5	2	22	0·0413
583	14·7	0·4	34	4·9	2	21	2	40	0·0466
642	16·4	0·5	33	5·4	2	37	2	58	0·0518
700	18·2	0·6	32	5·9	2	54	3	16	0·0571
758	20·0	0·7	32	6·3	3	11	3	34	0·0623
817	21·8	0·8	32	6·8	3	28	3	52	0·0676
875	23·6	0·9	31	7·3	3	45	4	10	0·0729
933	25·4	1·0	31	7·8	4	3	4	29	0·0784
992	27·3	1·1	30	8·3	4	21	4	48	0·0840
1050	29·2	1·2	30	8·8	4	39	5	7	0·0896
1108	31·2	1·3	29	9·3	4	58	5	27	0·0954
1167	33·2	1·4	29	9·8	5	17	5	47	0·1013
1225	35·2	1·5	29	10·2	5	36	6	8	0·1075
1283	37·2	1·6	29	10·7	5	55	6	30	0·1139
1342	39·3	1·7	28	11·2	6	14	6	54	0·1210
1400	41·4	1·9	28	11·7	6	34	7	20	0·1287
1458	43·5	2·0	28	12·2	6	54	7	48	0·1370
1517	45·6	2·2	28	12·7	7	14	8	18	0·1459
1575	47·8	2·3	27	13·2	7	34	8	50	0·1554
1633	50·0	2·5	27	13·6	7	54	9	24	0·1656

This table is obtained thus:—

Column 1.—In this column are set down the ranges at convenient equidistances.

Columns 2 *and* 6.—One of these columns is obtainable from the other. If the tangent-sight bar is divided to degrees and minutes, and the curves previously described have been plotted accordingly, the height on the tangent-sight bar is obtained by multiplying the tangent of the angle of elevation by the radius for sighting (in this piece 35·9″); or in symbols

$$h = r \tan \phi ;$$

h being the height on the tangent-bar required, r the radius for sighting, and ϕ the angle of elevation. If, on the other hand, the tangent-sight bar is divided into inches, the angle of elevation is obtained from the formula reversed,

$$\phi = \tan^{-1} \frac{h}{r} .$$

Column 3.—The figures in this column are obtained by plotting the deflections at five ranges, *deflection* being taken as ordinate and *range* as abscissa, striking a curve and reading off intermediate deflections.

Column 4.—If we take the difference between two adjacent heights on the tangent-sight bar from column 2, say 18·2 − 16·4 = 1·8 tenths of inch, and the difference of the corresponding ranges from column 1, that is 700 − 642 = 58 yds., we get the proportion

$$\overset{\text{t.}}{1\cdot8} : \overset{\text{t.}}{1} :: \overset{\text{yds.}}{58} : x = 32 \text{ yds.}$$

Column 5.—To find the deflection of the projectile due to 0·1″ on the deflection scale, we have the proportion

$$35\cdot9'' : 0\cdot1'' :: \overset{\text{yds.}}{700} \times 3 : x = 5\cdot9 \text{ ft.}$$

Column 7.—The angles of incidence in this table seem to have been calculated from the height on the target of the mean point of impact and the distance behind the target of the mean range from

$$\tan\theta = \frac{Ah'}{a\,(A - a)};$$

where θ is the angle of incidence, h' the height above the plane of the mean point of impact, A the range up to the graze of the projectile, a the distance of the target from the gun. Five such *angles* being calculated and taken as abscissæ, the *ranges* being taken as ordinates, and the points obtained being joined by a continuous curve, the intermediate angles for intermediate ranges can be read off by inspection. The angles in this column are slightly less than those obtainable by calculation from the ordinary formula.

Column 8.—The figures in this column are obtained from a table of natural tangents.

The following extracts from similar tables will be of use further on in working out an example.

B.

Distance.	Height of tangent scale.	Deflection sight left.	Alteration in range due to 0·1″ on the tangent sight.	Lateral translation due to 0·1″ on deflection sight.	Angle of elevation.	Angle of incidence.	Tangent of angle of incidence.
yds.	tenths of in.	tenths of in.	yds.	ft.	° ′	° ′	
			Charge, 1·9 lbs.				
1225	39·1	1·8	26·8	10·2	6 13	6 55	0·1213
			Charge, 1·7 lbs.				
1225	44·4	2·0	23·3	10·2	7 3	7 54	0·1388

In addition to the above table, a small table of the mean quadratic deflection is required; that is, the mean lateral and the mean vertical deflections are assumed to be identical.*

C.

Mean quadratic deflection and amount by which the height of the mean point to be struck in breaching should be diminished.

12-pr. Steel Gun.

Distance in yds.	Charges.			
	2·48 lbs.	1·8 lbs.	1·13 lbs.	0·68 lbs.
	ft.	ft.	ft.	ft.
233	0·3	0·3	0·2	0·6
467	0·8	0·8	0·6	3·5
700	1·4	1·4	1·4	8·5
933	2·2	2·3	2·9	14·0
1167	3·3	3·9	6·1	20·0
1400	4·7	7·1	12·2	—
1633	6·5	13·2	21·9	—

With a series of tables such as above described, the gunner can easily find an answer to the problem proposed at the beginning of this paper.

The Russian formula is as follows:—

$$\tan \theta = \frac{\frac{A}{A-a}(h \pm H) \mp H}{a};$$

where A = horizontal range in feet up to face of wall,
a = horizontal range in feet up to crest of covering work,
h = height of crest of covering work above muzzle of gun,
H = height or depth of point to be struck on the face of the wall to be breached, above or below the horizontal line through the muzzle of the gun.

The *upper* signs in the formula are to be used when the point to be struck is *below* the horizontal line through the muzzle of the gun; the *lower* signs when the point to be struck is *above* the horizontal line through the muzzle of the gun.

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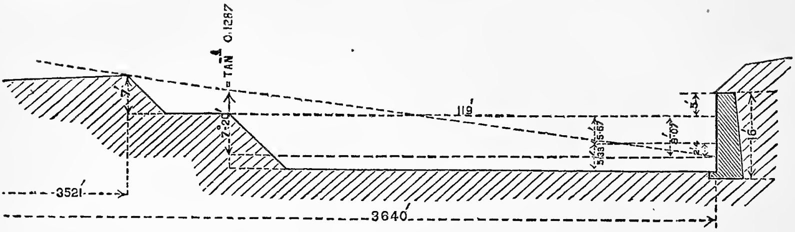
* This assumption, if assumption it be, though perhaps not absolutely correct, seems to be sufficiently so for all practical purposes. See Hélie, "Traité de Balistique Experimentale," Paris, 1865, p. 500. The Russian tables show them to be alike, or very nearly alike, up to 1200 yds. range.

Fig. 2.



To apply this formula, let it be supposed that an escarp wall covered by a counterguard (Fig. 2) is to be destroyed. Let the revetment be at a distance of 3640 ft., and the crest of the covering breastwork at a distance of 3521 ft. from the gun; let the vertical height of the crest of the breastwork be 7 ft., and that of the revetment 16 ft.; the height of the cordon being 5 ft. above the horizontal plane.

The most favourable height to make a good breach is about $\frac{1}{3}$ of the total height of the wall from its base; the point of aim will then be 5·67 ft. below the horizontal plane and 12·67 ft. below the crest of the counterguard. The horizontal distance between the crest of the counterguard and the wall to be breached will be 119 ft. The ratio $\frac{12 \cdot 67}{119} = 0 \cdot 1065$ will give a first approximation to the tangent of the angle of incidence. On examining the practice table above given (A), we find that the tangent of the angle of incidence 0·1075 at a range of 1225 yds. = 3675 ft., with a charge of 2·08 lbs. is the nearest. But as 2·08 lbs. is almost midway between 2·48 lbs. and 1·8 lbs., we may expect to have a mean vertical deviation of $\frac{3 \cdot 3 + 3 \cdot 9}{2} = 3 \cdot 6$ ft. (see Table C), midway between the mean vertical deviations with a 1·8 lb. and a 2·48 lb. charge at a mean range of 3640 ft. But as the height of the wall to be breached is more than double the above deviation, and as $\frac{2}{3}$ of the wall is to be fired at, we may take $\frac{2}{3}$ of 3·6 = 2·4 ft. and add it to 5·67 ft.—the height of the point to be hit below the horizontal plane—to obtain the height $H = 5 \cdot 67 \times 2 \cdot 4 = 8 \cdot 07$ ft. *below* the horizontal line through the piece. To obtain the tangent of the angle of incidence we have

$$A = 3640 \text{ ft.}; \; a = 3521 \text{ ft.}; \; H = 8 \cdot 07 \text{ ft.}; \; h = 7 \text{ ft.}$$

$$\tan \theta = \frac{\frac{3640}{119}(7 + 8 \cdot 07) - 8 \cdot 07}{3521} = 0 \cdot 1287.$$

On referring to the table (B) we find that at a range of 1225 yds., with charges of 1·9 and 1·7 lb., the tangents of the angle of incidence are 0·1213 and 0·1388 respectively; that is, that with a mean charge of 1·8 lb. we may expect to have a tangent of 0·1300, approximating to 0·1287. The mean height on the tangent scale (Table B) will be

$\frac{44{\cdot}4 + 39{\cdot}1}{2} = 41{\cdot}8$ tenths of inch; or the mean angle of elevation will be $\frac{6° \, 13' + 7° \, 3'}{2} = 6° \, 38'$. If we use the quadrant we must deduct the ground angle of which $\frac{5{\cdot}67}{3640} = 0{\cdot}0016$ is the tangent; or an angle of 5′, since the object to be hit is below the level of the piece.

We have, by means of the tables and the formula, learnt what the angle of elevation and charge of a certain piece, firing at a given range, should be, so as to throw its shell clear of the crest of a covering work and to strike the escarp wall at the proper height to make the best breach. *Q. E. F.*

When we come to consider what an advance in ballistics we have in this system of breaching, what saving of life there would be under such a system as compared with the old system of breaching from batteries erected on the crown of the glacis, I believe I shall have most artillerymen with me in expressing the hope that tables such as I have described for all guns of the siege train should be drawn up from careful practice carried out for this purpose; further, that similar tables for all field guns should be constructed, for use in shelling occupied villages and field fortifications.

EXTRACTS FROM MAJOR KODOLITSCH'S

REPORT ON THE ABYSSINIAN EXPEDITION.

TRANSLATED FROM THE GERMAN BY

LIEUTENANT DOUGLAS F. JONES, R.A.

Lord Napier, Commander-in-Chief of the Bombay Army, was entrusted with the command of the army of Abyssinia. He was the head, body, and soul of this undertaking, which was so glorious of its kind, and crowned with as complete a success as could have been expected.

Lord Napier possesses the requirements of a great general. Beloved by his troops, he combines with the simplest, kindest, and most engaging manners, great energy and independence of character. He is able to watch over and carry out his plans with the most determined consistency. The first in rank, he is also the first in energy. He shares all fatigues, labours, and privations with his troops; the same ration, the same camping-ground, is measured out for all. The want of spirituous liquors among the soldiers, during the days preceding and following the fall of Magdala, was equally perceptible at the table of the Commander-in-Chief.

A thorough knowledge of the Hindoo languages, a high respect for the religious and national customs of the Indian troops, and a proper appreciation of their worth, won for him the most unconditional submission on their part; but notwithstanding this, he never lost sight of the superiority of the English troops, which secured for him their affections also. To extraordinary theoretical knowledge of war, he added a practical experience gained on the battle-fields of India, Persia, and China.

On the first sign of the possibility of an expedition to Abyssinia, Lord Napier, with the help of his staff, immediately instituted the fullest enquiries regarding the nature and condition of the country and people against whom war was to be made, the resources they might hope to find, and the difficulties that were to be dreaded; the political, religious, and statistical condition; the topographical, geographical, climatic, and meteorological aspects, &c.—in short, on all points bearing on the preparation of a campaign. He personally superintended these researches. There can be no doubt but that the necessary information concerning the resources of this country was obtained in the most practical, cautious, and discreet manner, and that this information was on the whole accurate, and the plan of campaign based on these data marvellously correct. At the same time, all questions of detail were thoroughly discussed—a sure characteristic of a great general.

Another point which received particular attention from the Commander-in-Chief deserves to be brought to light, as it exercised a great influence over the successful termination of the campaign. It is the treatment of the natives, and the clever use made of the political relations existing between the several chiefs; so that, among other things, they were kept from every offensive demonstration, and were unwittingly made useful in furthering the entire undertaking. To effect this, the greatest care was taken to prevent a collision between the troops and the natives. The most liberal payment was ordered for all services rendered and goods delivered, and thereby the great result was obtained that one always received trustworthy information and messengers, and had the full resources of the country at one's disposal.

In regard to the chiefs, the general had obtained all possible information concerning their feelings, interests, and inimical or friendly relations between one another, which, cleverly used, enabled him to paralyze those who were disposed to be unfriendly, and cause the indifferent to help him by their actual support—which in fact happened when the two rival Gallas queens helped to surround Magdala with their armies, and thereby rendered impracticable any attempt at flight Theodore might have made. Lord Napier, in his personal dealings with these native chiefs, displayed the greatest discrimination and tact; for they were thoroughly impressed with the power and greatness of the nation which he represented, and yet convinced of his personal friendliness and kindly feeling towards them individually.

From the moment in which he was given the command of the Abyssinian expedition, he devoted his chief attention to the organisation of the Land Transport Corps. He knew that this was the greatest difficulty of the whole undertaking, and that success chiefly depended on its thorough organisation and successful working. The Commander-in-Chief, and other generals in the English and East Indian armies, have the right to choose their own staff, which has a very great advantage, and when not the case often leads to unfortunate results. In the English army there is no regular organised staff corps. The members which would form such a corps in other armies, are in this always chosen from their various regiments. The purely scientific and technical duties which belong exclusively to the staff in continental armies, in this fall to the lot of the Artillery, Engineers, &c. This certainly has the advantage, especially if the officers generally be well instructed; for amongst such men, many may always be found who have been entrusted with the practical management of troops, and who have a facility for winning the affections of their men, while, on the other hand, one is less liable to fall into the mistake of considering a mere technical and scientific education as a sufficient qualification. This last-named mistake is especially liable to occur after a long peace in those armies to which the choice of the staff is confined to a distinct corps, for too great importance is placed on the above-named qualities, and too little stress laid on force of character, self-reliance, an enterprising spirit, &c.

This system is well organised. Officers who have served five years with their regiments, after giving proof of the necessary attainments in a severe examination, become eligible for the staff, but when thus employed they return to their regiments at the end of every five years. This good principle must not, however, be adhered to too strictly; for it would be disadvantageous if it were not possible in certain cases to retain special abilities on the staff beyond the appointed term of five years, though it would be detrimental to keep individuals permanently on it.

It is a striking fact that there remained much to be wished for in carrying out the service of the Quarter-Master-General's department. It was especially perceptible that those entrusted with the duties of getting the columns into marching order did not exercise sufficient influence, neither did they do so during the march. The only explanation I can offer for this is the general character of the English officer, which itself arises from that of the nation. The English officer is not sufficiently accustomed to enter by direct surveillance and personal dealing into the details of the service; too much is left to the discretion of a few. So long as you have to deal with bodies of troops consisting of old non-commissioned officers and old well-trained soldiers, this answers very well; in the Abyssinian army, however, the Land Transport consisted of heterogeneous elements thrown together on the spur of the moment, so that an accurate conformity to regulations and a constant watchfulness became necessary. Here a mere supervision did not answer, and disorders on the marches were the necessary results.

Cavalry.

The saddlery and equipment of the cavalry is excellent, though the saddle might be a little lighter and smaller, and the total weight (322 lbs.) the horse has to carry is enormous; in fact it was found necessary to lighten this weight from Tocado, and reduce it to 210 lbs. The remainder of the men's baggage was carried on mules, which increased the length of the train to an undue proportion; however, it was the only means of making a march possible in such a country, and I firmly believe that if the cavalry of the future is to maintain its position against the improved arms of the day, great though the disadvantage may be, it will be necessary to resort to like means for European cavalry in European wars—namely, to carry the men's baggage in carts, and only to allow absolute necessaries to be carried by the horses. Their manœuvres appeared clumsy, and similar to the Austrian Drill Regulations of 1854. However, trials are now being made in England of the new Austrian drill, which is certainly by far the best in existence. It was impossible to form an opinion as to their value, capabilities, and rapidity in marching, in a column consisting of men and animals of all races and descriptions.

Artillery.

The artillery consisted of twenty-four guns, two mortars, and fourteen rocket troughs. The whole of this artillery was brought as far as Magdala, except two Armstrong guns left behind in the entrenched camp at Addigerat, and the six S.B. mountain guns, which did not advance beyond Senafe. The two 7-pr. steel batteries, of which I received as accurate a description as it was possible for me to obtain, have answered very well. The *matériel,* ammunition, and service of the guns were excellent. In regard to accuracy and range, I hold that they are inferior to our 3-pr. mountain guns. The excellent qualities which characterise these batteries are:—

1. Their portability.
2. They are arranged for vertical as well as horizontal fire.

3. The change from pack to draught can be made in the shortest time, and the mules set free by this arrangement can then be employed for mounting the gunners.

The sight consists of a rectangular steel bar on the right side of the gun, inclined so as to give 3° deflection. The fore-sight consists of a cylindro-conical stud, on the right side of the piece, which is screwed into a projection tapped with a screw thread. This arrangement was not found to be practical; for, from the frequent mounting and dismounting, the fore-sight constantly broke off close to the screw socket, and considerable delay was caused in extracting the end left in the socket. In order to remedy this defect the sight had to be removed during transport, which caused a delay in getting the gun ready for action. The incendiary power possessed by the double shell issued to these guns is very great, and by their introduction into our service the main defect in our mountain guns would be remedied.

Two rocket V's for Hale's rockets, which had never been used on active service before, were attached to each 7-pr. mountain battery, and gave very satisfactory results under the circumstances existing in Abyssinia. These rockets produced a certain moral effect on these barbarous tribes, partly through the fact of their being visible throughout their flight, and partly on account of the noise made by the escaping gas; but their actual effect is insignificant, chiefly because they have only solid heads. The heavier natures of naval rockets have hollow heads, which are filled and used as shells, and this principle might perhaps with advantage be applied to the lower natures. If such a rocket strikes a hard object before being burnt out, it will burst and set fire to any combustible material in the vicinity. As yet, the question of rockets has not been solved. In their present state they will not be of much use in European wars, but with a few improvements they may yet be introduced for mountain service and for flying cavalry columns, on account of their great portability, range, and tolerable accuracy. One horse can easily carry a V and from fifteen to twenty rockets.

Special pack-saddles were made for the transport of the 7-pr. guns, with their carriages and stores. The gun is placed transversely on the mule's back, and the carriage lengthwise. No delay ever occurred, even in the narrowest passes, and the advantage gained by bringing the load nearer to the animal's back outweighs all disadvantages.

The men who served these guns consisted of English artillery soldiers, all old hands, and for the most part intelligent men; the non-commissioned officers especially, not to mention the officers, gave one the impression of a scientifically instructed corps.

The Englishman is with justice proud of his sailors, and the Commander-in-Chief, with a proper estimation of their qualities and of the national feeling in their favour, decided to form a so-called Naval Brigade, to be employed in serving two 6-pr. rocket batteries, thus giving them the opportunity of showing their countrymen at home that the British sailor knows how to behave like a man on shore as well as at sea. Nor did they cause any disappointment, for they were quite at home in their new occupation, and formed, in a word, a first-rate corps.

The most interesting circumstance connected with the 12-pr. Armstrong battery was that four of its guns (two remaining at Addigerat) were carried from Antalo, whence there was no road, on the backs of elephants, over the most difficult ground—the steepest, stoniest, and narrowest passes and mountain gorges.

The elephants possessed a wonderful degree of training, not to say intelligence. These animals, so docile and obedient to their keepers, made an immense impression on the inhabitants, who only knew them in their wild state. It was a bold experiment to employ these animals, accustomed as they were to the hot Indian climate and good roads, on such vile roads and in such a variable temperature as that of Abyssinia, but they would have been of material service if Magdala had been more vigorously defended; for there is no doubt that if Theodore had not given up the positions of Fala and Islamgee, in consequence of his unaccountable attack on the 10th of April, and the consequent demoralisation of his troops, a severe bombardment would have been necessary. This circumstance alone made it possible to bombard Magdala from the dominating position of Islamgee, and to take this almost impregnable position. The experiment, however, succeeded capitally, and the elephants, in spite of all obstacles, arrived before Magdala with the troops, in a surprisingly good condition.

These animals were treated with the greatest care, and even if the whole army had been obliged to suffer from hunger, the Commander-in-Chief would yet have given the elephants their full rations. They had, however, to suffer great privations in some places, in consequence of the enormous quantity of water they require, and where it was impossible to give them sufficient to drink. They suffered most before and after the capture of Magdala, as there, as well as on the plateau of Arrogy, there was no water, and the poor beasts had to go six miles to drink the water of the Bashilo, which was tainted with the carcasses of dead animals. At first it was feared that the stony roads would cut their feet, and in consequence thick leather shoes were provided for them. It was soon seen, however, that this precaution was unnecessary, as the elephants picked their way so cleverly, and even pushed stones on one side with their trunks, that their feet suffered little —much less than the camels, which, notwithstanding the climate agreeing with them better, could not on this account have borne the march as far as Magdala. Their saddles were very cumbersome, and the whole arrangement struck me as very primitive. To mount the guns on them, the elephants were made to kneel down, when two skids were placed resting against them, and the gun pinched and parbuckled up. The two 8-inch mortars were carried in a similar way.

The gunners of the Armstrong battery were very muscular, fine, soldier-like men; many had taken part in several previous campaigns, and some had as many as five medals.

Infantry.

There was no opportunity of forming an accurate opinion of the power of manœuvring of the English infantry, as the only time I saw them formed up and exercised was at the review held at Senafe in honour of the birthday of Her Majesty the Queen. The English infantry is formed up in two ranks, three (?) paces from one another. On the march, the rear rank closes up to the front rank to such an extent, that the feet of the rear rank men can only tread in the intervals of the feet of the front rank, which of course hinders their advance very much, and struck me as incredibly unpractical. The movements are rather complicated, and devoid of that pliancy and lightness which are such prominent qualities of good infantry, and which are found to such an extent in our riflemen, and in the French light infantry, and are very properly admired. This arm in general gave the impression of great solidity, and of as great moral and physical courage and steadiness as is to be expected from the descendants of those troops who won such immortal fame in Spain, and who were considered by Napoleon and Marshal Bugeaud as the best in the world—which, however, refers more to their actual fighting power than to movements.

The English infantry were armed with the Snider rifle. The disadvantages of this rifle appear to be the extra motion entailed by drawing back an extractor used to disengage the old cartridge, and the recoil is very great. It has the appearance of our Wängel rifle, has a similar simple construction, only it is more clumsy and heavier.

Land Transport Corps.

The success or failure—yea, the very possibility of carrying out the undertaking at all, depended upon the organisation of the Land Transport Corps. Lord Napier, with a true military eye, foresaw the importance and difficulties of this department, and his most earnest attention was devoted to the organisation of this corps.

Unfortunately, at the very commencement, he met with the greatest difficulties from the Bombay Government, which consisted of five members, amongst whom Lord Napier was the only military authority. His very proper demands met with no adequate consideration, but in the end his wishes had to be complied with. However, this was not done till the last moment, in the greatest hurry, and in consequence the arrangements were of necessity defective, which gave rise to many difficulties.

The train had drivers of all nations, and the pack animals consisted of camels, mules, donkeys, horses, and bullocks. The camels and bullocks did not answer at all well. The pack-horses answered well; they carried nearly as much as the mules, and their mortality was less. It is impossible that horses, mules, oxen, and camels can march together without one delaying the other. I consider this the chief cause of the bad and straggling marches, and the unnecessary weariness of the troops. There were pack-saddles of every description—the Otago, M'Mahon, Jacob, Hungarian, Punjaub, &c. The one which I consider the best, on the whole, is the Otago saddle, with a few modifications, only it is rather heavy and expensive. As the improvement of pack saddles and cavalry saddles is of special importance to the military profession, it would really be worth while to offer a prize for the best pack and the best cavalry saddles, which would probably be the means of making some forward step in this question. At the close of the expedition many of the beasts were sold, others shipped off to India, and some given as presents to the Prince of Tigre.

So ended the Land Transport Corps, the raising of which had cost so much in trouble and money. Yet the sad experience it taught will not have been lost; for repeatedly have I heard the question mooted of giving this corps a permanent organisation for the Indian army, of which the cadres at least should be always maintained.

Commissariat.

The Commissariat of the Indian army is stated by all competent officers to be much better than the English one. Yet its organisation was not sufficiently elastic for such a variety of circumstances—from what cause I am unable to say; perhaps it was short in numbers, or perhaps the Civil Government of Bombay wished purposely to cut down the *matériel* with which the Commander-in-Chief had to carry out this difficult task; but there is no doubt that the *personnel* and *matériel* were too small for such a gigantic undertaking.

The whole had the character of great looseness. It was often difficult to decide where the desirable independence ceased and the want of organisation began. The want of a regulated administration and organisation was perceptible, like that which caused the unfortunate results which happened in the Crimean war.

Sanitary Arrangements.

The arrangements of the hospital ships could not be called good. They were old wooden boxes, with bad ventilation and defective arrangements, and however wonderful this may sound of English ships, much was to be desired in the way of cleanliness.

Postal and Courier Arrangements.

Altogether it cannot be said that these were sufficient. One of the most important defects was, that no Post-Masters were sent out from England, who would at least have set it all in good working order in a short time. Another evil was, that the packets of letters were allowed to be opened at every station. At the Post Office at Zoulla all letters should have been sorted and divided, and so sent direct to their proper stations.

Na	ximate rules for g length of fuze onds for a given	Remarks.
5 seconds	e range by 2,* and 1000 add 1.	Painted red.
9 〃	e range by 2,* and	These fuzes, when issued for field or boat service, have increased priming round the head.
20 〃	1000 ...... 1 to 2000 ... 2 to 3000 ... 3	
Pettman's g	—	
5 seconds	e range by 2,* and 1000 add 1.	Painted red.
9 〃	e range by 2,* and	
20 〃	1000 ...... 1 to 2000 ... 2 to 3000 ... 3	
Pettman's g	—	
"C" percus	—	
Time, diaphr	t 6 from the .*	
Time, comm	t 5 from the .*	
9 seconds M	do.	
20 〃	do.	
Mortar, larg	7 to range.*	For ranges below 750 yds., double the range plus 10.
〃 smal	4 to range.*	
Pettman's la	—	
〃 ge	—	

e same remark will apply.

econds.

N *aval" shell, for S.B. ordnance, are distinct projectiles.*

TABLE OF SERVICE FUZES.

Name of fuze.	Length of composition, inches.	Time of burning, seconds.	Shells used with.	Gauge of fuze-hole.	Other natures that the fuze can be used with on an emergency.	Approximate rules for obtaining length of fuze in $\frac{1}{2}$ seconds for a given range.†	Remarks.
M.L.R. ORDNANCE.							
5 seconds M.L.O.	2 Mealed powder.	5	Shrapnel for M.L.R. field guns.	General service.	All shells for M.L.R.O. and S.B. naval shell, when time of flight does not exceed 5 seconds.	Divide range by 2,* and if over 1000 add 1.	Painted red.
9 „ „	2	10	All shells for M.L.R.O.	do.	—	Divide range by 2,* and add— Up to 1000 ...... 1 1000 to 2000 ... 2 2000 to 3000 ... 3	These fuzes, when issued for field or boat service, have increased priming round the head.
20 „ „	4	20	Do., except shrapnel.	do.	—		
Pettman's general service	Percussion.	—	Do., except shrapnel.	do.	—	—	
B.L.R. ORDNANCE.							
5 seconds B.L.R.O.	2 Mealed powder.	5	Shrapnel for 12 and 9-pr.	General service.	All shells for B.L.R.O. or M.L.R.O., when time of flight does not exceed 5 seconds.	Divide range by 2,* and if over 1000 add 1.	Painted red.
9 „ „	2	10	Common, segment, or shrapnel for 7-inch, 64 and 40-pr.; common for 20-pr. S.S.	do.	Shrapnel for 12 and 9-pr. and all shells for M.L.R.O.	Divide range by 2,* and add— Up to 1000 ...... 1 1000 to 2000 .. 2 2000 to 3000 ... 3	
20 „ „	4	20	7-inch, 64 and 40-pr. common, and 20-pr. S.S. common.	do.	Do., except shrapnel.		
Pettman's general service	Percussion.	—	do.	do.	—	—	
"C" percussion	do.	—	Common or segment for 20, 12, 9, and 6-pr.	Field service.	—	—	
S.B. ORDNANCE.							
Time, diaphragm, shrapnel	1	5	All diaphragm.	Common.	Any S.B. common shell, if time of flight does not exceed 5 seconds.	Subtract 6 from the range.*	
Time, common	2	10	All S.B. common.§	do.	—	Subtract 5 from the range.*	
9 seconds M.L.O.	2	10	Naval.	General service.	—	do.	
20 „ „	4	20	do.	do.	24 and 12-pr. common shells, when fired from bronze mortars and time of flight exceeds 10 seconds.	do.	
Mortar, large	6	30	13, 10, and 8-inch mortar shells.	Mortar.	—	Add 17 to range.*	For ranges below 750 yds., double the range plus 10.
„ small ‡	3	15	24 and 12-pr. common, when fired from $5\frac{1}{2}$ and $4\frac{2}{5}$-inch mortars, at times of flight over 7 seconds with $5\frac{1}{2}$, and 10 seconds with $4\frac{2}{5}$-inch.	Common.	Any S.B. common shell.	Add 14 to range.*	
Pettman's land service	Percussion.	—	All S.B. shells having a × on the plug.	do.	—	—	
„ general service	do.	—	Naval.	General service.	—	—	

* In hundreds of yards in each case. These rules are not in every case suitable for very short ranges.

† The numbers on all fuzes, excepting mortar fuzes, denote $\frac{1}{2}$ seconds; in the mortar fuzes, if the figures be multiplied by 10 the same remark will apply.

‡ This fuze must be packed when used with the $4\frac{2}{5}$-inch shell.

§ Including 24 and 12-pr. common shells, when fired from the bronze mortars and the time of flight does not exceed 10 seconds.

N.B.—All the rifled ordnance time fuzes can be used as percussion, against earthworks, ships, &c. *It should be remembered that "common" and "naval" shell, for S.B. ordnance, are distinct projectiles.*

THE MOBILITY OF FIELD ARTILLERY;

PAST AND PRESENT.

BY LIEUT. H. W. L. HIME, R.A.

[No. III.]

"Die Schöpfung der reitenden Artillerie . . . . kann als kein zufälliges Ereigniss angesehen werden, sondern war unzweifelhaft ein Ausdruck der tief empfundenen Nothwendigkeit, die vergeblich angestrebte Beweglichkeit der Feldartillerie auf einem andern als dem bisherigen Wege zu erreichen."—*Gen. von Taubert.* "*Der Gebrauch der Art. im Feldkriege.*"

THE close of the first half of the 18th century left the military world actively engaged in the attempt to construct some system of artillery that could move as well as fire, and the beginning of the second half of the century found it engaged in the self-same task. The matter was one which received the greatest attention; for men were impressed, and justly impressed, with the conviction that that state which first became possessed of a powerful artillery would obtain a marked preponderance in the affairs of Europe, and the feeling was daily growing stronger and stronger that, in the words of Frederick the Great, "l'artillerie fait dans tous les temps le destin des états." The system of artillery so eagerly sought after would naturally be first constructed in that country in which circumstances were most favourable for its invention. The seed had been sown broadcast over Europe, and the flower would necessarily spring up first where the soil was best suited to its growth. The successful state, in short, would be that in which the five following conditions were most perfectly fulfilled:—First, the nation should be involved in some great war, which would render the possession of a powerful artillery a matter of imperative necessity. Secondly, it should possess a well-disciplined cavalry and infantry, which could move with such precision and celerity as to throw the immobility of the artillery into striking relief. Thirdly, circumstances should exist to render a closer connection between the artillery and the other arms desirable, if not necessary. Fourthly, the state should contain at least one man of ability devoted to the artillery service. Fifthly, this man should possess the power to enforce the adoption of his plans.

Most countries in Europe fulfilled the first of these conditions, but none so perfectly as Prussia. In the Silesian wars she fought for conquest, but there were moments during the Seven Years' War when she fought for existence. No nation at the time I speak of was engaged in so gigantic a struggle.

As regards the second condition, Prussia far outstripped all competitors. By some freak of fortune, Frederick William, who ruled during the earlier part of the century, was born a king, not a corporal. With many hateful eccentricities, which in later times would have consigned him to a madhouse, he possessed one ungovernable passion—a passion for drill. A detestable martinet, like most martinets he had no claim to be called a soldier, and his gigantic troops would have been probably overborne had they engaged in war under his leadership; for his whole life had been devoted to insignificant details, and like Bunyan's "Man with the Muck Rake," he became so engrossed with the dust at his feet that he was unable to lift up his eyes and look around him. He was profoundly skilled in the dimensions of a shako, the rolling of a strap, the fitting of a buckle, and the position of a knapsack; yet he was contemptibly ignorant of everything connected with war. He was a saddler, he was a tailor—he was anything but a soldier. Happily for his country and for his successor, Frederick William's love of drill was coupled with a love of peace, and he consequently handed over to his son intact the best drilled cavalry and infantry in Europe.[1] In no army, therefore, was the slowness of movement of the field artillery so conspicuous; in no army did it clog the motion of the other troops to so great and so palpable an extent;[2] and it was but natural for Frederick the Great on his accession to regard the artillery as little more than a necessary evil.[3]

The third condition was fulfilled only in Prussia. On his accession to the throne, Frederick the Great found that his cavalry had been drilled to fire in line at the halt.[4] The pernicious consequences of this system were so evident at the battle of Molwitz that he abolished it without delay, and by so doing rendered a closer connection between the artillery and the cavalry a matter of essential importance to the latter. The cavalry had been deprived of their fire, and the necessity thus arose for the creation of a branch of artillery that could manœuvre with that arm.[5]

In the fourth condition Austria rivalled Prussia, and France equalled her, if she did not surpass her; for if Prussia possessed Frederick, Austria owned Prince Lichtenstein,[6] and France could boast of Gribeauval. But in the fifth condition Prussia outstripped both; for while Frederick was an absolute monarch, whose will was law, Lichtenstein's influence, although great, was by no means supreme, and Gribeauval was for years exposed to the attacks of stupidity and the accusations of calumny.

Thus, while all the powers of Europe fulfilled some of the five conditions, Prussia alone fulfilled them all. In Prussia, therefore, by the principle of Natural Selection, the invention would be made, and there as a matter of fact it was made.

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[1] "Die Entwickelung der Taktik," von Boguslawski. Berlin, 1869, p. 187.

[2] "Als impediment der Heeresbewegungen hatte er (Frederick) die Artillerie vorgefunden." "Die Beziehungen Friedrich des Grossen zu seiner Artillerie," von Troschke, p. 3.

[3] "Er die Artillerie geradezu für ein notwendiges Uebel erklärte."—Ibid. p. 5.

[4] Nolan's "Cavalry Tactics," p. 30.

[5] "La Cavalerie ne rend pas de feux, et ne peut se battre qu' à l'arme blanche. C'est pour subvenir à ce besoin qu'on a créé l'artillerie à cheval."—Napoleon, in Montholon, Tom. III. p. 261.

"Friedrichs II. Kavallerie verlangte eine feuerwaffe. 'Ihr sollt sie haben und zwar die beste von der Welt,' erwiederte der König, und er gab ihr die reitende Artillerie."—Von Troschke, p. 39.

[6] For a brief description of the improvements introduced into the Austrian artillery by Prince Lichtenstein, see "Die Kriegsmacht Oesterreichs." Wien, 1871, p. 35.

But to render the invention of horse artillery a signal one, it was necessary that some means should be devised of carrying on the gun-carriage or limber such a quantity of ammunition as would make the gunners and their gun independent, to a certain degree, of the wagons, and would enable them to make rapid movements, within certain limits, without the contingency of being perplexed and delayed by ammunition carts; for to enable the guns and their detachments to move with rapidity unaccompanied by the ammunition, would be as glaring an absurdity as to render the guns and ammunition capable of rapid movement unaccompanied by their gunners. Field artillery consists of three elements—the gunners, the guns, and the ammunition, and I have already defined its mobility to be the capacity of moving, not one or two of these elements, but the three combined in one whole, from point to point of a battle-field. The want in question was supplied by the invention of limber-boxes, shortly after the beginning of the Seven Years' War. Whether Captain von Holtzman of the Prussian artillery stumbled across this invention independently,[1] or whether it was suggested to him by the small limber-boxes of the French battalion guns,[2] or by the trail ammunition-boxes of the Austrian 3-prs.,[3] I know not; but certain it is that about the beginning of the Seven Years' War, limber-boxes were known in Germany. This invention is the fourth landmark in the history of the mobility of field artillery.

The artillery of the army which Frederick led into Silesia in 1741 consisted of 42 pieces—viz., twenty 3-prs., eight 12-prs., four 18-pr. howitzers, and ten 50-pr. mortars.[4] At the very first battle of the war, Molwitz, Frederick saw for himself that the fire of his guns was ineffective, and that the guns themselves could only be moved from position to position with extreme difficulty. To remedy the first of these evils, he commanded the captains and lieutenants of artillery to spare no pains in placing and laying their guns, for the efficacy of whose fire he made them exclusively responsible,[5] and he afterwards framed rules to protect his artillery officers as much as possible from the ignorant, irritating, and mischievous interference of generals and staff officers, by whom gunners in all ages have been sorely let and hindered in the execution of their duty.[6] To remedy the second evil, the king saw clearly that extensive and radical changes were required, and of such pressing

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[1] "Ausser den bereits erwähnten Kammerstücken ist die hochwichtige Erfindung der Kastenprotze von ihm ausgegangen, welche in der Zeit bis zum siebenyährigen Kriege diejenigen Veranderungen erlitt."—Von Troschke, p. 10.

[2] "Ladite pièce à la Suédoise sera montée sur son affût et un avant-train; elle sera garnie d'un coffre qui contiendra les munitions nécessaires."—Second Article of an Ordonnance of the French king, 20th January, 1757, given in the Emp. Napoleon's "Etudes, &c." Tom. IV. p. 95.

[3] Ibid. Tom. IV. p. 100.

[4] Von Troschke, p. 20.

[5] "The Captains and Lieutenants of Artillery shall point their guns themselves, and not trust the duty to the gunners."—Extract from General Orders issued the day after Molwitz by Frederick the Great, in the "British Military Library." London, 1801, Vol. II.

[6] "It likewise happens that the general in command, or some other general, is himself forgetful, and orders the guns to open fire too soon, merely to astound his own troops, without considering what injurious consequences may result from it. In such a case an artillery officer must certainly obey, but he should fire as slowly as possible, and lay the guns with every possible accuracy, in order that all his shots may not be thrown away."—Frederick, in Taubert, "On the use of Field Artillery," p. 78. This order was published some forty years after Molwitz, it is true, but it shows the bent of the king's mind, and the Potsdam Regulations were probably elaborated from some earlier code.

necessity did he consider it to commence these changes without delay, that on the 11th Aug. 1741, only four months after Molwitz, he communicated to Prince Leopold of Anhalt-Dessau a scheme for the re-organisation of the field artillery. The king proposed to suppress 6-prs. altogether, and to supply their place with 3-prs., because the latter were easy of draught and could be fired rapidly.[1] From the king's letter it is evident that he had been revolving in his mind the whole question of the equipment, if not the organisation, of field artillery, and the most natural and reasonable solution of this profound problem, viewed from his standing point, was undoubtedly the adoption of 3-prs. In our days, when we can read the present by the light of the past, and when the field artillery question has been discussed again and again, it would be easy to criticise with a remorseless criticism the proposals of Frederick. Let us remember, however, that in his time military history can scarcely be said to have existed, and that field artillery was still in a state of puling infancy; that the organisation of the means of draught—the drivers, the horses, and the harness—was so bad that even the lightest guns had to be moved by hand when under fire; and that the field artillery question is at once so extensive, so complicated, and so variable, that a final solution of it is impossible. It may be solved to suit particular times, and particular places; but, I repeat, it can never be solved generally and finally. For the state of artillery at any given period is ultimately dependent upon the state of chemistry and metallurgy at that period; and who can fix the bounds, or determine the course, of the arts and sciences?

The first point to be settled in organising a system of field artillery, is the means of draught available for the guns. There are but five known means of draught for artillery purposes—men, oxen, elephants, traction engines, and horses. If the guns are to be of any effective calibre, the accumulated experience of ages proves that men are too feeble for the work; and if the guns are to move at a rapid pace, it is no less certain that oxen are too slow. Elephants are too timid,[2] and the question of traction engines is still in embryo.[3] The horse, therefore, remains as the last and best means of draught at the present time.

The nature of the means of draught being settled, the next question to be determined is the greatest number of horses that can work together effectively at the three paces available for draught which the horse possesses—the walk, the trot, and the gallop.[4] On such matters as these there will always

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[1] "Ich bin gesonnen . . . dass solche aus 60 3-pfündern bestehen soll, hingegen ich alle die 6-pfünder abschaffen und umgiessen lassen will, weil erstere besser zu traktiren sind und damit geschwinder gefeuert werden kann."—Fred. to Prince Leopold, in Troschke, p. 22.

[2] It is said that the difficulty of bringing elephants under fire arises as much from the unwillingness of the drivers as from the timidity of the elephants; and I am informed that during the action of Meeah Gunj, in Oudh, 1858, where the drivers were threatened with instant death unless the guns were brought up without delay, the elephants showed little signs of reluctance.

[3] See Mr. H. Bessemer's letter, in the "Railway Times" of the 15th Oct. 1870, and an account of experiments carried on at Lincoln on the 30th Nov. 1870, in the Dublin "Daily Express" of the 26th Dec. 1870. Mr. I. Brunel concludes a lengthened comparison of the horse and traction engines with the following words:—"There is not at present any substitute for horse power on common roads, and, as far as the public is concerned, nothing has yet been done."—"Essay on Draught," in Youatt on "The Horse," 1859, p. 543. I believe the introduction of traction engines for heavy field artillery to be merely a question of time.

[4] "The canter is a pace of ease, quite inconsistent with any exertion of draught."—Brunel's "Essay on Draught," p. 547.

be a diversity of opinion; but perhaps the majority of officers will agree that 12 horses, 4 abreast, are the greatest number that can draw together effectively at a walk;[1] that 8 horses, 2 abreast, are the greatest number that can draw together effectively at a trot;[2] and that 6 horses, 2 abreast, are the greatest number that can draw together effectively at a gallop.

The third step is to consider, first, what is the maximum load that 12 horses, 4 abreast, can draw effectively at a walk; secondly, what is the maximum load that 8 horses, 2 abreast, can draw effectively at a trot; and thirdly, what is the maximum load that 6 horses, 2 abreast, can draw effectively at a gallop. The answer to the first question is, in round numbers, 80 cwt.; that to the second, 40 cwt.; and that to the third, 30 cwt.

And here the question abruptly leaves the province of mobility and enters that of efficacy of fire, the next consideration being the proper weight of the projectile for field artillery that walks, field artillery that trots, and field artillery that gallops—or in other words, for heavy, medium, and light field artillery. The weight of the projectile being settled in each case, the number of rounds that ought to be carried in the gun-limber must be determined. This is a difficult question, and on its solution depends the weight of the limber, which must be reduced to a minimum. The sum of the weights of the ammunition and the limber being subtracted from the total weight behind the horses, in each of the three cases, the remainder gives the total weight of the gun and carriage. The diameter of the shot, and consequently the calibre of the gun, is determined by the equation—

$$\text{Power of gun} = \frac{w}{d^2}$$

where w is the weight of the projectile, and d its diameter. The value of the equation must be made, within certain limits, a maximum. The calibre of the gun being thus found, and the sum of the weights of the gun and carriage being known, the ratio of the weights of the gun and carriage must be calculated, on the principle that the weight of the gun should be maximum, and the weight of the carriage minimum.[3]

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[1] I have seen 24 horses, 2 abreast, employed to drag guns through the deep sand on the banks of the river Chumbul, in Central India, but I believe 12 horses, 4 abreast—certainly 16 horses, 4 abreast—would have done the work more efficiently. In the case I refer to, none of the wheel harness gave way, but several traces belonging to the foremost pairs of horses snapped, and one of the lead horses burst a blood-vessel in his head.

[2] I am inclined to think the Swedish mode of draught with 8 horses the best—*i.e.*, 3 horses in the lead, 3 in the centre, and 2 in the wheel. See Jacobi's "Etat actuel de l'Artillerie de campagne Suédoise; traduit de l'Allemand par Lenglier." Paris, 1849, p. 88. By shifting the shafts from double to single draught, and hooking swingle-trees to the outside trace-hook-eyes, we can work three horses abreast in the English field artillery—the lead driver riding the centre leader, and the wheel driver the near wheeler. The leading rein of the off wheeler can be lengthened by the swingle-tree strap.

[3] I do not venture even to suggest a solution to these problems, because they lie beyond the bounds of the subject I am writing on—the Mobility of Field Artillery. Let them be solved by those who have studied them carefully and understand them better than I do. See Col. H. H. Maxwell, on "The Field Gun for India," in the "Proceedings, R.A. Institution," Vol. VI. p. 479; Lieut. C. Jones, R.A., on "The Future Armament of our Field Artillery," Ibid. Vol. VII. p. 252; and Lieut. J. Sladen, on "The merits of a Large Bore and Small Bore contrasted, in reference to Rifled Artillery," Ibid. Vol. VII. p. 273.

The matter again enters within the sphere of mobility at this point, and now must be arranged the means of conveying the gunners with their guns and ammunition, and of thus combining into one whole the three elements of which field artillery is composed;[1] for though the gun be never so light, and though the horses be never so swift, the arm possesses no real mobility unless the guns, gunners, and ammunition are bound together by indissoluble bonds.

There are but five modes of establishing a connecting link between the guns and ammunition and the gunners:—First, by mounting the gunners on horses, or the detachment system; secondly, by mounting them on the off-horses of the gun and wagon teams, or the off-horse system; thirdly, by mounting them on the gun-carriage and limber, or the gun-carriage system; fourthly, by mounting them on carriages specially constructed for their conveyance, or the car system; and fifthly, by mounting them on the ammunition wagons, or the wagon system.[2]

Such is a rough outline of the formidable problem, or group of problems, with which Frederick suddenly found himself face to face, and which he endeavoured to solve practically by adopting an equipment of 3-prs. He proposed 3-prs. for the reasons I have already mentioned, and his scheme certainly fulfilled the two conditions which the best writers of the day considered essential to the success of the arm. "Un Commandant d'Artillerie," says the Marquis de Quincy, "doit avoir deux buts principaux dans une bataille. Le premier est de rendre son artillerie si légère qu'il puisse la conduire partout avec diligence. Le second, de pouvoir s'en servir frequemment et vivement."[3] The Prussian king and the French marquis alike fell into the double error of mistaking lightness for mobility and rapidity of fire for efficacy of fire; and further, they confined their attention to one head only of that Hydra-headed monster, field artillery. We shall judge their errors with the more lenity if we consider that they have been carefully perpetuated, and may be met with, not only in our daily newspapers, but in some standard works on artillery.

Prince Leopold of Anhalt-Dessau was an able man, and his answer to the king's letter proposing the adoption of 3-prs. and the suppression of 6-prs. was at once reasonable and firm. The 3-prs., the prince thought, might be doubled in number; but no train of artillery, in his opinion, would be complete without two or four howitzers, six 12-prs., and ten 6-prs.[4]

The king's correspondence on artillery matters, which thus began with Prince Leopold, was not only continued with him, but gradually extended itself to other officers, and as time passed on and the king's desire to improve his artillery became more generally known, changes were proposed by many of them in the *matériel* of the arm, and a series of experiments was set on foot. These discussions and experiments finally resulted in the entire separation of

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[1] This question, it is almost needless to say, arises only in the medium and light field artillery, where the rate of motion of the gun and ammunition exceeds that of men on foot. Dismounted gunners can keep pace with heavy, or position artillery.

[2] There are, of course, innumerable combinations of these five systems; but in a paper of limited length, like the present, it would be impossible to descend into such details. I venture to do nothing more than state the question broadly and generally.

[3] "Maximes et Instructions sur l'Art Militaire." Paris, 1726, p. 323.

[4] Von Troschke, p. 22.

field from garrison artillery, and the organisation of the former into brigades of ten guns each, instead of the old system of massing the guns in three or four huge unmanageable trains.[1]

Throughout these discussions may be clearly perceived the tendency of the king towards mobility, and the counter-tendency of his officers towards efficacy of fire. His thoughts were continually directed towards the care of the teams,[2] and so convinced was he of the value of light guns, that he caused a number of 1-prs. to be constructed for the Free-Battalions.[3] Had Frederick been one of those men whom Mediocrity loves to call her own, or had his naturally powerful mind been narrowed by prejudice and dulled by routine, his influence on the fortunes of the artillery at this critical period of its history would have been as pernicious as it was great. But his exalted position enabled him to soar above the mists of ignorance and custom, and his eagle glance penetrated through the paltry intrigues and petty factions of men in office and men seeking office. Beset by the arguments of his officers, and moved, perhaps, to a certain extent by the results of experiments, the king at length gave way before public opinion, and during the second year of the Seven Years' War he ordered a large number of field guns, and among them the obnoxious 6-pr., to be constructed—writing, however, to General von Linger at the same time, "Ihr wisst, dass Ich vom 6-pfünder nichts halte."[4]

Although doubtless they little dreamed that their movements were determined by forces which had come into operation before they were born, yet Frederick and his officers were but the agents of those large general influences which, as I have pointed out in a previous paper, brought about a return to heavy calibres towards the year 1759, and which directed the course of field artillery, not in Prussia only, but in every country of Europe. Frederick was the representative of the spirit of reaction; his officers were the representatives of the spirit of *statu quo;* and it is to the conflict between the two, carried on by free discussion and honest experiment, that we owe the invention of horse artillery. The end which the king proposed to gain was good, but the means by which he sought to reach it were bad, and in as far as related to the 6-prs., the movement of the party represented by Prince Leopold was undoubtedly in the right direction. The king gave way before their calm and reasonable arguments, but he gave way exclaiming, "Ihr wisst, dass Ich vom 6-pfünder nichts halte." He was persuaded by the beneficial opposition of his artillery officers of the badness of the means by which he sought to reach the desired end; but he remained convinced beyond persuasion of the supreme goodness of that end, and he was thus led to apply his splendid intellect to the task of devising some new and better

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[1] Von Troschke, p. 24.

[2] Ibid. p. 20. Frederick's "Secret Instructions."

[3] Ibid. p. 28.

[4] Ibid. p. 29. I cannot admit the comparison which Gen. von Troschke draws between the suppression of the French 4-prs. and 8-prs. by Napoleon in his Italian campaigns, and the suppression of the 6-prs. by Frederick; because if Napoleon's account of the matter be accepted, there is no analogy between the two cases. Napoleon says:—"L'Empereur a supprimé les pièces de 4 et de 8; il y a substitué les pièces de 6; l'expérience lui avait démontré que les généraux d'infanterie faisaient usage indistinctement de pièces du calibre de 4 ou de 8, sans avoir égard à l'effet qu'ils voulaient produire."—"Correspondance de Napoleon I." Tom. XXXI. p. 326.

method of increasing the mobility of his artillery. Years passed over before the matter came to a definite issue, and it was not until the 21st April, 1759, that Frederick communicated the result of his meditations to his minister, von Schlabrendorf, in a Cabinet Order given at the camp of Landshut,[1] directing him to issue from his treasury the sum of money required to equip a battery of light guns on the first, or detachment system.

So sprang into existence horse artillery, a branch of the field artillery service which owes its origin to no sudden inspiration, no happy accident, but to patient thought and a series of experiments extending over a period of 18 years.[2] Its invention forms the fifth landmark in the history of the mobility of the arm.

Little is known of the details of the carriages of Frederick's first horse battery. A large amount of ammunition, however, appears to have been carried in the limber—eighty rounds of round shot and twenty rounds of

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[1] "Mein lieber Etatsminister von Schlabrendorf!

Weil nach der Einlage zur Bedienung 6 6-pfündiger Kanons das darin specificirte erfordert wird, so kann ich es nicht ändern, als dass Ihr die dazu erforderlichen Gelder mit 2227 Thlr. 12 Gr. aus Eurer unterhabenden Militair-Casse bezahlen, auch deshalb mit dem Obersten von Krusemark correspondiren müsset, weil alles gemacht werden muss, und er solches und das uebrige schaffen soll. Alles dieses aber pressirt sehr. Ich bin Euer wohlaffectionirter König,

FRIEDRICH.

Landshut, den 21 April, 1759.
An den Etatsminister
von Schlabrendorf."

Die in der Einlage aufgestellte Bedarfs-und Kosten-Nachweiweisung lautet:—

"Zur Bedienung 6 6-pfündiger Kanons werden erfordert,

3 Unterofficiere,
42 Kanoniere.

Summa, 45 mann.

Dieser beritten zu machen kostet:—

45 Stück Pferde à 40 Thaler	1800 Thlr.	
45 Sättel nebst Zubehör à 6 Thaler	270 „	
45 Paar Stiefeln à 3 Thlr. 12 Gr.	157 „	12 Gr.

Summa, 2227 Thlr. 12 Gr."

See "Die königlich preussische reitende Artillerie vom Jahre 1759 bis 1816," von Strotha, p. 577.

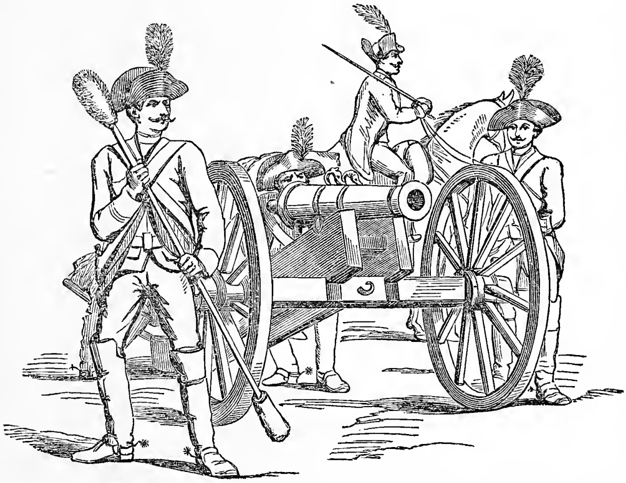
[2] According to the bombastic tract, "Ueber reitende Artillerie, was sie ist, sein sollte, und sein konnte," Leipsig, 1818, the author of which has wisely concealed his name, the invention of horse artillery was due to a kind of revelation:—"Herrliche, vortreffliche Waffe! die in dem Geiste des grossten Königes empfangen und geboren wurde, wie einst Minerva aus dem Hampte des Jupiters hervorging!" (p. 3).

With regard to the claim of the Russians to the invention of horse artillery, supported by Behrenhorst, Kalkreuth, and Seyfarth, I entirely agree with Gen. von Strotha (p. 1); "es ist jedoch möglich, dass die russischen Kavallerie-Geschütze Friedrich den Grossen auf die Idee gebracht haben, eine reitende Artillerie zu errichten; er gab ihr aber durch entsprechende Organisation die Befähigung zu einer höheren Bestimmung, und ist als der Schöpfer dieser Waffe zu betrachten." See also Gen. von Troschke's excellent *brochure*, p. 38.

The French claim rests upon a weaker foundation than the Russian; for even if Capt. Vregille independently invented horse artillery in 1762, he was three years behind Frederick. See the appendix of Nollet's "Mémoire de Gén. Drouot"—the worst of bad biographies.

canister, both fixed, according to General von Strotha.[1] There were six draught horses and three drivers for each gun, and the detachment consisted of seven or eight mounted gunners, one of whom acted as horse-holder. The riding horses of both teams and detachments carried dragoon saddles, behind which were fastened a corn-sack, a forage-cord, a bundle of hay, and a picketing-peg—an arrangement which made mounting and dismounting most serious operations, not lightly to be undertaken. The off-horses of the teams carried pads, and the officers and men were dressed much the same as the rest of the artillery. Each division of the battery was commanded by an under-officer, and the whole by an officer. A wagon-master and an artificer were responsible for the completeness of the carriages, and the drivers and horses were entrusted to the care of a commissary of horse. As the said commissary was generally some debilitated old drunkard ("halbinvalide Trunkenbolde"), and the drivers were selected from the scum of the army ("die Proletarier des Heeres"), one can easily understand how it happened that the Prussian horse artillery was destroyed in the first two great battles in which it took part, Kunersdorf and Maxen.[2]

Fig. 1.



Nothing can be further from the truth than to suppose that the new

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[1] "Die in der Protze mitgeführte Munition scheint, wie bei der Fussartillerie, 80 Kugel und 20 Kartätsch-Schüsse betragen zu haben."—Von Strotha, p. 3. The author of the "Ueber reitende Art. &c.," p. 20, mentions 90 rounds as the number carried in the earlier horse artillery. During the wars of the French Empire the number had decreased to 60. The English then carried 40. "Die Engländer führen etwa 40 Schuss auf der Protze; wir wollen eine Mittelzahl annehmen und 50 sagen."

[2] For the particulars of Frederick's first horse battery, see Von Strotha, pp. 1–3, 577–599; von Troschke, p. 36 et seq.; and Seyfarth's inaccurate description in his "Leben und Regierungs Geschichte Friedrich des Andern," Vol. II. p. 543.

Fig. 1 is a sketch of Frederick's horse artillery, from "Die Soldaten Friedrichs des Grossen," von E. Lange, p. 320.

I have to thank Lieuts. Place, Costobadie, and Craufurd, R.A., for the willing assistance they gave me in translating my German authorities. To Lieut. Lorraine, R.H.A., I am under very great obligations, for his never-failing help and advice.

invention was received with universal approbation. It was met with decided opposition, and the opponents of change were again the officers of artillery.[1] Again the upholders of stolid Conservatism were in violent collision with the champion of Liberalism, but on this occasion they were discomfited and overthrown; for the king, luckily for the artillery service, would brook no further opposition, and who could break down the fixed resolution of that iron will? Instead of entrusting the trials of the new battery to some captious and dilatory committee, the king in person undertook the task, and an English officer "saw him nearly every morning exercising this new corps himself, and directing its manœuvres."[2] The king was satisfied with what he saw, and horse artillery was assigned a permanent place in the unwilling ranks of the Prussian artillery.

It was not in Prussia only that the artillery were opposed to the new invention; for so infatuated were all the gunners in Europe with the lumbering *matériel* of a by-gone time, that for thirty years the Prussian was the only horse artillery in Europe.[3] The artillery was in those times a far more isolated and a far less educated service than it is at the present day, and, buried in prejudices and the worship of the past, the artillery officers for a dreary succession of years slept a sleep that knew no waking. A German writer, who never writes sensibly when speaking of the horse artillery, but who seldom writes foolishly in treating on other subjects, describes the gunners of Frederick's time as overwhelmed in ignorance, stupidity, bigotry, and self-conceit, both in his own country and in England,[4] and Gribeauval paints matters in France in even darker colours.[5]

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[1] "Die Officiere der Artillerie waren dagegen." Gen. von Kalkreuth, in the "Hist.-Biog. Nachrichten zur Gescht. der Brandenburghisch-Preussischen Artillerie," von. Schöning, 2 Theil.

The opposition encountered in its earlier days by the horse artillery, which he regards with superstitious veneration, calls forth unmeasured sympathy from the author of the "Ueber reitende Art. &c." p. 7:—"Herrliche Waffe," he exclaims, "du hast eine freudenlose Kindheit verlebt!" General Kalkreuth says, "much falsehood has been written about the horse artillery;" he might have added, much trash.

[2] "British Military Library," Vol. I. p. 19.

[3] Von Strotha.—Vorwort, p. VII.

[4] "Ueber reitende Art. &c." "Die Artilleristen der damaligen Zeit waren ungleich befangener als jetzt; die Laboratorienarbeiten, das mechanische Ausüben einer Wissenschaft, die eben nicht seit langer Zeit erst dazu erhoben worden war, und deshalb einen ansehnlichen Antheil von zunft-und handwerksmässigem Stoff hinterlassen hatte,—ein gewisser unausbleiblicher Schlendrian, und endlich die zu hohe Meinung, welche die Nichtartilleristen von der Artilleriewissenschaft hatten, alle diese Dinge legten der Freiheit des Gedankens," &c., &c.—p. 6.

"Von den Offizieren" (of the English artillery) "wird fast gar kein Theorie, aber desto mehr Praxis gefordert. Die hohe commission in Woolwich versügt über alles, was irgend nur zu dem theoretischen Theile gehort. Der Artillerist weiss wenig mehr, als dass die Kugel bei dieser Richtung so weit und bei jener so weit geht. Um alle übrige Mysterien der Geschützwissenschaft kümmert er sich nicht. Er hält fest an den Glauben, dass die in Woolwich es am besten wissen. 'Denn,' sagt er, 'wäre diese, oder jene Einrichtung nicht gut, so hätten wir sie nicht.'"—p. 64. The state of the English artillery in the middle of the 18th century may be judged from this account of its condition in the beginning of the 19th.

[5] "Un homme éclairé, sans passion, qui connoîtroit bien les details, &c., prendroit dans ces deux artilleries" (the French and Austrian) "de quoy en composer une qui décideroit presque toutes les actions dans la guerre de campagne: mais l'ignorance, l'amour-propre, ou la jalousie s'en mêlent toujours; c'est le diable, et l'on ne peut changer cela comme la façon des habits."—Gribeauval to M. de Choiseul, French War Minister, 3rd March, 1762; in the Emperor Napoleon III.'s "Etudes, &c." Tom. IV. p. 96.

In 1787 Frederick the Great died. No reaction, however, similar to that which occurred on the death of Gustavus Adolphus, took place in the artillery world. For Frederick had lived long enough not only to force upon the Prussian service, and compel the officers to accept for a number of years, the innovations of which he was author, but to educate his army to so great a degree as to convince them that his innovations were improvements; while Gustavus, appearing with the suddenness of a winter torrent, disappeared as suddenly into the realms of death—

> "Ins Baverland, wie ein geschwollern Strom,
> Ergotz sich dieser Gustav. . . . . . ."[1]

The Prussian artillery, therefore, did not retrograde, although perhaps it did not progress, after the death of Frederick.[2]

About the middle of the century the Austrians betook themselves to the task of creating a light field artillery, and, rejecting the detachment system which had been adopted in Prussia, they chose the fourth, or car system.[3] Owing, no doubt, to the feeble fire of the 3-prs. with which these batteries were armed, and to the inherent inconveniences of cars, the Austrians reorganised their cavalry artillery in 1778, and introduced the third, or gun-carriage system.[4] The new batteries consisted of six 6-prs., drawn by six horses each, and one 7-pr. howitzer, drawn by four. The carriages differed only from those of the medium guns in having a longer trail, on which was constructed an ammunition box which contained fourteen rounds for the gun and six for the howitzer.[5] Astride of this box rode five gunners, one behind the other, while a sixth gunner rode on the off-centre, or off-wheel horse of the team. The howitzer was commanded by a mounted bombardier, and each division of the guns by a corporal. On the limbers there were no ammunition boxes, but to each piece were attached two drivers and four pack-horses, which carried in their pack-saddles eighty rounds for the guns and forty for the howitzer.

In 1792 General Cardell organised a light artillery in Sweden after the Prussian fashion;[6] but owing probably to its costliness, the Swedes grew

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[1] Schiller's "Death of Wallenstein," III. 13.

[2] "Preussen stand still . . . Preussen war gezwungen fremde Erzeugnisse sich anzueignen, anstatt den Fremden ein Vorbild zu seyn."—"Ueber reitende Art. &c." p. 5.

[3] "Die Kriegsmacht Oesterreichs," Wien, 1871, p. 40. Scharnhorst, "Handbuch der Artillerie," Hanover, 1806, Band. II. p. 545.

[4] "Die Kriegs. Oesterr." p. 40. The "British Military Library," London, 1799, Vol. I. p. 19, gives the date as 1783; Carl von Decker says 1780; "Geschichte des Geschützwesens und der Artillerie in Europa," Berlin, 1822, p. 150. I am quite unable to explain these contradictions. In a note on a paper, "Ueber den ersten Gebrauch und die allgemeinere Einführung der reitenden Artillerie," which appeared in the Berlin "Militair-Wochenblatt," Part 30, p. 21, the editors make the following remark:—"In dem baierschen Erbfolgekriege, 1778, erschien sie schon als ein Haupttheil der preussischen Feld-Artillerie und die östreichsche Armee setzte ihr eine ähnliche leichte Artillerie entgegen." From this it might be inferred that the Austrians possessed a light field artillery on the detachment system in 1778. It is quite certain, however, that such was not the case. The only resemblance between the Austrian and Prussian light guns at the time in question lay in their lightness.

[5] Decker says the trail ammunition box contained only ten rounds for the gun. "Geschichte, &c," p. 150.

[6] Ibid. p. 147.

dissatisfied with it in 1797, and adopted a system which was a combination of the detachment and off-horse systems. The following table shows the constitution of the Swedish light artillery at the time I refer to:—[1]

	Under officers.	Bombardiers.	Trumpeters.	Gunners mounted on		Drivers.	Horses.		Remarks.
				Draught horses.	Detachment horses.		Draught.	Detachment.	
6-pr. guns (6)	4	2	1	36	30	—	36	37	The number of gunners available for the guns was much less than might be imagined at first sight, as a certain proportion were necessarily employed as drivers and horse-holders.
Wagons (3)	—	—	—	—	6	9	18	6	
7-pr. howitzers (1)	1	5	—	3	—	3	6	6	
Wagons (1)	—	—	—	—	2	3	6	2	
1 Surgeon......... 1 Collar-Maker 1 Shoeing-Smith	—	—	—	—	—	—	—	3	
Spare gun-carriages (1)...	—	—	—	—	—	3	6	—	
Train Wagons (1)	—	—	—	—	—	2	4	—	
Spare wagons (1)	—	—	—	—	—	3	6	—	
Reserve......................	1	1	—	—	—	4	8	2	
Total	6	8	1	39	38	27	90	56	
Grand total	6	8	1	77		27	146		

The partial rejection of the detachment system by Sweden and Hanover,[2] and its absolute rejection by Austria, did not escape the observation of the orthodox, and the apostacy of these powers called forth loud lamentations from a fanatical horde of horse artillerymen, who believed that the detachment system had been stolen from heaven by a modern Prometheus, and

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[1] Gen. von Strotha. "Die königlich preussische reitende Artillerie vom jahre 1759 bis 1816," Beilage XI.

[2] C. von Decker positively states that the Hanoverians followed the Prussian system; Scharnhorst as positively declares that they did not. The truth appears to be that the Hanoverian system was a compound of the detachment and gun-carriage systems. One N.C. officer and four gunners (including two horse-holders), were mounted on horses; two gunners were seated on the limber, and two on the trail. See Decker's "Geschichte der Geschützwesens, &c." p. 150; Scharnhorst's "Handbuch der Artillerie," Band II. p. 533.

that horse artillery was a branch rather of the cavalry than of the field artillery service.[1]

When Gribeauval returned to Paris from Germany in 1763, where he had studied all the details of the Prussian and Austrian artilleries,[2] he found the French artillery in a deplorable condition.[3] The French could only reap as they had sowed, and they were now reaping the bitter fruit of de Vallière's system. De Vallière *père* died in 1747, and was immediately succeeded by de Vallière *fils*, who inherited all his father's failings in an aggravated form and maintained all the vices of his father's system with a blind obstinacy which has happily been rarely equalled in military history:—

"Aetas parentum, pejor avis, tulit
Nos nequiores, mox daturos
Progeniem vitiosiorem." [4]

But his hour was fast approaching. The house was built upon the sands, and when the storms of war descended upon it it fell, and great was its fall. "La situation dans laquelle se trouve l'artillerie est effrayante; il est certain qu'il faut avoir du courage et de la fermeté pour oser en faire l'exposition." Such are the words in which M. Dubois described the state of the French artillery in an official report drawn up by order of the War Minister in 1763[5] Such a terrible pass, indeed, had affairs come to, that in spite of his unblushing effrontery and court influence, de Vallière *fils* was suspended in 1765, and Gribeauval was ordered to re-organise the artillery. To this formidable undertaking Gribeauval brought a powerful mind, a rare talent for organisation, and a large experience in the field. He drew out a comprehensive and able plan of reform without delay, and was about to carry it into execution when the intrigues of de Vallière and his disciples prevailed against him, and his star set:—

"Still her old empire to restore she tries,
For, born a goddess, Dulness never dies." [6]

His star set, but only to rise again in redoubled brightness after the lapse of a few years. For civilisation, with the attendant arts and sciences, was

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[1] "Oesterreich und Schweden verletzten ihn," cries the author of the "Ueber reitende Art. &c." p. 4, "und würdigten das Götterkind zum Krüppel herab; sie raubten der Waffe ihre schönsie Eigenthümlichkeit, und unter ihren Händen wurde sie ein gebrechliches Zwitterwerkzeug ohne Einklang, Kraft, und Geist."

[2] He commanded the Austrian artillery (or portions of it) on many occasions during the Seven Years' War, and he further visited Berlin for the purpose of making himself acquainted with the details of the Prussian artillery. Favé's "Hist. et Tact. des Trois Armes," p. 145. Von Troschke, p. 15.

[3] Speaking of the disasters of the French arms in the middle of the 18th century, the Emperor Napoleon III. says:—"L'Exposé de l'état désastreux oú se trouvait notre matériel d'artillerie sert à la fois à faire comprendre l'infériorité hontense des armées françaises à cette époque et l'importance des changements qui ont suivi."—"Etudes, &c." Tom IV. p. 103.

[4] Horace.

[5] "Etudes, &c." Tom. IV. p. 103.

[6] Pope's "Dunciad."

"The dictum that truth always triumphs over persecution, is one of those pleasant falsehoods which men repeat after one another till they pass into commonplaces, but which all experience refutes. History teems with instances of truth put down by persecution. If not suppressed for ever, it may be thrown back for centuries."—Mr. J. S. Mill's "Essay on Liberty," p. 16.

advancing with swift and irresistible progress in France;[1] the spirit of reform was fast undermining the strongholds of Dulness; and her chief priest, de Vallière *fils*, was laid with his fathers in 1776. On his death, Gribeauval was recalled to office.

Judged by his work, taken as a whole, Gribeauval was the greatest reformer, certainly in the *matériel*, probably in the *personnel*, the artillery world has yet seen; and the uniformity, simplicity, solidity, and lightness of his system, which was founded upon the complete separation of field from siege artillery,[2] have deservedly gained for him an honourable and enduring reputation. But his system by no means attained to that absolute perfection which critics whose criticism consists of either unqualified praise or unmixed blame would have us believe. His carriages, though lighter than those of the Vallière system,[3] were still too heavy; his gunners were afoot; not a shot could be fired on coming into action until his guns had been shifted from the travelling to the firing trunnion holes;[4] and holding fast by the antiquated notion that guns should be dragged about by men when under fire, he laid much stress on the man-harness he constructed for that purpose. Finally, thwarted by the irrational and malicious opposition of a self-interested faction,[5] he was unable to force into the French service the two great inventions of

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[1] Buckle's "History of Civilisation," chaps. 9, 10, 11, 12, 13.

[2] "L'Artillerie de compagne n'avait été reellement séparé de l'Artillerie de siége que par Gribeauval."—"Etudes, &c." par l'Empereur Napoleon III. Avant propos, p. IX.

[3]

	Weight of 12-pr. gun.	Weight of 12-pr. carriage and limber.	Total.	Weight of 8-pr. gun.	Weight of 8-pr. carriage and limber.	Total.	Weight of 4-pr. gun.	Weight of 4-pr. carriage and limber.	Total.
	cwt.	cwt.	cwt.	cwt.	cwt.	cwt.	cwt.	cwt.	cwt.
De Vallière's system ……	28·5	15·7	44·2	18·8	13·2	32·0	10·2	11·5	21·7
Gribeauval's 〃 ……	16·0	17·4	33·4	10·7	15·4	26·1	5·3	10·8	16·1
Difference…………………	12·5	–1·7	10·8	8·1	–2·2	5·9	4·9	·7	5·6

"Etait ce la peine de faire tant de dépense et tant de bruit, pour perdre d'un côté et gagner si peu de l'autre?" Such is the comment of a supporter of Vallière on these conclusive figures! "Lettre d'un Officier du Corps Royal de l'Artillerie au Lieut.-Colonel du Régiment D. . . . ." 1774, p. 34. Scharnhorst's "Handbuch der Artillerie," Band II. p. 589.

[4] With the carriages of the 18th century it was necessary, before limbering-up, to change the gun from the firing to the travelling trunnion holes. The prolonge was consequently highly thought of and extensively used, because it saved a long and laborious operation.

[5] "Allein die meisten Officiere von der Artillerie, und insbesondere die beiden Valière, Vater und Sohn, welche bisher an der Spitze des Artillerie-Corps sich befanden, und grosse Verdienste um dasselbe hatten, waren mit dieser Erleichterung nicht zufrieden."—"Handbuch der Artillerie," von Scharnhorst, Band II. p. 588.

the century—limber-boxes and horse artillery.[1] His system thus failed to fuse into one whole the three elements of which field artillery consists—the guns, the gunners, and the ammunition—and its mobility was, consequently, of necessity limited; but, taken all in all, the changes effected by Gribeauval were a gigantic stride in the right direction, and his system, which forms the sixth landmark in the history of the mobility of field artillery, remains to the present day the most important and the most conspicuous of all.[2]

But three short years had passed away after the death of the great reformer, when France found herself at war with Europe, single-handed and without an ally; and the imperious necessities of the case compelled the French to adopt that light field artillery which the senseless, unpatriotic, and odious opposition of a faction had prevented Gribeauval from introducing. The hand of the age was upon these evil councillors, and they could no longer resist. They could not turn back the stream of reform; they could not even stop it; they could not prevent it from rushing onwards and overwhelming them in its irresistible course. They were struck down, and humbled, and silenced; they were cast into outer darkness; and the work of reform was recommenced by a man who was equal to the occasion.

On the 21st April, 1792, General Lafayette addressed a letter to M. de Grave, the French War Minister, urging in strong terms the importance of introducing horse artillery into the French service.[3] The minister lost no time in carrying into effect the recommendations of the general, and during the month of May two batteries of horse artillery were equipped and took the

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[1] "En 1762, M. de Clausen, campé vers Wolfenbuttel, ayant une expédition à faire qui exigeait une grande célérité, se plaignit à M. de Vregille . . . de la pesanteur de l'artillerie, et lui demanda de la seconder dans son opération, qui devait être exécutée rapidement. M. de Vregille, officier d'artillerie distingué, ne prit qu'un caisson par pièce, doubla ses attelages, fit monter sur les chevaux les cannoniers, partit, arriva à dix heures du matin, fut trois heures en batterie et revint ayant fait seize lieues dans la journée. L'Artillerie à cheval la mieux exercisée ne serait pas plus célère. Cet officier parla depuis cette operation au Général Gribeauval, et du projet d'organiser une artillerie à cheval en consequence. Ce général lui repondit; 'vous voyez la peine que j'ai à détruire d'anciens préjugés, et les ennemis que m'ont suscités les changements que j'ai opérés; un jour nous exécuterons votre projet, preparez-le; pour le présent ce serait trop vouloir!'"—"Aide-Mémoire de l'Officier d'Artillerie," par Gassendi.

Colonel Durtubie refers to the unreasonable opposition raised against the introduction of limber-boxes, in his "Mémoire, &c., sur l'Artillerie à cheval," p. 6, note—an essay which has only one fault, its shortness.

Limber-boxes do not appear to have been adopted in France as late as 1825. See "Traité Elementaire d'Artillerie," par E. Decker. Traduit de l'Allemand, par Col. R. de Peretsdorf et Capt. Nancy. Paris, 1825, pp. 315, 337.

[2] For a full account of Gribeauval's system, see the Emperor Napoleon III.'s "Etude sur le passé et l'avenir de l'Artillerie," Tom. IV.; Favé's "Hist. et Tact. des Trois Armes," pp. 145–155; "Conférence sur l'Artillerie de Campagne," Paris, 1869, pp. 14–19.

[3] "Permettez, Monsieur, à un homme qui a causé sur cet objet" (the formation of horse artillery) "avec le feu roi de Prusse" (Frederick the Great), "le Prince Henri, le Duc de Brunswick, le Général Müllendorf, avec les Maréchaux de Landon et de Lasey, enfin avec les principaux généraux de Prusse, d'Autriche, et d'Allemagne, qui a bien examiné et bien réfléchi sur cette institution; permettez lui de répresenter que le prompte formation d'une artillerie à cheval est un des plus grands service que le ministre de la guerre puisse rendre à l'armée française."—"Mémoires du Gén. Lafayette," Tom. III. p. 430.

The question was laid before a committee by M. de Narbonne, and it was decided that the horse artillery was only to differ from the rest of the field artillery by the rapidity of its movements.—Grose's "Military Antiquities," Vol. II. p. 197.

field—the one with Luckner's, the other with Lafayette's army.[1] Lafayette was at first undecided as to the proper armament of the horse artillery, but a month's experience in the field convinced him that there are limits to mobility as well as to weight of metal, and that the gun best suited for the purpose was the 8-pr.[2] The wisdom of this decision was proved ere long, for the French 8-pr. showed its superiority over the Prussian 6-pr. almost immediately.[3]

Although the French had adopted the detachment system, they were far from being blind to its inherent defects, and three years after the introduction of the flying artillery appeared a pamphlet, written with almost judicial calmness, in which an artillery officer discusses the relative merits of the detachment and wagon systems, and sums up in favour of the latter.[4] Colonel Durtubie's pamphlet in France forms the complete counterpart of the memorandum sent in to the Master-General of the Ordnance, three years previously, by the Woolwich Committee in England; with this difference, that while the French officer only discussed the relative advantages of two systems—the detachment and the wagon—the English officers balanced the advantages of three—the detachment, the wagon, and the gun-carriage.

The state of the artillery in England on the close of the Seven Years' War was as bad, if not worse, than in France.[5] The English field artillery had taken a part, and a most distinguished part, in the final campaigns of that war, under the four celebrated captains, Phillips, Drummond, Foy, and Macbean—Phillips being one of the ablest officers that ever led a battery of British artillery into action;[6] and on their return to England they exerted themselves

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[1] "Mémoires du Gén. Lafayette," Tom. III. p. 297.

[2] "Je balançais d'abord entre des pièces de 8 et de 4; mais j'ai reconnu par l'expérience que celles de 8 et les obusiers sont très-préférable."—Ibid. p. 440.

[3] (L'Artillerie à cheval) "est notre seul point de supériorité sur les Prussiens."—Ibid. Lafayette says (Mémoires, Tom. III. p. 430) that the Prussian horse artillery was armed with 3-prs.; but it is probable that he is mistaken, as Gen. von Strotha positively states that it was armed with 6-prs., "Die königlich preussische reitende Artillerie," p. 28. To the best of my belief, the only 3-prs. ever possessed by the Prussian horse artillery were those belonging to the Potsdam Horse Artillery Depôt in 1772. See von Strotha, p. 14.

[4] "Mémoire et Observations sur l'Artillerie à cheval, et Remarque sur l'Innovation des machines proposées pour l'équipages de cette Artillerie," par T. Durtubie, Chef-de-Brigade d'Artillerie, Paris. L'an troisième de la République. "Notre opinion," says the author, when expressing his preference for the wagon system, " est toujours subordonné à l'expérience de la guerre."—p. 10.

[5] The train of artillery which served in Germany during these campaigns, under General Belford, consisted of 32 guns, 2 howitzers, and 6 small mortars. For the draught of these 40 pieces of ordnance 1415 horses were employed, in the following proportions:—

For each 12-pr.	15	horses.
" " 9-pr.	11	"
" " 6-pr. (long)	7	"
" " 6-pr. (short)	2	"
" the flag gun (a 12-pr.)	17	"

The number of horses in the teams is odd, because the horses drew in pairs, with the exception of the shaft horse, who drew single.—See Muller's "Treatise on Artillery," London, 1780, Vol. I. p. 192. These figures show that, as far as mobility was concerned, the field artillery of the Seven Years' War was certainly not a century in advance of that of the Thirty Years' War.

[6] "Superlative practice on *our* right by Capt. Phillips," says Mr. T. Carlyle, describing the effect of the British artillery at Minden, 1759.—"Hist. of Fred. the Great," Vol. V. pp. 451, 452. At the battle of Warbourg the following year, Gen. Mostyn was obliged to trot the English cavalry

to convince those in power of the necessity of introducing into the English service the improvements that had been adopted on the continent. But far from being able to accomplish the positive good of forcing these improvements into the service, their combined influence was not strong enough to effect the negative good of keeping out of the service some extravagant and silly inventions that were made about this time. Thus it happened that in 1774, one Colonel Weidemann, a German, abetted by the Duke of Cumberland, succeeded in foisting upon the country a number of 6-prs. of 2·5 cwt., "constructed of pieces of copper rolled up and soldered together."[1]

Cut off from the continent by a "silver streak of sea," the English military authorities slumbered and slept until they were rudely awakened from their dreams by the thunder of the French Revolution, and then fear wrung from them concessions which neither the dictates of common sense nor the entreaties of their artillery officers could induce them to yield. The first low mutterings of the storm that was brooding over France became unmistakeably audible in 1788, and the Master-General of Ordnance, the Duke of Richmond, sent instructions in that year to Woolwich to equip a number of field guns which would be "capable of accompanying cavalry" in the field.[2] To obtain this object the Duke considered it would be necessary to mount the gunners on horseback; but the artillery officers, like their brethren in Austria some years before, objected to the detachment system. The Woolwich Committee[3] fully appreciated the advantages of constructing a field artillery possessed of great mobility. They objected, not to the end proposed by the Duke, but to the means he suggested of gaining that end, and they pointed out with considerable acuteness the vulnerable points of the detachment system. "Royal howitzers, or long 3-prs. upon new-pattern carriages,"[4] says Major Adye, in his account of the proceedings of the Committee, "can make rapid movements at a much less expense than such pieces as require the artillerymen to be mounted on saddle-horses. As, for instance, the new-pattern carriages allow four men and fifty-six rounds of ammunition to be carried upon the gun-carriage and its limber, which can be drawn by four

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near five miles to enable them to share in the battle, yet Phillips, who was attached to the cavalry, "made so much expedition with his cannon as to have an opportunity, by a severe cannonade, to oblige the enemy—who had passed the Dymel and were formed on the other side—to retire with the utmost precipitation."—"Gentleman's Mag.," Vol. XXX. p. 387. "Capt. Phillips," says an eye-witness, "brought up the English artillery at a gallop, and seconded the attack of the cavalry in a surprising manner."—"Operations of the Allied Army, 1757 to 1762, under H.S.H. Prince Ferdinand," by an officer of the British forces, London, 1764. Phillips' conduct on this occasion has drawn forth the eulogies of even a French writer, the Marquis de Ternay.—"Traité de Tact." Tom. I. p. 601. For Phillips' services in America, see "Proceedings R.A. Institution," Vol. IV. p. 248.

[1] Muller's "Treatise on Artillery," Introd. p. 4. Speaking of the righteous resistance made by the Royal Artillery to the introduction of these guns into the service, this writer impudently remarks:—"It was not without great difficulty that they were received, and no less than the express command of H.R.H. the late Duke of Cumberland could have prevailed over the servile attachment for an old-established custom, though ever so erroneous, which, when once covered by the veil of time, becomes in a manner sacred." As may be guessed from the turn of the phrase about the Duke of Cumberland, Mr. Muller held a subordinate office in H.R.H.'s household. The Duke would have done well to leave artillery questions to be settled by those who understood them.

[2] MS. Notes, by Major S. P. Adye, R.A., in the Library of the R.A. Institution, Woolwich.

[3] Colonel D. Drummond, Major W. Congreve, and Major T. Blomefield.

[4] In this system of carriages, two gunners sat upon the limber-boxes, and two gunners upon seats on the gun axle-tree boxes.

horses at the rate of six miles an hour, and if six horses be used, they can travel ten miles an hour; whereas a gun which is mounted so as not to allow the artillerymen to ride upon its carriage,[1] will require at least two horses to draw it, two to an ammunition cart, four for its artillerymen to ride, and one for a person who is to hold the saddle-horses when the gun is in action; which is five horses more than is required when the artillerymen ride upon the gun-carriage and are drawn by four horses, and three when six horses are used to draw the field-piece with four men riding upon the gun-carriage. This makes a difference in the first case of £321 1s. 3d. for one gun, and £1944 7s. 6d. for a brigade of six pieces; and in the second case, £194 8s. 9d. for one gun, and £1166 12s. 6d. for a brigade of six pieces per annum in favour of the new carriages, supposing Government to pay 1s. 10d. per diem for each horse, including the driver, and for keeping each horse 1s. 5d. per diem for 245 days, and 2s. per diem for 120 days, which was the price paid in the last German campaign."[2] A discussion thus arose between the Duke and the Committee which lasted until 1792. In that year war was virtually declared with France,[3] delay became no longer possible, and the Duke called upon the Committee for their ultimatum. Upon this the Committee forwarded to his Grace on the 19th August, 1792, the three following schemes, *A*, *B*, and *C*, which correspond closely, the first with the present English field battery system,[4] the second with the present English horse artillery system, and the third with the present Prussian field battery system; the Committee strongly recommending the last. "We cannot," they said, "but prefer upon every consideration the men being carried on the guns, as they are thereby attached solely to the use of them. We apprehend much embarrassment in the case of the horses" (in the detachment system) "while the guns are firing. We would propose the artillerymen to be armed with pistol and pushing sword. We leave to your Grace whether the artillery soldier should not have the same security for his head and shoulders as a dragoon." Some further correspondence ensued, and on the 20th Dec. of the same year the Committee explained more fully their views as to the tactical use of the brigade. "We conceive this brigade ought never to be stationary, and scarcely ever to act on the defensive . . . and in all rapid manœuvres four horses only should be used, the third pair accompanying as spare. . . . The artillerymen" (in *A* and *C*) "are to march on foot until the service requires them to advance with greater expedition."[5] The Duke lost little time in coming to a decision on the difficult and complicated question before him, and guided probably by the example of the French in the preceding year, he ordered two troops to be organised according to scheme *B*, in January 1793.[6]

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[1] These carriages were of the same character as the galloper carriage, a sketch of which I gave in my last paper.

[2] Major Adye's MS. Notes.

[3] First coalition against France, 26th June, 1792.

[4] The comparison of course only holds good in a general way, for the equipment and organisation of one division of a battery in the *A* scheme was entirely on the horse artillery system, Colonel Williams' carriages affording no means of carrying gunners.

[5] Major Adye's MS. Notes.

[6] "Bei der Englischen Armee gab man den Kanonieren bei der Artillerie des Emigranten-Korps Pferde, um sie nur einigermassen zweckmässig gebrauchen zu können."—"Ueber reitende Artillerie, &c." p. 40.

The construction of gun axle-tree seats in the "new pattern gun-carriages," proposed by the Committee in scheme *C*, forms the seventh and last landmark in the history of the mobility of field artillery.

So ended the 18th century, a century distinguished before all others by the radical and signal changes that took place during its progress in the field artillery service.

Brecon,
September 1871.

A.

The Plan of a Brigade of Artillery to accompany Cavalry, manned by a Company of the Royal Artillery; the guns and carriages being on the principle established by His Grace the Duke of Richmond, M.G.O., in 1788.

Detail.	Horses.	Drivers.	Ammunition.	Distribution of detachment.					Civil List.	Remarks.
				Captains.	Lieuts.	N.C.O.'s.	Gunners.	Drummers.		
5½-inch howitzers (2)	12	6	160	1	1	2	18	—	—	
Wagons (2)	12	6								
3-prs. (2)	12	6	480	1	1	2	18	—	—	
Wagons (2)	12	6								
6-prs., Col. Williams' (2) ...	4	2	160	—	1	2	18	—	—	
Tumbrils (2)	4	2								The detachment was necessary for Colonel Williams' guns, because the carriages did not afford seats for the men. For the howitzers and 3-prs., 2 men were carried on each limber and 4 on the body of the wagon.
Horses for detachment	20	—	—	—	—	—	—	—	—	
″ ″ two supernumeraries to each 3-pr. and howitzer	8	—	—	—	—	—	—	—	—	
1 Forge cart	3	1	—	—	—	—	—	—	—	
1 Wagon for artificers' stores	3	1	—	—	—	—	—	—	—	
Serjt.-Maj. & Clerk of Stores	2	—	—	—	—	2	—	—	—	
Drummers with bugle horns	2	—	—	—	—	—	—	2	—	
2 Conductors of horse	2	—	—	—	—	—	2	—	—	
1 Collar-Maker	1	—	—	—	—	—	1	—	—	
1 Wheeler	1	—	—	—	—	—	1	—	—	
1 Blacksmith	1	—	—	—	—	—	1	—	—	
1 Farrier	1	—	—	—	—	—	1	—	—	
Civil List.										
1 Commissary of horse	1	—	—	—	—	—	—	—	1	
Total	101	30	800	2	3	8	60	2	1	

DUNCAN DRUMMOND,

Colonel.

B.

The same; the Gunners being mounted on Horseback.

Detail.	Horses.	Drivers.	Ammunition.	Distribution of detachment.					Civil List.	Remarks.
				Captains.	Lieuts.	N.C.O.'s.	Gunners.	Drummers.		
5½-inch howitzers (2)........ Wagons (2)	8 8	4 4	160	1	1	2	20	—	—	4 men held the horses in action.
3-prs. (2) .... Wagons (2)	8 8	4 4	480	1	1	2	20	—	—	Ditto.
6-prs., Col. Williams' (2) ... Tumbrils (2)	4 4	2 2	160	—	1	2	20	—	—	Ditto.
Horses for detachment	66	—	—	—	—	—	—	—	—	
2 Serjts.—Serjt.-Maj. and Clerk of Stores.........	2	—	—	—	—	2	—	—	—	
Drummers, to have bugle horns and act as orderly men	2	—	—	—	—	—	—	2	—	
1 Forge cart	3	1	—	—	—	—	—	—	—	
1 Wagon for artificers' stores	3	1	—	—	—	—	—	—	—	
Officers' horses not included.	—	—	—	—	—	—	—	—	—	
Civil List.										
1 Commissary of horse	1	—	—	—	—	—	—	—	1	
2 Conductors of horse	2	—	—	—	—	—	—	—	2	
1 Collar-Maker	1	—	—	—	—	—	—	—	1	
1 Wheeler	1	—	—	—	—	—	—	—	1	
1 Blacksmith	1	—	—	—	—	—	—	—	1	
1 Farrier	1	—	—	—	—	—	—	—	1	
Total......	123	22	800	2	3	8	60	2	7	

DUNCAN DRUMMOND,

Colonel.

C.

Plan of a Brigade of Artillery to accompany Cavalry; substituted for Colonel Williams' 6-prs., two light 6-prs. mounted on 3-pr. carriages.

Detail.	Horses.	Drivers.	Ammunition.	Distribution of detachment.					Civil List.	Remarks.
				Captains.	Lieuts.	N.C.O.'s.	Gunners.	Drummers.		
5½-inch howitzers (2).........	12	6	160	1	1	2	18	—	—	Four men rode upon each gun and wagon; and the N.C. officer and another supernumerary upon horses, which were held by the drivers in action.
Wagons (2).....................	12	6								
3-prs. (2).........................	12	6	480	1	1	2	18	—	—	
Wagons (2).....................	12	6								
6-prs., light (2)	12	6	240	—	1	2	18	—	—	
Wagons	12	6								
Horses for 2 supernumerary men for each howitzer and gun	12	—	—	—	—	—	—	—	—	
1 Wagon for artificers' stores	3	1	—	—	—	—	—	—	—	
Serjt.-Maj. & Clerk of Stores	2	—	—	—	—	2	—	—	—	
Drummers with bugle horns	2	—	—	—	—	—	—	2	—	
2 Conductors of horse	2	—	—	—	—	—	2	—	—	
1 Collar-Maker	1	—	—	—	—	—	1	—	—	
1 Wheeler	1	—	—	—	—	—	1	—	—	
1 Blacksmith	1	—	—	—	—	—	1	—	—	
1 Farrier	1	—	—	—	—	—	1	—	—	
1 Forge cart......................	3	1	—	—	—	—	—	—	—	
Civil List.										
1 Commissary of horse	1	—	—	—	—	—	—	—	1	
Total......	101	38	880	2	3	8	60	2	1	

DUNCAN DRUMMOND,

Colonel.

REMARKS WITH REFERENCE TO

MOBILITY OF LIGHT FIELD ARTILLERY.

BY

LIEUT.-COLONEL G. CARLETON, R.A.

It may be assumed that our present light field battery system will be changed before long. A system that either necessitates gunners accompanying light field guns in action on foot, or else requires them to be carried for the most part on the ammunition wagons of their battery, is surely far behind the requirements of an age of such improved small-arms and rapid and open infantry manœuvring as the present.

It is a question whether all *light* field artillery should not be organised as horse artillery; but even should this not be done in future, we may at least take for granted that our light field artillery will have its gunners all carried into action with their guns, while none will, under any circumstances, be mounted upon the ammunition wagons. We have now, perhaps, arrived at as high a degree of perfection in our light field guns and their projectiles as the present condition of science and the mechanical arts admits of; and attention, stimulated by the events of the late war, is at last being turned to the imperfect *mobility* of our light field batteries. It is hardly too much to say that organised as at present, none of them can be pronounced thoroughly fit. In addition to the defect above referred to it may be added that, packed as light field limbers and wagons now are with knapsacks, camp-kettles, tents, &c., they are injuriously over-weighted and hampered; and yet with all this, the manœuvres laid down in the field artillery exercise book are drawn out on the supposition that the wagons move with and conform to their guns. Surely all drill instruction ought to be given with a view to adaptability on service.

The want of mobility due to three-fourths of the gunners having to walk, is now so thoroughly appreciated that it is unnecessary to dwell upon it; but there is another point of hardly less importance concerning this defect upon which I beg leave to offer a few remarks, in the hope that the attention of others better able to discuss the matter may be attracted. I allude to our present form of ammunition wagons.

It is obvious we must include in the term *mobility* the mode in which ammunition can best be kept supplied in action, no less than the manner in which the men can be brought up to work the guns.

As a chain is no stronger than its weakest link, so the mobility of light field artillery is no more perfect than its least perfect detail; and to be able to move men and guns promptly from one position to another will be of comparatively small avail, unless the guns can be readily supplied with ammunition under fire beyond what accompanies them in the gun-limbers. In this respect we appear capable of improvement quite as much in our horse as in our light field battery artillery—nay even more so, considering the more rapid movement required from the former. I believe, in order to ensure perfect efficiency in this respect, it will be found necessary to give up our present system of composite four-wheel carriages, drawn on service by six horses—that is to say, our wagons with limbers—and to substitute a system of two-wheel carts drawn by one or at most two horses.

What can be more cumbrous or less scientifically arranged for draught than our ammunition wagons, *limbered up* as they now are? The only excuse for retaining limbers elsewhere than with the guns is, that in the event of a gun-limber becoming disabled, that of its wagon may be used in moving off the gun; but it would be easy to adapt the proposed carts to this purpose, and if necessary to have a proportion of spare gun-limbers in each battery. The advantages of the two-wheel over the four-wheel carriage appear sufficiently great to warrant at least the experiment. Among them may be noted the greater ease with which a pair of horses can be managed by their driver than three pairs harnessed in team can be managed by three drivers. Another is the greater ease with which the two-wheel carriage can be moved over bad or confined ground. Again, there is the greater safety and rapidity with which exhausted limbers could be relieved in action; and lastly, there is the greater economy, both in men and horses, and the saving of much of the present wear and tear of harness and carriages incident to the constant manœuvring at ordinary regimental parades of wagons along with their guns. This last, irrespective of the change here suggested as to wagons, would no doubt be gained to a great extent by the impending change in the tactical organisation of our light field batteries; but so long as the plan of having three pairs of horses harnessed in one team is maintained, the difficulty of getting three drivers to act together in draught is so great that it is necessary to have them frequently practised in the driving of the wagons.

The system here suggested of double-wheel ammunition carts, drawn by one or two horses, would also probably be found more suitable to the adoption of an organisation for field batteries in time of peace that would most readily admit of expansion in time of war.

June 24, 1871.

NOTE.—We know that in a team of six horses harnessed in pairs, the front and centre pairs each draw less than $\frac{1}{3}$rd of the weight; the wheel pair, therefore, has more than its fair share, and what the front horses do not draw may be considered as in a measure waste of their power. But it is evident that under fire each pair, though not doing equal work, is equally exposed with its driver. It seems then that with three separate carts, each drawn by one pair of horses with one driver, as each pair is equally close to its work there is less waste of power, and therefore more weight may be drawn with the same amount of effort; *how much more* is matter for experiment and calculation, but if the Prussian General Scharnhorst's estimate be correct—viz., that the centre pair of horses in a team of six draws $\frac{5}{6}$ths and the front pair only $\frac{5}{9}$ths of what the wheel pair draws, it would appear that the total weight distributed in three separate two-wheel carts, to be drawn by two horses each, might at all events be equal to that now drawn in one cart (for practically the wagon with limber is one cart) by three pairs of horses, and that too with less exertion on the part of each pair than is under the existing system exacted from the wheel pair; the driving at the same time being simplified, and the exposure of drivers, horses, wheels, &c. &c., in replenishing ammunition under fire being lessened.—G. C.

THE CLOCK SIGNAL-VANE.

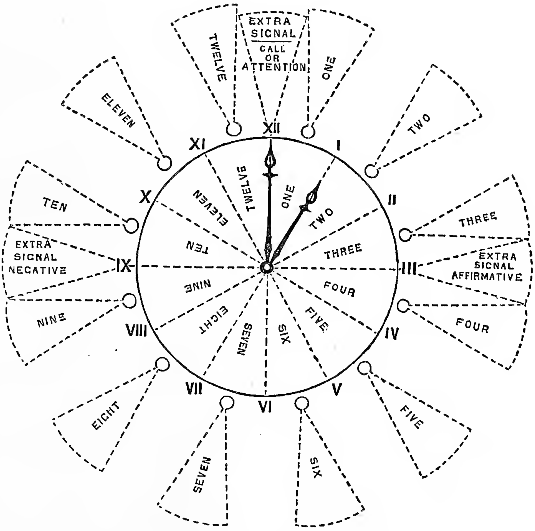
BY

CAPTAIN W. L. YONGE, R.A.

Instruction.

The following proposal for a new system of signalling is based upon the fact, which will scarcely be disputed, that every soldier in the army is able to read the clock. Armed with this fact, I would place before the soldier a representation of a clock, as in Fig. 1. To avoid complications I dispense with the minute hand. I then remind the pupil that the first hour is in progress while the hand of the clock passes from the figure XII. to the figure I., which period of time is represented by the space between the figures XII. and I. This constitutes the first hour space, or ONE. In like manner, the interval between the figures I. and II. constitutes the second hour space, or TWO, and so on through the series of the twelve hours. These several hour spaces are shown divided off in Fig. 1, and numbered accordingly. I would then point out that the several spaces are identical in outline, and differ only in their relative positions as regards the centre and circumference of the imaginary clock dial. The segments are then detached from the circle (Fig. 1) and shown singly, each in its own relative position. Each segment then becomes a representative of the signal vane.

Fig. 1.



I venture to assert that no man who has once mastered these rudiments can ever again forget them, and by the aid of the accompanying diagrams any soldier may be converted into a skilled signalman in a few minutes, and whenever he sees the signal vane he can immediately name the numeral indicated by asking himself the question, "What's o'clock?" I have said the *numeral* indicated, but it will be observed there are twelve signs, which need not all be used; they are only there if wanted; and it is thought that XI. and XII. will be found useful.*

Such being the system, the signal vane is constructed as follows:—The "Handbook for Field Service" (p. 346), states that cones with 2 ft. base and 4 ft. side transmit signals five miles with great rapidity and facility, and this is the size adopted for field service in the army. If this be the case, a vane of the same dimensions should also be visible at the same distance. (To make it more conspicuous, I would attach a small disc to the tail of the cone, to avoid its termination in a mere point).

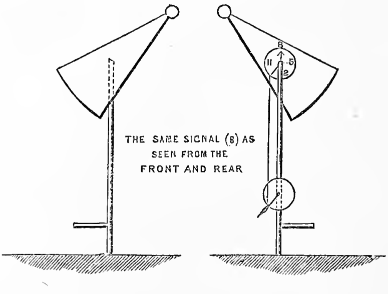
The vane can assume three cardinal positions in each quarter of the circle, viz.:—

1. One side may be vertical.
2. One side may be horizontal.
3. Both sides may be inclined to the horizon.

There is nothing more remarkable than the facility with which the eye can recognise the vertical or horizontal position of a line or straight-edge, and if one of the sides of the vane be placed either vertical or horizontal (as hereafter provided for), the fact will be at once recognised by the observer. From this it will follow that the negative of this assertion will be equally true. If the sides be neither vertical nor horizontal, they must be inclined, and therefore the three cardinal positions can be identified and named.

The ordinary signal is of course intended for use in one direction, but if seen from the rear it may still be interpreted, for it will then indicate a number which, with the *proper* number, will make the number 13. Thus, if 4 be indicated to the front, the same signal will be read 9 when seen from the rear, and may be interpreted at leisure. In like manner, 8 to the front will be read as 5 to the rear, but in all cases the observer must be instructed to report *what he sees,* leaving it to the responsible officer to interpret the sign. I would indicate the proper front by some conventional sign, as in

Fig. 2.



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* A reference to Fig. 1 will show that three additional signals are available for *special use*—such as Attention, Affirmative, and Negative.

the old semaphore, by a horizontal bar thrust out to the "proper right." Those who see this bar on the "proper left" will know that they are in rear of the vane, and must interpret the signal accordingly.

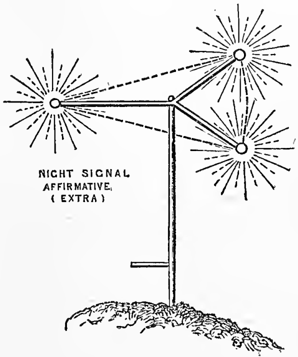
For ordinary field purposes, such as for practice ranges (artillery and infantry), and for moderate distances, I am inclined to adopt the dimensions recognised as sufficient in the present flashing system—viz., a vane measuring 4 ft. by 2 ft. For permanent works and for communicating with detached forts, the size can be increased according to circumstances, still retaining the same proportion. For field work no mechanism is necessary, but in the larger sizes for permanent stations a simple crank and lever, connected with an index finger below, can be adjusted so as to work the vane at any moderate height above the parapet.

The vane may be used with any existing code. The foregoing remarks presuppose the use of a code, but if spelling be required, a simple method of converting figures into letters will at once suggest itself. The above provides for 12 numerical signs, while the alphabet for telegraphic purposes can be reduced to 24 letters; thus, by the aid of a repeat signal—such as the complete rotation of the vane—the ordinary numeral indicated can be augmented by 12 and represent a letter. Thus 5 with a repeat would signify 5 + 12 = 17, which, according to the key used, may indicate any letter or cipher. A spelling system is, however, not so rapid as a code.

The vane may conveniently be made of sheet zinc, sufficiently thick to prevent bending, and pivoted at the centre of the figure by means of a ball and socket joint, which permits the vane to rotate in one vertical plane. Such a vane weighs about 3 lbs., if of the dimensions already stated, but the weight is so very inconsiderable that the dimensions might be increased with advantage. If perforated with holes, it would offer less resistance to the wind. The post or standard may be made of a few feet of iron gas-pipe, into which the socket of the vane may fit. They can be made for about five shillings each. A more portable vane may be made on a framework similar to the frame of an umbrella. The umbrella should open quite flat, and the vane be painted in white on the black background of the umbrella, which can be closed when not in use.

A modification of the vane can be made available for night signals, as shown in Fig. 3, which consists of a frame of three arms pivoting at the

Fig. 3.



centre. To the outer end of each arm a lamp is suspended on gimbals, the whole apparatus being accurately balanced. As the three lamps form a figure of the same shape as the vane for day signalling, and as the lights at the circumference are nearer to each other than to the third and central light, the position of the signal can always be ascertained; for one of the lights at the circumference may either mark a horizontal or vertical line in connection with the centre light. It has, however, been found that lights cannot be distinguished from each other unless they are at considerable distances apart, according to the range at which they are to be visible. White lights are far superior to coloured lights, and three white lights, arranged as in Fig. 3, may be made to assume any of the forms indicated in Fig. 1, as also the three or four extra signals available for special use. When these extra signals are used at night, the two lights nearest each other (at the circumference), would assume the vertical or horizontal positions, and thus be easily distinguished from the ordinary clock-signals when these lights are never either in a horizontal or vertical line.

October 7, 1871.

THE

MULTIPLYING ALIDADE, OR PRACTICE REGISTER.

BY

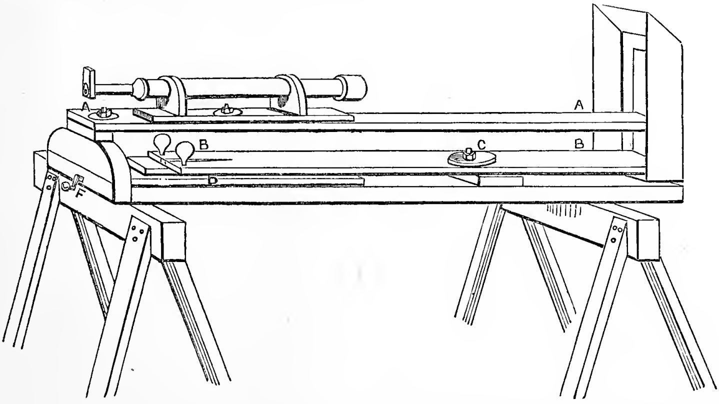
MAJOR A. INNES,

ABERDEENSHIRE ARTILLERY VOLUNTEERS.

[COMMUNICATED BY LIEUT.-COLONEL C. F. YOUNG, R.A.]

THE multiplying alidade is an optical instrument for recording mensural observations, and is constructed on a principle not hitherto applied to purposes of gunnery. It is intended to fulfil the following requirements:—

1. That it shall be under the easy management of one person, pivoting on the eye of the observer and capable of the most exact and instantaneous alignment.
2. That it shall have the power of multiplying the angular measurement as shall best suit the scale adopted for the register.
3. That the observations shall be spotted at regular intervals by successive perforations of the register, without removal of the eye of the observer, or disturbance of the line of collimation of the instrument with the target.
4. That the scale of the alidade, laid down in minute subdivisions, shall be capable of affording the most perfect comparative measurement of the results of practice, whether individual or *in cumulo*.*
5. That it shall possess the properties and be applicable for all the purposes of a level and range-finder.



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* *i.e.*, the measurement of the cumulative result of the series of rounds from one gun as distinguished from those of other guns or detachments on the same register.

The multiplying alidade affords the means of recording the position of every shot as it falls on the water around the target in succession, with the utmost precision and expedition, so as to obviate the possibility of the mistakes and inaccuracy which must prevail in the absence of this or some similar instrument of measurement.

The alidade, as at present constructed, consists of two telescopes, quadrant, eye-piece, diaphragm, hood, and cross wires, mounted on a superior radial arm *AA*, 6 ft. long, connected with and acted on by an inferior radial arm *BB*, pivoting at any distance, as may be adjusted, for recording the practice upon the register according to any convenient scale that may be required by the range.

The record is made on a register of one or more thicknesses or sheets of paper, by means of perforation by a steel point, acted on by a spring and trigger attached to the index of the inferior radial arm.

The register is stretched on a table, mounted on a traversing bed *D*, acted on by a guide screw *F*, advancing the register at regular intervals for receiving the successive observations.

The observations taken under the cross wires at the extremity of the superior radial arm are thus brought back to the hand of the observer at the recording apparatus attached to the inferior radial arm, with a power of angular measurement which may be multiplied or reduced by the position of the pivot *C*, the inferior radial arm, to suit the nature and range of the observation.

When practice is about to commence, the alidade, secured to a gun or other support, is to be carefully aligned upon the target, the index being secured at zero. The back sight and cross wires being then in collimation with the target, the eye-piece and cross wires of the telescope will also be found in collimation; if not, the necessary adjustment is also to be made. The line of collimation being now marked on the register, the index liberated, and the hammer raised, the instrument is ready to register the position of the first shot as it falls.

This operation is effected by bringing the falling shot or bursting shell under the cross wires, by moving the alidade index to the right or left, and spotting the position on the register by touching the trigger, thus marking the position of the shot in or out of the line of collimation above referred to. For the second shot, nothing further is required than to raise the hammer as before, advance the register one-tenth of an inch by one turn of the guide screw, spotting the second shot, and so on to the end of the practice.

The second telescope, mounted with the quadrant, is required when the instrument is to be employed as a range-finder.

There being at present no system of prize competition with heavy guns established for the practice of the Royal Artillery, the necessity with which I have been familiar for the last ten or eleven years, for an accurate and reliable test of the relative value of the practice of competing detachments and gunners will not be so apparent; but if we consider the admirable materials of the Royal Artillery, both in guns and gunners, the importance of any system leading to the improvement and accuracy of practice is so apparent that an attempt promising in any degree to aid in its development will sufficiently commend itself for examination.

Having had occasion to undertake the superintendence of shot and shell practice, and to organise for the first time a system of competition with heavy guns at sea ranges, I became impressed with the want of some means of accurately recording practice, and constructed the multiplying alidade for the purpose of instructing the eye and testing the powers of the pointers in laying guns of position.

The use and value of it were sufficiently demonstrated to me in the result of the competition at Shoeburyness, in August, 1866—one of the detachments I took up, which was trained with it, having some thirty points above the highest average of some eight days' practice during that competition. Since that time some improvements increasing the facilities in its use have been made, while the first principle of its construction remains the same.

The application of this instrument for recording practice on occasions of artillery competitions, suggests some important means for getting over difficulties that always present themselves from the want of this or some other effectual mode of measuring range and deflection of artillery fire at floating targets; so as to obviate the necessity for a constant reference to the arbitrary decisions of an umpire, formed of necessity on some empirical law or rule of thumb, inconsistent with the just appreciation of the relative value of the practice of competing detachments.

The merit of the alidade consists in its power of measuring the exceedingly small angular distance of a shot falling near a target moored, it may be, at 1800 yds. or 2000 yds. from the observer, and of bringing back the result of the observation to the hand of the observer, to be spotted on the register with a considerable multiplying power with the greatest facility and despatch.

The simple principle of the construction of this instrument may shortly be described as follows:—When the alidade is in collimation and aligned on the target *C* the index is at zero, but on measuring a distance to the right or left a triangle *ABD* is formed, of which one side *DB*, as extended from the cross wires at *D* to the index at *E*, forms the exterior angle *ABE*, equal to the interior opposite angles at *A* and *D*; or in other words, in the case where the sides *AB*, *BD* are equal, the angle *ABE* formed by the line of the index is double the angle *BAD* to be measured; much more then, as in the case of the present construction, where the angle at *D* has been designedly increased, does it multiply the result, which has been calculated as most convenient for the size of register of ranges between 1500 and 1800 yds. The instrument for the use of the range party is of simpler construction, with an angular measurement on a more restricted scale.

March, 1871.

SYSTEM OF

IRON-PLATING A CRUISING SHIP.

BY

CAPTAIN M. TWEEDIE, R.A.

Vessels of war in the present day, owing to the peculiar services required of them, may advantageously be classed as "ships of the fleet" (iron-clad), "cruising ships for the protection of our commerce and colonies" (more especially in times of peace), and "harbour and coast defence ships" (virtually movable batteries).

It is with regard to the second class of ship—the cruising ship—that I venture to treat.

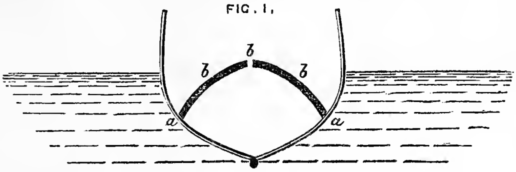
The requirements of a ship of this class are: that she must be a first-class sea boat, comfortable, and fit for the accommodation of a crew during a long commission, probably in a great diversity of climates, capable of repair in foreign parts, and in the event of a sudden outbreak of hostilities, neither liable to become an easy prey to any iron-clad nor liable to be sent to the bottom by the first shot fired at her.

Now, I think it will be at once admitted that neither the iron-clad nor the wooden ship fulfil these conditions—the iron-clad on account of the injurious action of the salt water upon her iron plating exposed to it, the difficulty of repair in foreign parts, and doubtful qualities as a sea boat; the wooden ship on account of her being an easy prey to any iron-clad enemy on a sudden outbreak of hostilities, and her liability to be sent to the bottom by the first shot fired at her.

It appears to me, with regard to iron-clad ships, that seeing we have got almost if not quite to the limit of thickness of iron plating that can be put on the outside of a ship, and yet can make a gun to penetrate it, we must now look for additional strength not from extra thickness, but by (if possible) altering the position of the armour on the ship.

It is this principle that I venture to recommend as applicable to cruising ships, and am inclined to believe that iron armour may be so applied to a ship as not to entail any of the disadvantages appertaining to iron-plated vessels, at the same time allowing her to be a comfortable sea-going ship, fairly capable of holding her own with any iron-clad on an emergency, and almost if not quite unsinkable.

FIG. 1.



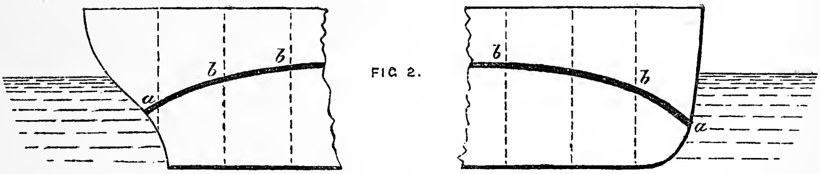


FIG. 2.

Figs. 1 and 2 represent roughly the transverse midship and longitudinal sections respectively of a ship of about 3000 tons. Trace a line (*a*, *a*, *a*) round the hull of the ship at such a distance below water-line that it will never be exposed above water during the roll of the ship in any weather that a ship can fight her guns in, and from a parallel trace to this on the inside of the hull spring an arch of iron plating (*b*, *b*, *b*), the top surface of the arch being above water-line. The advantages of this system would be somewhat as under:—

1. The plating would be all inboard, free from the action of salt water, and the hull would be wooden, coppered, and capable of repair on foreign stations. The plating, owing to its position, even should it be fractured, could quickly be repaired by bolting plate-iron over it, and be just as strong as ever.

2. The plating would be placed in its most advantageous position for resistance; every shot striking it must glance off.

3. The plating would be most advantageously placed for the load of the ship, making her by its position a good sea boat, and in place of straining her by hanging on to her sides, actually give additional strength.

4. The ship would be well protected from vertical fire.

5. No fire could get into the lower part of the ship, and all above the plated iron arch, on occasion of the ship clearing for action, would be divided into fire-proof compartments by light iron shutters, and each compartment supplied with water laid on through the arch.

6. The engines would be completely protected below the arch, and any necessary openings through the arch could be secured by iron shutters being drawn over during action if necessary, and in such a way as to admit of the air required being drawn down through them.

7. The ship, however much she might be knocked about, unless this arch were penetrated (and this would be almost impossible), could not sink; and as an additional security, of course all below the arch would be divided into water-tight compartments by light iron bulk-heads.

The ship would carry an armament of sufficient weight for ordinary cruising purposes, and in addition could have one heavy gun on each side in a box battery, iron-plated, for engaging an iron-clad with, in case of meeting such a ship.

The above views are, it must be borne in mind, only suggestions, not matured plans. I am fully aware that the danger from fire and splinters will be urged against a ship so plated, but these disadvantages appertain to a still greater extent to the present wooden cruising ships. The chief advantage claimed is that the ship, though a cruising ship, shall be virtually unsinkable.

PORTSMOUTH,
June 1, 1871.

ENTRENCHMENT OF FIELD ARTILLERY.

BY

CAPTAIN G. B. MACDONELL, R.A.

The latest edition of the "Field Exercise and Evolutions of Infantry" contains instructions for carrying out a system of entrenchment for that arm of the service—a system which, if somewhat wordy and smacking rather of the drill-serjeant and his love of minute descriptions in uncomfortable positions, is on the whole, when mastered by the trained soldier, excellent, and enables him to rapidly construct good, safe, and bullet-proof cover.

In our branch of the service, taking a retrospect through the last few years, since the introduction of breech-loading small-arms in the infantry has rendered the service of guns in the field to be far more difficult and dangerous than it formerly was, and has prevented field artillery from asserting its proper position and preponderance among the arms, we find that little or nothing has been done—a few isolated experiments excepted—to establish a system of entrenchment to protect our field guns from the destructive effects of the fire of improved small-arms, and thereby increase their efficiency. There may be some who will object to the adoption of entrenchments, and will hold that any such system would tend to destroy the mobility of the arm, and reduce it to the *rôle* of artillery of position; and also a few others may say, "Best leave well alone; if entrenchment is wanted it can easily be done." Of course it can; but the disadvantage of this latter plan is that the men must be untrained, and any experience that may be required will have to be acquired in presence of the enemy, where failures may be disastrous, and modern warfare cannot allow of any disasters arising from want of preparation or previous instruction.

As regards the decrease of mobility, such an objection hardly needs an answer; since the extended and accurate range of modern ordnance render the movement of batteries during an action less necessary than formerly with the S.B. guns, whose inaccurate and feeble fire necessitated the assembly of the batteries close to the points where the effect was required to be produced. In an ordinary battle-field of the present day, the fire of the guns could be massed on any given point without entailing the very frequent movement of the batteries. Besides, the practice of making and using artificial cover would only come into operation in defensive positions, while the power of passing to the offensive would be unimpaired, and the advantage would remain that while acting on the offensive, the result of previous instruction would appear in the increased ability that there would be to rapidly take advantage of inequalities and accidents of ground—which would mean so many projectiles arrested or diverted, so many lives saved, so much longer effective life to the batteries.

So far is it from the wish of the writer to see the mobility of field artillery decreased, that he hopes that the day is not very far off when, by the adoption of improved axle-tree seats, and arrangements for carrying the detachments, the field gun may be enabled to go anywhere at good speed, and always attended by its full complement of men.

Field entrenchments would enable a force armed with inferior weapons to oppose a prolonged resistance to another possessing those of superior power and range; and in England it must be borne in mind that the great majority of batteries in India are armed with the antiquated S.B. bronze 9 pr. guns—for the most part unserviceable, and with the very best of which it is a matter of much wonder and congratulation if the lucky gunner manages once in 40 rounds to hit a 5 ft. × 5 ft. target at the very moderate range of 700 yds.—guns which, taking a most partial view of them, are only fit for firing case or salutes, more especially the latter, or better than all, are only fit for that limbo of antiquity, the marine store shop.

Should it ever be found necessary to send an auxiliary Indian army, say of two corps, to Egypt, Asia Minor, or Turkey, the greater part of the artillery contingent that would accompany this force would be armed with the above weapon; and it would be needless to point out that without resorting to some expedient, such as entrenchments, portable mantlets, &c., these S.B. guns would easily be overpowered long before they could fire an effective round.

The necessity of some authorised instruction in entrenchment may therefore be considered as established.

The question is, how to obtain the best cover with the least amount of labour. Two methods of obtaining cover present themselves:—

1. The sunken, or gun-pit battery.
2. The elevated, or gun battery.

It is assumed that at least 6 ft. of good cover must be obtained. The sunken or gun-pit battery seems to be the best expedient for obtaining this cover:—

(1) As it supplies its own parapet from the interior excavation.
(2) The parapet and trench increase simultaneously, thus halving the labour.
(3) It presents a very small target, and half of the parapet is perfectly impenetrable to any projectile.
(4) The labour of construction is not excessive.

While on the contrary, the elevated or gun battery—

(1) Requires double the labour to construct.
(2) Presents a larger mark.
(3) Is pervious to shot or shell at its strongest part.

In comparison with the gun-pit, it has the advantage of being tenable in all weathers, while the gun-pit is liable in wet weather to get filled with water.

But then positions for action are seldom held for longer than five or six hours, and even should the pits become filled with water during an action, the guns can be run back and fought in the rear with advantage, as in the case of a screen battery.

The gun-pit, with a parapet the maximum thickness of which is 6 ft. only, requires about 300 cubic feet to be excavated; while the gun battery, with a parapet of the same thickness as the gun-pit, requires about 600 cubic feet of excavation.

Thus the balance of advantage remains with the gun-pit.

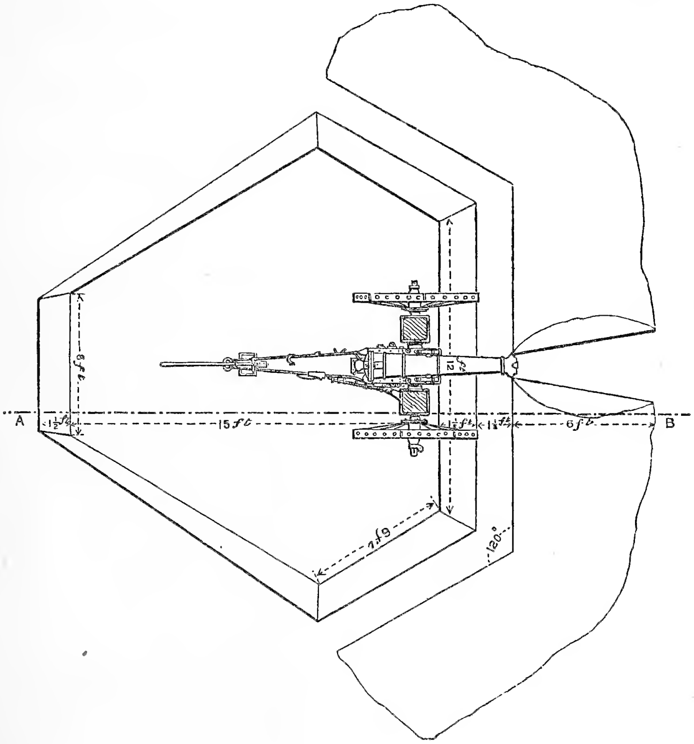
It was intended by the writer to have carried out the experiment of gun-pits *versus* gun batteries with his battery at Cannanore; but in India the time in which Europeans can work in the open air is so very short, that experiments were only made in the formation of gun-pits.

The battery having marched a distance of four miles into the country, formed line on an open plain sloping very gently to the front, and proper points for entrenchment being selected, echellons of subdivisions were thrown forward from both flanks, and the order was given to entrench.

The ground was light, arable, and sandy, and covered with roots of coarse bent grass, as is common in the plains of India. The pick was not required to be used.

Previous to breaking ground, the men, in order to obtain the trace, were instructed in a preliminary drill devised for the occasion. Working drawings were issued by division officers to Nos. 1 the day before.

Fig. 1.—Gun-Pit.



SECTION on A B

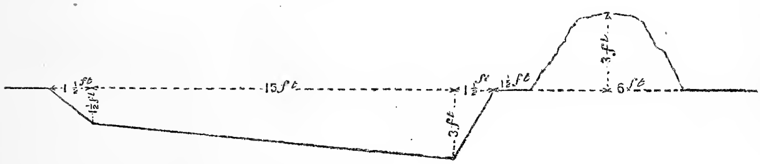


Fig. 1 is a *fac simile* of the drawing issued to No. 1 subdivision. Only four subdivisions were practised, as, on account of the paucity of men in a single battery station where duty is heavy and absorbs so many effectives, it was impossible to get full detachments; so the gunners of the centre division were sent to complete the flank divisions, and bring up their numbers to full strength.

The right division was commanded by Lieut. Ditmas; the left by Lieut. Hepburne.

The drill was as follows:—

Instruction.

Words of command.

Prepare to entrench.

On the command "prepare to entrench," the detachments will dismount and provide themselves with tools as follows:—

Nos. 2 and 3 a pick each.
Nos. 4 and 5 a shovel each.
Nos. 6 and 7 a spade each.
Nos. 8 and 9 two gun buckets each (to be used as earth carriers).

And having done so, fall in at "detachment front."

Right turn, Left wheel, Double march.
Halt—dress.

The points for entrenchment having been selected and indicated to the Nos. 1, these will order their detachments "right turn," "left wheel," "double march;" and when they arrive at the point determined on, will give the command, "halt—dress," to their men.

Nos. 1 will dress their men in prolongation of the line of fire.

Outwards turn.
Take two paces.

The dressing being completed, Nos. 1 will order their detachments to "outwards turn;" and having done so, the ranks will be directed to close up to each other, back to back, and ordered to "take two paces," when each rank will step two long paces of a yard each direct to its front, and then all will turn to the rear.

Nos. 2 and 3, Outwards turn.

Nos. 2 and 3 will mark the distances they have paced, and Nos. 1 will then order them to "outwards turn," when each will turn outwards 30°, and Nos. 1 will see that this turn is done correctly, and will resume their position in front on the central line, then step 5 yds. directly to their rear, halt and front, and then will, at right angles to the central line, pace 1 yard to the right and 1 yard to the left, and mark these points.

Nos. 2 and 3, Two paces—march.

Having done this, Nos. 1 will order, "Nos. 2 and 3, Two paces—march," when these numbers will step 2 yds. in the direction they have been facing, and mark these points.

Connect the trace.

The above being done, Nos. 1 will give the command, "connect the trace," upon which Nos. 2 and 3 will cut a line through all the points marked out.

Commence work.

When this has been satisfactorily completed, Nos. 1 will give the order to "commence work," upon which all the numbers will commence excavating, throwing the earth the distance of the length of a sword-blade, or 2 ft. 11 ins., clear of the trace, so as to form a small banquette.

The depth of excavation in front must be 3 ft., sloping up to a depth of 18 ins. in rear. When this depth has been reached and the interior of the pit clear, a slope of 1 in 1 is made in rear into the pit to serve as a ramp, and the inner banquette ledge of the sword's blade length is halved and sloped down to form the interior slope of the pit. A small embrasure is formed, with a breadth at the neck of 15 ins. and a slight outward splay at the mouth. The pit is now ready for service. In stiff soils the breadth of the banquette ledge may be reduced, and the solid interior slope of the pit cut down perpendicularly.

The following table will show an abstracted account of the works:—

No. of subdivision.	No. of men at work per gun.	Time occupied in construction after the order, "commence work."	Nature of ground.	Nature of cover.	Interior accommodation.
		minutes.			
1	9	43	Light, arable, sandy, and covered with bent grass.	Detachments totally invisible from the front parapet, 18 in. thick at top.	Ample in every case.
2	9	50			
5	9	52			
6	9	41			

An experimental pit was made on the previous day by some of the officers, N.C. officers, and volunteers of the battery in 58 minutes; but this was finished off with care, the slopes being neatly smoothed and dressed. As a field work, it was not more efficient than those mentioned above. Two mounted detachments of six men each were moved to the front, under an officer, with orders to advance to the attack as cavalry, and furnish objects to point the guns at. They advanced in line, with an interval of 100 yds. between each, and orders were given to the Nos. 1 to point their guns on each party in succession from right to left, and back from left to right.

Firing was ordered to be commenced as the object party came into sight on rounding a hillock about 900 yds. distant, and five deliberate rounds per gun were fired before the party came within 250 yds. of the leading guns. This shows that the pits were quite roomy and commodious enough for quick firing.

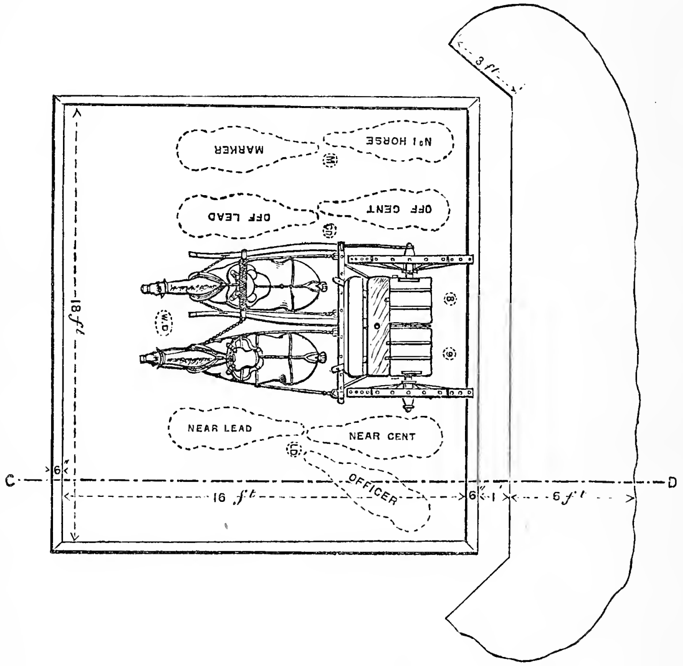
The rapidity of fire was then increased, and ten rounds per gun were fired, in order to test the stability of the parapets and embrasures, which on examination were found to be in good order, the earth standing firmly and apparently little affected by the concussion.

The officer in command of the mounted object party reported that the entrenched detachments were quite invisible to him during the whole of his advance. At the termination of the firing, the guns were easily run back for limbering up.

In a bare, level country it will be necessary to construct limber pits. This would be done by the infantry escort, who in addition should run a line of shelter trenches between the gun-pits.

The horses would be disposed as shown in Fig. 2; where the limber is backed on to the parapet, the wheel horses remain hooked in, the centre unhooked and held heads to the front on either side of the limber, by the leading driver on near side and centre driver on off side. The leading driver will also hold his riding horse, head to the rear. The off-lead is held in the same manner by the centre driver. The leading driver will also hold the officer's or staff-serjeant's horse, while the marker will hold his own and No. 1's horses outside of the off-lead and centre horses. The whole of the drivers, horses, &c., will thus be under cover.

FIG. 2.—LIMBER-PIT.



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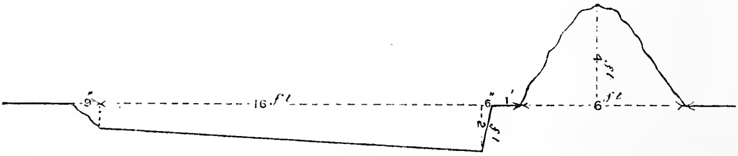

The pit may also be made so that the limber and horses will stand at right angles to the line of fire; but unless some rise or inequality of ground, the direction of which may favour this method of construction, be at hand and be taken advantage of, the plan shown in the drawing would seem the more preferable of the two.

The addition of four short planks to the equipment of a battery would be of great advantage in damp, marshy positions, where the wheels and trail are liable to embed themselves. They would be used —one under each wheel, one under the trail and at right angles to it, and the fourth over this last in the direction of the line of fire. These would greatly facilitate the traversing, and could be easily carried strapped to the trail without materially increasing the weight.

On attentively considering the subject, the question will arise: is not the present allotment of carbines rather in excess of the requirements of a battery?* Two per subdivision would seem ample for everything; indeed the number of men equipped with cartridge-pouches would point that two per subdivision, or twelve per battery, is the proper number that should be carried. The two others now carried could be replaced with two spades, at a saving of about 11½ lbs. less to carry per subdivision. Two shallow leathern baskets might also be carried as earth trays, as the gun buckets are too clumsy to be useful as earth carriers.

The necessity for adopting entrenchments as proposed may not be so seriously felt with batteries armed with rifled guns, whose long range enables them to have a greater choice of ground, and to take advantage of any intervening cover that may occur; but, as already remarked, it must be remembered that a very large portion of our batteries serving in the East are still armed with S.B. guns; and taking our very intermittent and uncertain energy of production into consideration, these batteries will remain so armed, or unarmed, for many years yet to come; and should in the meantime any emergency arise in which it may be necessary to place a force meeting the modern requirements of magnitude in the field, we will be sadly deficient in power; and unless some expedient to ensure the safety, and thus increase the effective fighting value, of our gunners be devised, we will lay ourselves open to the risk of having a great portion of our artillery arm paralysed by an enemy who, in addition to being better armed, may also be superior to us in many essential points, although perhaps inferior in the observance of the petty and trifling details towards which we have directed so much of our attention, to the detriment of those of more vital importance.

June, 1871.

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* Perhaps some readers of the above would kindly inform the writer, through these pages, when and where have field batteries been reduced to the use of their carbines, and what was the result?

A SKETCH

OF

THE AUTUMN MANŒUVRES OF 1871.*

BY

CAPTAIN W. S. M. WOLFE, R.A.,

BRIGADE-MAJOR, SCHOOL OF GUNNERY.

"L'Artillerie prend sa place."—*Napoleon I.*

THE motto before you was one of the tersest, and most comprehensive of the military aphorisms that Napoleon I. ever uttered; and now, at a time when the power of artillery has increased so immeasurably, and the results of the recent campaign were mainly attributable to the scientific use of artillery, its repetition comes somewhat strangely; more especially as the motto, in French, was to be seen emblazoned on the triumphal arches that were erected to welcome home the victorious army of Germany, after the conquest of the descendants of that army, with the ancestors of whom, the originator of the maxim had crushed their forefathers.

Let us see how the motto applies to the recent campaign at Aldershot.

For years, a constant agitation had been kept up by artillery officers as to the greater development of their arm, but unsuccessfully, and up to this summer was to be seen the senseless practice of what was called "artillery conforming to infantry." No one knew what was meant by this process, and the result was that field artillery with accurate and long shooting rifled guns were "sentenced" (and I use the word "sentenced" advisedly, as it meant complete destruction), to march side by side—*i.e.*, the leaders' heads in line with the front rank of the lines of infantry; halt when they halted, and move when they moved.

This pernicious system had become so fixed, that no ordinary authority had apparently the power of changing it; but at the outset of the campaign, the "cry of lamentation" from captains of batteries and others "went up," and on the recommendation of Sir Collingwood Dickson, K.C.B., V.C., who was appointed Major-General Commanding the Artillery for the manœuvres, His Royal Highness the Field-Marshal Commanding-in-Chief was pleased to cause the following order to be promulgated to the commanders of corps, divisions, and brigades.

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* Lecture at Shoeburyness on the 2nd October, 1871.

Memorandum relative to the employment of Horse and Field Artillery.

Memo. General officers commanding divisions or detached brigades should indicate to the officers commanding artillery under their orders, the general object of the movements about to be executed, and these officers should give directions to the captains of batteries as to the best mode of co-operating with and supporting them.

Officers commanding batteries should be permitted (under the direction of their own commanding officers) to use their own judgment in selecting the best positions to enable them to operate with advantage either in covering an attack or retreat, conforming of course as much as the nature of the ground will permit with the movements of the corps to which they are attached.

Any special directions received by the officer commanding artillery from the general or other officer in command of troops, relative to any change in the disposition of the batteries during the movements, will of course be promptly carried out.

No battery ought to be exposed to the risks of infantry fire, unless under unavoidable circumstances which occasionally occur in action.

By command,
C. R. EGERTON,
Major-General,
Deputy Adjutant-General.

ALDERSHOT, 17th September, 1871.

I fancy the memo. was not kindly received in all quarters, yet the advantage of it was most apparent; as it not only allowed the commanders of batteries to cover the movements of their infantry in an effectual, professional, and scientific manner, but it released the infantry commanders from having to drag about with them an "incubus" which they could not get rid of, and knew not how to use.

As I had the honor of serving on the staff of Sir C. Dickson, I had the opportunity afforded me of collecting matter for the following few remarks, which I hope will interest you, and at the same time give some a clearer insight into the execution of the scheme than could have been gathered by the daily and desultory reading of the newspapers. Of course all the movements and operations of which I propose to make mention did not come under my personal observation; but from subsequent conversation with officers who were eye-witnesses of those I did not see myself, I hope I shall be able to place before you concisely the manner in which the plan of the campaign was executed.

It is generally allowed that the actions of all public men are liable and open to fair criticism, and general officers cannot claim exemption on this point; but at the same time, the first duty of a soldier, namely discipline, forbids anything like offensively hostile criticism, and I venture to hope that nothing I shall say may be construed in the smallest degree to a want of strict discipline and subordination on my part.

I propose to follow as nearly as possible the daily movements of each corps; and I use the word corps, because each separate force represented more nearly in its composition a *corps d'armée*, although a small one, than a division, which does not usually contain portions of all branches of an army, but generally signifies a large force of a separate arm—as "divisions of infantry," or "divisions of cavalry," to which may be, however, and nearly always is, attached a proportion of artillery. Towards the close of my remarks I shall make allusion to what has been generally admitted as shortcomings in our first attempt, which I would premise, as a first attempt, may be pronounced a success, and more than carried out what our facetious friend "Punch" designated recently as "all's pretty well."

The map before you represents upon a large scale the country over which the operations took place. The ground was limited in area, as you probably know, by an act of Parliament, and although before the manœuvres commenced some critics took exception to the small extent of ground, yet it proved quite large enough for the force employed, and rather too large for the powers of the transport service. As you will observe, the ground assumed every phase—mountain, moor, bog, wood, cultivated land, parks, and villages, intersected by railways, canals, streams, and roads of all natures, from the good level turnpike to the merest forest or moorland track; at the same time several lakes and ponds, whilst adding to the difficulties of the country, facilitated the watering of large bodies of cavalry.

Aldershot Camp lies as nearly as may be in the centre of this tract of country, and as from it principally supplies were drawn, I think the locality was well and judiciously chosen as the site of our first attempt. We must walk before we can run, and it was at least prudent to guard against the contingency of an utter collapse.

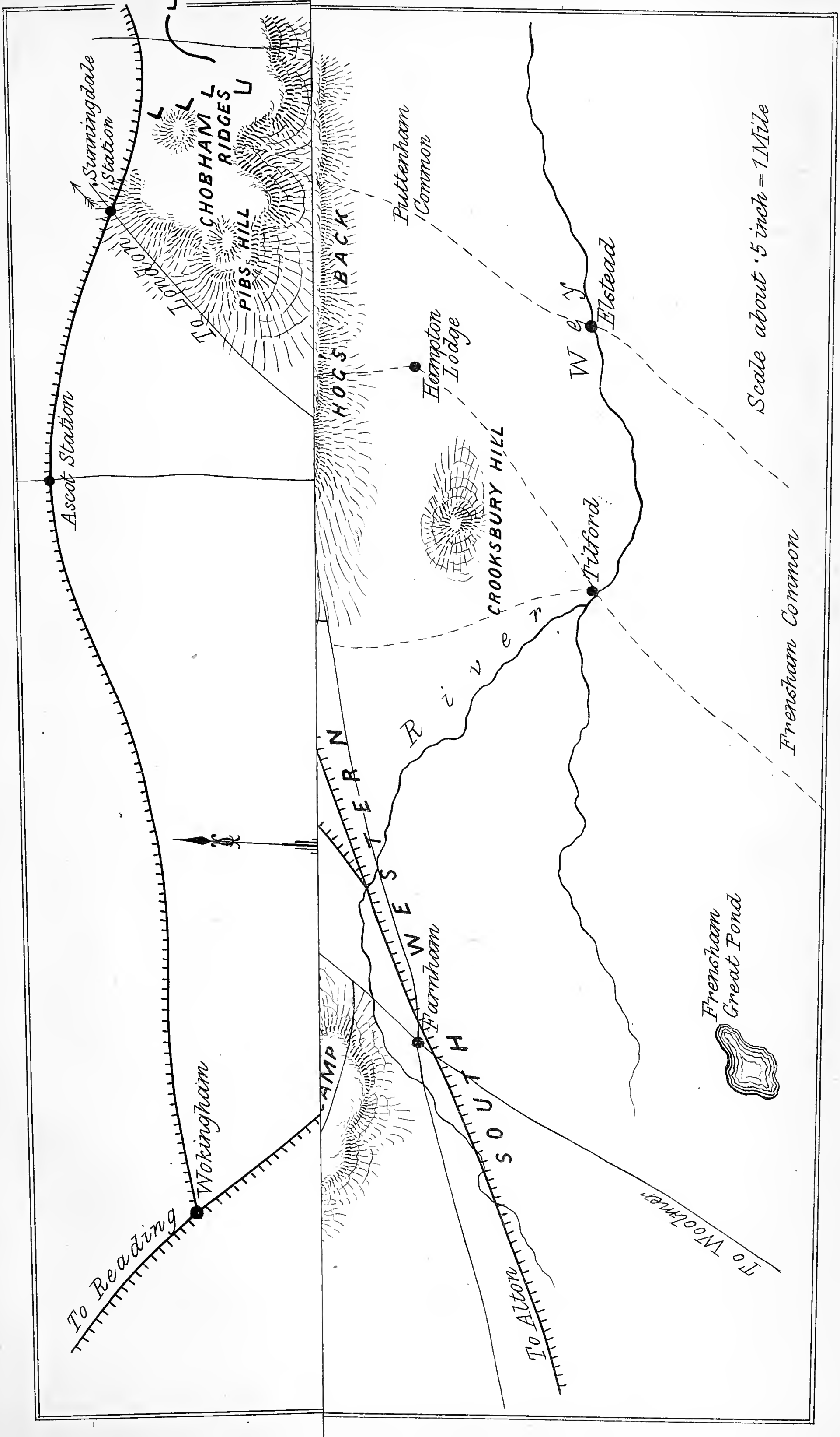
The troops began to assemble at Aldershot about the commencement of the month, and the earlier period was consumed in teaching the militia to drill, the cavalry to picket their horses, and the staff—many of them entire strangers, not only to the country, but to the troops with whom they were called upon to serve—to make acquaintance with their new duties. Some difficulties presented themselves from the want of transport, which as you all know is the most vital necessity in a campaign, and one that is most neglected in England, for it has been truly said that an army marches not upon its feet but upon its belly.

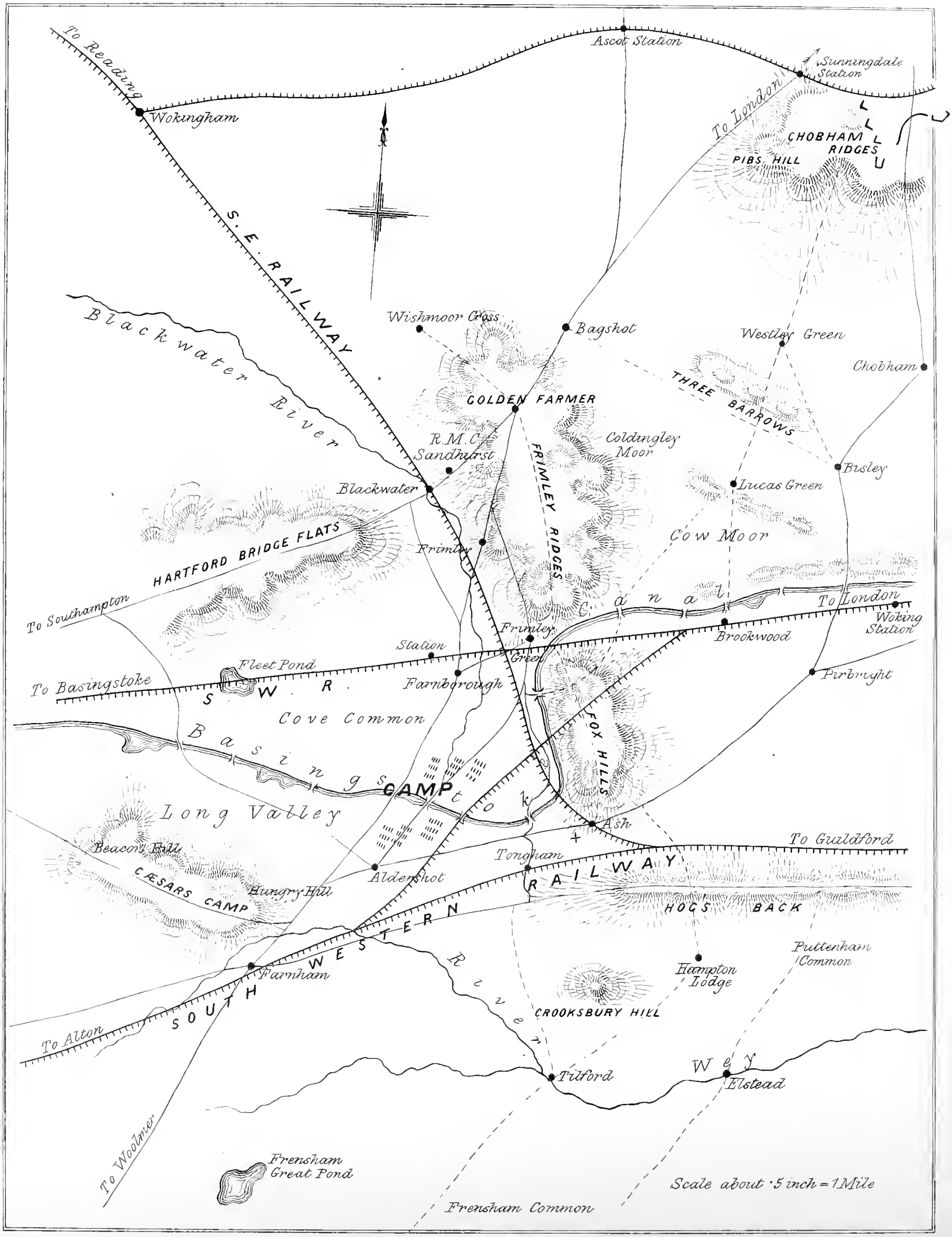
As soon as the transport began to assume some form, two corps were formed and left the camp of Aldershot on the 8th September, one for Hartford Bridge Flats, another for Woolmer Forest, leaving enough to form another corps at Aldershot pending the further organisation of the Control Department. For some time it was doubtful whether this corps could march further than half-a-day's march from Aldershot (returning thither every night), but everyone was rejoiced when on the 12th inst. the force under Sir Hope Grant left Aldershot and marched to Pirbright Common.

The positions of the three corps were on the evening of the 12th inst. as follows:—

1st, Grant's	Corps ...	Pirbright (subsequently to Chobham).
2nd, Carey's	" ...	Hartford Bridge.
3rd, Staveley's	" ...	Woolmer.

Everyone felt that the presence of three distinct bodies in the field,


To Reading
Wokingham
Ascot Station
Sunningdale Station
To London
CHOBHAM RIDGES
PIBS HILL
HOGS BACK
Puttenham Common
Hampton Lodge
Elstead
River Wey
CROOKSBURY HILL
Tilford
Frensham Common
Frensham Great Pond
CAMP
Farnham
SOUTH WESTERN
To Alton
To Woolmer
Scale about ·5 inch = 1 Mile


To Reading
Ascot Station
Sunningdale Station
Wokingham
To London
CHOBHAM RIDGES
PIBS HILL
S. E. RAILWAY
Wishmoor Cross
Bagshot
Westley Green
Chobham
Blackwater River
THREE BARROWS
GOLDEN FARMER
R.M.C. Sandhurst
FRIMLEY RIDGES
Coldingley Moor
Bisley
Blackwater
Lucas Green
HARTFORD BRIDGE FLATS
Frimley
Cow Moor
Canal
To Southampton
To London
Woking Station
Frimley Green
Brookwood
Station
Fleet Pond
To Basingstoke
S W R
Farnborough
Pirbright
Cove Common
FOX HILLS
Basingstoke
CAMP
Long Valley
Ash
Beacon Hill
To Guildford
CÆSARS CAMP
Tongham
Hungry Hill
Aldershot
RAILWAY
HOGS BACK
SOUTH WESTERN
Farnham
River
Puttenham Common
Hampton Lodge
To Alton
CROOKSBURY HILL
Wey
Tilford
Elstead
To Woolmer
Frensham Great Pond
Scale about ·5 inch = 1 Mile
Frensham Common

and in almost immediate presence of one another would render the conception of a scheme of operations very difficult, as under any circumstances, from the equalisation of the bodies, the forces opposed to one another would be in the proportion of two to one.

Head-Quarters Army Corps,
Aldershot, 13th September, 1871.

General Sketch of Manœuvres.

General order. The enemy having effected a landing on the south coast of England, has refused the direct roads upon London, and is endeavouring to turn the strong positions between Reigate, Dorking, and the Hog's Back, and so to gain the valley of the Thames, and march upon London.

His advanced corps (the 2nd Division) has reached Hartford Bridge Flats, and the main body (the 3rd Division) is at Woolmer.

A defending force (the 1st Division) has been collected in the vicinity of London, and has moved to Chobham.

Such is the position this day.

On the evening of the 13th the programme appeared, and it was, at a glance, clear that it was based upon false premises, but this was unavoidable, owing to the want of water, transport, and many other incidental matters of that sort. For instance, if the 2nd Corps had ever reached Hartford Bridge, and commanded the passage of the Blackwater, nothing short of a general action would have forced it to retreat, situated as it was on the high road, and as near to London as the 1st Corps; nor would the latter have ever thought of holding Fox Hills or the Hog's Back, were the 2nd Corps where it was, viz. almost in his rear. Again, the 3rd Corps would never have attacked the position of the Hog's Back, but would have advanced to its left front, and have assisted to maintain the 2nd Corps in the position it was fortunate enough to find itself in—a very easy operation, as the capture of a small chain of hills and Farnham would have effected the double purpose of reinforcing the 2nd Corps and turning Grant's position on the Hog's Back and Fox Hills. However, circumstances, as I have before told you, led to the selection and adoption of the scheme by the highest authorities, and it only remained for us to carry it out.

Each corps contained—

3 batteries of artillery,
3 (1st Corps 4) regiments of cavalry,
11 battalions of infantry.

The corps were numerically nearly equal as well as similar in their composition, if you except the 1st Corps, that had no light cavalry and was forced to perform its outpost duties with the heavy cavalry of the guard, who, however, showed themselves quite equal to the occasion. Five batteries of artillery were at first left, for reasons of supply, at Aldershot, and were called generally "the reserve," but on the 16th they were dispersed—three batteries to the 1st Corps, and two batteries to the 3rd Corps.

Umpires were appointed to give their opinions, to decide questions as to who were beaten on occasions of collision, and to prevent troops crossing bridges over railways and canals after they had been blown up or destroyed, until sufficient time, as in their opinion, had elapsed for their repair.

General order. THURSDAY, 14th.—The officer commanding defending force having got information of the position and estimated strength of the enemy's advanced corps, breaks up his camp at Chobham, and advancing to Chobham Ridges, threatens its communications, throwing out cavalry to Frimley, Farnborough, and across the canal to Pirbright.

The enemy (the 2nd Division) ascertaining this move by his scouts, falls back across the Basingstoke Canal, and takes up a position near Cæsar's Camp, sending information of the advance of defending force to the main body, which moves to his support, and encamps at Frensham.

FRIDAY, 15th.—The enemy's advance corps continues its retreat, and effects a junction with its main body near Frensham.

The defending force continues to advance, and encamps at Pirbright, throwing out advanced posts to occupy the commanding ridge of the Hog's Back.

SATURDAY, 16th.—The opposing forces being now in contact, the general operations will commence.

By command,
C. R. EGERTON,
Major-General,
Deputy Adjutant-General.

The encampments of these corps up to this time had been made upon no fixed principles of offence or defence, but solely with the view of affording the greatest facilities for water and transport, and if you except a raid made by the cavalry of the 2nd Corps upon the outposts of the 1st Corps, before war was declared, near to Bagshot, peace reigned everywhere. In conformity with the programme, the 2nd Corps retired to Frensham Great Pond on the 15th, and the 1st Corps advanced to Pirbright Common, the latter holding the line of the Hog's Back with his outposts, which consisted of cavalry and weak picquets of infantry. The 3rd Corps threw out videttes as far as the high ground overlooking Crooksbury Hill and Puttenham Common.

HEAD-QUARTERS ARMY CORPS,
Aldershot, 15th September, 1871.

Continuation of General Sketch of Manœuvres.

General order. SATURDAY, 16th.—It is assumed that on the morning of Saturday, the 16th, the 1st Division (defending force) having failed in intercepting the enemy's advanced corps (2nd Division), and preventing its junction with the main body, has occupied a strong defensive position on the Hog's Back, his right being in the direction of Hungry Hill.

The division has been reinforced during the night by three batteries of artillery, and his right will for the day consist of a skeleton force of cavalry and infantry, representing 2000 men.

The 2nd and 3rd Divisions have effected their junction, and finding themselves in superior force, will make a combined attack on the position held by the defending force.

The 3rd Division will attack to its front, and the 2nd Division will endeavour to turn the enemy's right by a flank movement.

The senior officer of these divisions will regulate the advance.

The operations of the day must not extend beyond the Puttenham and Wanborough Road on the left of the position, and the Beacon Hill on the right.

The main bodies of the 2nd and 3rd Divisions will not move from their camping ground till 8 a.m., nor are the outposts to be thrown beyond the positions occupied during the night till that hour.

By command,
C. R. EGERTON,
Major-General,
Deputy Adjutant-General.

Sept. 16th. At daylight, the corps began to move: the 1st Corps to a strong position on Fox Hills, with outposts strengthened upon the Hog's Back and at Tongham Railway Station. This corps had been reinforced by a detachment composed of odds and ends picked up in the camp, consisting of about 2000 men and six guns. This little force was directed to hold the position of Hungry Hill and Cæsar's Camp, and so at a long distance protected the right of the 1st Corps and the main Farnham Frimley Road from any attempt of the cavalry of the 2nd or 3rd Corps, and had orders, on retiring, to blow up all the bridges across the canal. This flanking force were truly *enfans perdus,* for it was separated by about three miles from its main body, and would have had the greatest difficulty to escape at all from the grasp of the 2nd and 3rd Corps, let alone to hold the Cæsar's Camp position, which is really one of no strength from the south side.

2nd Corps.—The 2nd Corps left its camp, and passing through Farnham, sending its cavalry by a wide detour to its left, stormed and carried the line of Cæsar's Camp and Hungry Hill, and afterwards descended into the Long Valley and Aldershot Camp and Common, until it was checked by all the Basingstoke Canal bridges being blown up. Owing to the wide detour, and the time necessary to repair the bridges, together with the want of arrangement for its earlier departure, this corps never took part in the affair, but received orders, in the evening, to encamp on Cove Common for the Sunday.

3rd Corps.—This corps marched early, and crossing the Wey at Tilford and Elstead, took up with its right brigade of infantry and a portion of its cavalry, the high ground by Hampton Lodge and Puttenham Common, while the left infantry brigade and a portion of cavalry tried to effect a turning movement by Moor Park and Tongham; but owing to the bridges over the S.W. Railway being destroyed, this flanking force also failed to act in concert with its main body.

That is now the position of the three corps at the moment of collision, in which some of you may recognise a similarity of position with that of the French and Austrians before the battle of Magenta, 1859; only that MacMahon arrived in time, and succeeded in his turning movement.

The 3rd Corps advanced, covered by skirmishers, and drove in the advanced posts of the 1st Corps on the Hog's Back, who retired rapidly, destroying the railway arches and bridges on the main position of Fox Hill; and so cleverly did it manage to effect its retreat that the advance of the 3rd Corps failed to keep it in view, and lost its trail entirely. The right brigade and some cavalry of the 3rd Corps advanced in seeming security, without any feelers, until it found itself within the easy range of the artillery posted on Fox Hill, which opening fire, in a short time destroyed and demoralised this attacking force round Ash Church. The left brigade came up shortly after, and was treated in a similar manner.

The 1st Corps had, up to then, only engaged with its artillery, without calling on its supports in any way; and the umpires decided that the 1st Corps had succeeded in repelling and destroying the 3rd Corps.

Owing either to the want of transport or the want of organisation of it, the 1st Corps was compelled to fall back—leaving the strong position it had so successfully held—to Bisley Common, where it encamped for the night and for Sunday; and here came one of the ridiculous episodes of the campaign—the defender and invader marching peacefully side by side, sometimes actually on the same road, in order that the latter might find its forage and commissariat stores that had been deposited overnight four miles in rear of the defenders' position, and which of course they had too much good feeling to destroy, or to carry off if they could; which however was impossible, seeing that they could hardly transport their own stores.

We have now seen how the first day's manœuvres were rather a *fiasco*, and boded badly for the future.

Sept. 17th. Sunday was a day of perfect rest; not even outposts or picquets were placed.

HEAD-QUARTERS ARMY CORPS,
Aldershot, 17th September, 1871.

Continuation of General Sketch of Manœuvres.

General order. MONDAY, 18th.—The 2nd and 3rd Divisions will continue their operations; their object being to reach the valley of the Thames.

The area of operations is restricted on the north by the London and Southampton Road, and to the east by the Brookwood Station, London and South-Western Railway.

By command,
C. R. EGERTON,
Major-General,
Deputy Adjutant-General.

Sept. 18th. On Monday hostilities commenced. Again was to be clearly traced the pernicious tendency of the existence of three corps. For had the affair been real instead of what it was, the 1st Corps, having the command of the bridges of the canal, could and would have fallen upon the 3rd Corps, and either have beaten it off its junction with the 2nd Corps or destroyed it altogether; and it would have had yet time, under cover of the broken bridges on the north loop of the canal, to have turned round and smashed the 2nd Corps, as Napoleon I. did in 1814 when protecting his capital. It had the very great advantage of acting on interior lines to either of the others, and was in a position to fight either, without exposing its line of retreat by the Bagshot or Chobham roads to London. However, no such advantage was taken, and it remains only to relate the adventures of this day.

Again the 2nd Corps may be left out of the question, either from its marching too late, or the 3rd Corps attacking too soon; the cavalry only of the 2nd Corps arrived in time to see the end of the action, but not to take part in it, as it become considerably entangled in the swamps of Coldingley Moor.

As soon as eight o'clock—the conclusion of the armistice—struck, the horse artillery of the 1st Corps commenced to shell the camp of the 3rd Corps, which had not then been struck. Stung by this insulting demonstration, the skirmishers of the 3rd Corps advanced and drove those of the 1st Corps across, not only the railway but the canal, the bridges over both of which were blown up; and supported by a fire of artillery—principally at Brookwood Railway Station, where it was well sheltered in pits improvised with sleepers and railway iron—the pioneers and the engineers commenced making a bridge and repairing the others across the canal, but they were compelled to desist until the main body of the infantry of the 3rd Corps had been brought up to their assistance, when they were allowed to cross the canal. And now comes a question whether it was expedient to attack the right flank of the 1st Corps; by attacking that flank, as the 3rd Corps did, the 1st Corps were not only forced back *upon* their line of retreat, but were driven further away from the flanking movement of the 2nd Corps; whereas, had the attack been pushed on the left flank of the 1st Corps, it would have thrown its line of battle into the most disastrous possible position—namely parallel to, and in prolongation with, or *off* its line of retreat, and still more, would have tended to jam it effectually between the attack of the 3rd Corps and the flanking or turning movement of the 2nd Corps.

At any rate, the right of the 1st Corps began to fall back, and eventually was compelled to change front in retreat, harassed by the rapid advance of a demi-brigade of the 3rd Corps. After some desultory fighting, the 1st Corps took up an intermediate position on some rising ground in front of the cultivated lands of Bisley and Lucas Green, where it held its own until the cavalry and some infantry of the left of the 3rd Corps, ever pushing their success, began to outflank, when a general retreat, covered by cavalry was ordered, and entangled as it was in the narrow lanes of the village of Bisley, it is probable that a large portion of the corps would have been destroyed; however, the retreating force took up a very strong position, well garnished with artillery, on the New England and Three Barrows Hills, which being too strong for an attack in front, and the 2nd Corps not arriving in time to operate, if you except a portion of their light cavalry, the operations ceased for the day, and the 1st Corps drew off unmolested to its entrenched position of Chobham Redoubts.

The encamping grounds were that day as follows:—

The 1st Corps at Chobham Redoubts.
" 2nd " Wishmoor—cavalry at Sandhurst.
" 3rd " Barrows Hill and Bisley.

It is very doubtful whether in this day's fighting the 1st Corps could have ever been dislodged from the line of the canal, or that the canal could have been forced by an enemy numerically inferior, let alone been driven from one position to another; and excepting "common rumour," nothing as yet had been heard of the 2nd Corps being in co-operation with the 3rd to compel a retreat, and it would have been better perhaps if the appearance on Frimley Ridges of the 2nd Corps had been allowed to be made, before the 1st Corps was supposed to be driven from the strong position of the Basingstoke Canal. As it was, it had too much the aspect of a preconcerted field-day than a representation of real war.

HEAD-QUARTERS ARMY CORPS,
Aldershot, 18th September, 1871.

Continuation of General Sketch of Manœuvres.

General order. The 1st Division having on Saturday retired from the Hog's Back, and occupied a new position on the Chobham Ridges, was attacked in it this morning and forced further back in the direction of Chobham, where it is supposed to be entrenched.

The 2nd and 3rd Divisions will continue the advance to-morrow, and attack the 1st Division in position, moving from the camping grounds not earlier than 8 a.m.

There will be no limit to the area of operations except those laid down by the "Military Manœuvres Act," and land interdicted by the Commissioners, as clearly shown in the maps which have been furnished to general officers commanding divisions and brigades.

By command,
C. R. EGERTON,
Major-General,
Deputy Adjutant-General.

Sept. 19th. The 1st Corps having fallen back the previous evening to the fortified position already selected, and reinforced by volunteers and artillery, determined to give battle to the now nearly united 2nd and 3rd Corps, although the opportunity yet offered itself of attacking, by a sally from its lines, the two corps in detail. Morning broke with a slight affair of outposts in front of Pibs Hill and Sunningdale Railway Station; for the 2nd Corps, determining this time not to be out of the fight, had taken the initiative, and reinforced by nearly all the cavalry of the 3rd Corps, began to feel their way early across the main Bagshot road. The 1st Corps reinforced their outposts on the right flank, and for a time, supported by their cavalry and artillery, held their own, thereby compelling the 2nd Corps to deploy and unmask all their forces, and drew them on under the fire of the entrenchments.

Perhaps this forenoon's operations was, as a spectacle, the most perfect, as the weather added much to the brilliancy of the scene, and from the knolls could be seen the advances of infantry, the charges of cavalry, and the play of the guns. Still nothing had been heard of the 3rd Corps, which was really the corps to attack in front, and up to mid-day the flanking or 2nd Corps had been the only one to make any demonstration against the entrenchments; suddenly, however, a detachment of the 3rd Corps menaced the left of the position, and without advancing, drew off the defenders' attention from a junction that was being effected with the 2nd and 3rd Corps. It was felt that although the entire and now united force of invaders would probably have made no impression upon the works, yet that on the occasion of so many troops being assembled together, and taking into consideration the splendour of the day and the favourable nature of the ground for working over, that the attack had not been allowed to develop itself further, but in consideration of the distances marched over, and the distance back to the encamping grounds, that the troops had had enough, and they were ordered back to their encampments.

The nature of the works that sheltered the 1st Corps are worthy of some remarks. They roughly resembled a Y with their flanks resting on the railway cutting and woods, and were shallow trenches connecting works, sometimes redoubts, sometimes small bastions, with emplacements for field guns. The right face of these works were strengthened with detached redoubts, which would have been better had they been open at the gorge, and not exposed to be all of them directly enfiladed by guns placed upon a hill about 1700 yds. distant. The apex of the work was a knoll with triple lines of slight parapet and rifle pits, with a sand-bag screen for a couple of guns, and ill provided with flanking fire. Some of the works were not finished, and the tracing tape and profile had to do duty for earthworks. The lines of defilade had also received slight consideration.

Sept. 20th. This day was one of repose, which the troops, more especially the cavalry, much required.

HEAD-QUARTERS ARMY CORPS,
Aldershot, 20th September, 1871.

Continuation of General Sketch of Manœuvres.

General order. THURSDAY, 21st.—The defending force (1st Division) having yesterday maintained its position, has been reinforced and will this day advance.

The enemy (3rd Division) will endeavour to check the advance, and cover Aldershot.

There will be no limit to the area of operations except those laid down by the "Military Manœuvres Act," and such lands as have been interdicted by the Commissioners.

Each corps will move at such hour as will bring it into the position selected by the general officer commanding, from which to commence his operations, by 9 a.m.

The baggage of both forces is to be considered as neutral to-morrow.

By command,
C. R. EGERTON,
Major-General,
Deputy Adjutant-General.

Army Corps Orders.

ALDERSHOT, 20th September, 1871.

No. I.—ARMY CORPS.

The 2nd Division will for the operations of to-morrow be broken up and divided between the other Divisions, which will be constituted as follows:—

1st DIVISION—DEFENDING FORCE.

Major-General G. J. CAREY, C.B., Commanding.

CAVALRY.

General His Royal Highness the PRINCE OF WALES, K.G., Commanding.
Colonel Baker, 10th Hussars.

1st BRIGADE.	2nd BRIGADE.
Colonel Marshall, Commanding.	Colonel Wombwell, Commanding.
1st Life Guards.	10th Hussars.
2nd Life Guards.	12th Lancers.
Royal Horse Guards.	Hants Yeomanry.

2 Batteries Royal Horse Artillery.

INFANTRY.

Major-General His Serene Highness PRINCE EDWARD OF SAXE WEIMAR'S Brigade,
with 1 Field Battery.

Major-General LYSON'S Brigade,
with 1 Field Battery.

Major-General MAXWELL'S Brigade,
with 1 Field Battery.

2 Field Batteries from the Reserve Artillery.

The whole of this force to wear green leaves or heather in their head dress.

3rd DIVISION—THE ENEMY.

Major-General Sir CHARLES STAVELEY, K.C.B., Commanding.

CAVALRY.

Major-General Sir T. M'MAHON, Bart., C.B., Commanding.

1st BRIGADE.	2nd BRIGADE.
Colonel Seymour, Commanding.	Colonel the Hon. I. Fiennes, Commanding.
2nd Dragoon Guards.	7th Hussars.
3rd Dragoon Guards.	9th Lancers.
7th Dragoon Guards.	

1 Battery Royal Horse Artillery.

INFANTRY.

Major-General BROWNRIGG'S Brigade,
with 1 Field Battery.

Colonel STEPHENSON'S Brigade,
with 1 Field Battery.

Colonel SMITH'S Brigade,
with 1 Field Battery.

1 Battery Royal Horse Artillery and 2 Field Batteries from the Reservo Artillery.

These arrangements will be carried out on Thursday morning, the troops moving at such hours as the general officers commanding the divisions which they are to join may direct.

The baggage will return direct to Aldershot to-morrow morning.

From Chobham, by Pirbright.
From Bisley, by Brookwood.
From Sandhurst, by Frimley.

By command,
C. R. EGERTON,
Major-General,
Deputy Adjutant-General.

Sept. 21st. The 2nd Corps was for this day's manœuvres divided between the other two, and the programme left almost absolute liberty to the commanders of these corps. The 3rd Corps, strengthened by a portion of the 2nd Corps under General Staveley, were to prevent the return of the 1st Corps, reinforced by a portion of the 2nd Corps, to Aldershot.

Opposing Forces.

1st Corps.		3rd Corps.	
Cavalry........	6 Regiments.	Cavalry........	5 Regiments.
Infantry	17 Battalions.	Infantry	16 Battalions.
Artillery	42 Guns.	Artillery	42 Guns.

In order to do this, a long line had to be taken up or observed—viz., from the line of the Frimley Bagshot road on the left, to the Pirbright, Ash, Aldershot road on the right—a front of at least seven or eight miles, over nearly all of which every arm could be manœuvred.

I shall for simplicity still call the corps the 1st and 3rd.

The 3rd Corps held strongly the position of Chobham Ridges, with their left on Golden Farmer junction, with a brigade in Frimley and another on Frimley Green, with outposts along the top of the ridges overlooking Bisley Green and the Brookwood Railway Station. These detachments were formed of the reinforcements from the infantry of the 2nd Corps that were joining the 1st Corps from their camping ground at Wishmoor Cross. These detachments were subsequently closed in to their right on the main body, but hardly in time to save being cut off by an enterprising body of lancers who had appeared on their left flank as they were on the march. The commander of the 3rd Corps had rather prejudged the course of events, and had massed his forces on the south end of Fox Hills, as he conceived that the 1st Corps meditated a flank march by Ash into Aldershot, and his idea was at the first borne out by large columns of dust that were seen moving in that direction; but of these we must speak when following the movements of the 1st Corps.

The 1st Corps, moving from their camp, and reinforced by cavalry, artillery, and infantry of the now broken up 2nd Corps, advanced their cavalry until they ascertained that there was no force in their immediate front; then suddenly withdrawing them, they passed them over the canal and railway by the bridges at Woking and Cowmoor, and commenced an advance in three columns towards their left front; these columns caused the dust I have above alluded to, and tended to deceive the 3rd Corps. After the cavalry had made a demonstration to turn the right of the 3rd Corps, the infantry crossed the bridges lower down, and which were now repaired, and marched through woods and eventually deployed across the left flank of the position taken up by the 3rd Corps, whilst a portion moved round their left and rear, and hidden by woods awaited the attack. During the whole of this time the cavalry of the 1st Corps performed their duty so well, that whilst at the same time being perfectly aware of the position they were about to attack, from repeated small dashes up nearly to the guns, they entirely masked the movements of their infantry, and prevented any exploration on the part of the cavalry of the 3rd Corps, who remained *dismounted* in second line. On a sudden, a rattle of firearms announced that the attack had begun, and troops hurrying from right to left proclaimed that the position was attacked in flank. Some infantry had been hidden very skilfully, and made a dash at the wooded extremity of the position, and although numerically weak they effected a lodgment, and were speedily supported by others, while their cavalry slipped round in rear and commenced to show on and to protect their right flank. The attack developed, and the fire of guns showed that the position was turned. The cavalry of the defenders attempted to support their left flank, but were beaten by the ever-increasing cavalry of the attack; and in spite of the concentration of the fire on the part of the reserve artillery of the defence, they were forced to change front and bring up their infantry of their right flank in support towards their left in second line, and so prolong their front. This entirely denuded their right flank, and at an instant the brigade of invaders, that had been waiting for orders, crowned the heights almost unopposed, and completed the rout of the 3rd Corps, who retired to a second position with their backs to the canal, where destruction was inevitable. At this period all operations stopped, and the troops returned to their quarters, huts, and encampments in Aldershot; and so ended the first attempt at manœuvring British forces in the field.

Sept. 22nd. The following day there was a march past, at which all the foreign officers assisted, and were in loud praises of the manner in which the troops turned out, and marched, after the toils of the past ten days.

Sept. 23rd. On the 23rd several regiments left for their own stations, among others the cavalry regiments of the guard, who marched to London in 7¼ hours, a distance of thirty-four miles, thereby showing that they can not only look superb in the park, but can make long marches, as well as their comrades in the light cavalry. A battery of Royal Horse Artillery also marched to Woolwich in one day, a distance of forty-four miles.

It would ill become me, as holding a very subordinate position in the campaign, to presume to criticise the actions of the generals in command, yet I feel that the subject upon which I am now speaking would hardly be completely treated unless I were allowed to make some deductions from what came under my observation.

As you all know, it was an attempt at copying the Prussian system of manœuvres; but tied down as we soldiers are, by what is called "the liberty of the subject," it became impossible to assimilate to, or to copy their system absolutely, or to act as would be done in war time. I allude more particularly to the inability that the military authorities have in this country of billeting troops on the inhabitants. Now this simple want tends to diminish very vastly any similarity between mimic and real war, and it acts very hardly upon the newly formed and somewhat chaotic system of control, by forcing it to find transport for tents and camp equipments, which is perhaps the most bulky of all the *matériel* carried with an army. In future wars it is doubtful whether time will ever be given for the encampment of large bodies of troops, as was the case 100 years ago. If these manœuvres are to be repeated, it might be worthy of consideration whether any very great hardships would be enforced on the inhabitants of a district by the billeting officers and soldiers upon them for one, or two nights at most. At any rate, the country at large would be the gainer; and to judge by the business done in the villages during the recent manœuvres, the natives themselves would have no objection whatever to the society of the soldiers for a night or two. At any rate, no real experience can ever be gained by the control branch until the conditions of actual war are more closely imitated.

As you may doubtless have heard, there have been shortcomings, and the bringing of them to light can do no possible harm, if done in a fair and proper spirit. It has been too much the fashion to call out, "The control broke down," without waiting to enquire exactly what is meant by the sentence. If it be meant that the system broke down, that was impossible, for there was no system, it is in course of creation; if it be meant that the controllers and their subordinates were lazy or stupid, I beg to offer my distinct contradiction, as no department worked harder, and more cheerfully from before daylight until sometimes long after dark, at the end of which time, they were generally only received with grumbling, as a reward for their exertions; and I may with pride allude here to the self-denial and the zeal shown by the detachment of our own Regiment, lent for the occasion, without whose cordial co-operation the manœuvres could never have taken place.

It was always a difficulty to know where the duties of the control ended, and that of the regiments began, with reference to supply, and this was an endless source of discomfort to everybody. Again, there was a tendency on the part of the Control Department to assume the position of a separate body, responsible only to their own chiefs, and ignoring all military chain of authority. This is an item of most considerable importance, and as soon as that department act under and through the staff of the general, some progress may be made in the administration of the army, but as long as the body assert an independent and irresponsible position, with regard to the military authorities, so long will chaos and confusion exist, besides failing to secure for themselves, the support of the staff, and the confidence of the troops.

Some regiments adopted a system of regimental transport which answered very well; the artillery always did, and I think on the whole fared the best of all the arms employed. I need hardly say that the various tea carts, vans, drays, and shandy drans of sorts, supplied by civil contract broke down utterly in all directions, and were useless, or worse, to the army, whilst their drivers were subject to no discipline nor control whatever; although some of the drivers did their duty conscientiously, and to the best of their ability, they could however never be relied on, and their pace averaged from one to one and a half miles an hour.

I am afraid to think that the staff were hardly free from all blame; as a rule, the country was hardly thoroughly explored and known, and the constant collisions of troops on the march betoken a want of care, both in the selection of the routes to be followed, and the times of departure; whilst the absence of all co-operation in the first two days of the campaign of the 2nd Corps, showed clearly, how disastrous to an army, might and would be the ignorance and the neglect of the primary rules of *logistics*, by the close adherence to which, the Prussians owe in a very great measure, their successes in their last campaign in France.

The mounted portions of the corps were often widely separated from one another, and from their forage, and often had to go an unnecessary distance for water; while the entire encampments were often needlessly extensive, thereby rendering the circulation of orders tedious and embarrassing. The campaign also showed the advantage that would be derived in having one staff corps instead of three departments—viz., Adjutant-General's, Quarter-Master-General's, and personal.

Such maps as were issued were worse than useless; as besides being incorrect in the general features of the ground, they were obsolete, as far as roads and boundaries were concerned, the face of the country having altered so much since the date of their manufacture.

The cavalry, with few exceptions, clung to the traditionary movements in masses, sometimes under the close fire of infantry, and neglected the more important duties of being the eyes of the army: this more particularly referred to that belonging to the 3rd Corps, on the first and last days of the campaign.

The artillery and engineers appeared, if I may be allowed to say so, more at home at their work than the other branches, and this was remarked to me by more than one foreign officer; the issue of the order I read to you at the commencement of the lecture tended materially to develop our freedom of action, whilst it freed the generals from the constant restraint that the presence of artillery seems always to exert on their plans, and their mode of execution.

The infantry of the line marched and went through their work cheerfully and well, and if you except an entire disregard for availing themselves of cover, and a tendency to open fire at very long range, appeared to leave nothing to desire.

The militia showed their very marked inferiority in training, and *physique* to the line; though, probably, with an improvement in the professional knowledge of their officers, and a severer course of training on the part of the men, they might be reasonably looked to to supply vacancies in, and indeed be brigaded with, the line. But it is to be remembered that the militia at Aldershot could hardly be considered as a fair sample of the force.

Of the yeomanry little can be said, either for quantity or quality. Out of the large and much-talked-of body of this force in England, only about 170 put in an appearance, and these were ill-drilled, unsoldierlike men, badly mounted on unbroken, underbred horses, and could not be relied on either for moving as a body or for getting about the country. The force in the field was a direct contradiction to the generally received and ill-founded notion, that every man in the yeomanry is young, active, eleven stone, rides a £200 hunter, and that no country can stop him.

Of the volunteer infantry, such a very small force ever took part in the operations that one can form no judgment of the value of the force. Suffice it to say, that what were there did very well, and kept up the credit of their stay-at-home brethren. The handful of this force were *volunteers of volunteers,* should be taken as the very pick of this force, and no criterion whatever of what might be expected of it when called out in any numbers.

In conclusion, I am sure you will agree with me in hoping that the manœuvres may become annual, and that such a good beginning may not be allowed to drop; also, that the next may be more assimilated to actual war operations. In order to secure this, it must be an absolute necessity that they be removed for the future from even the atmosphere of Aldershot, and also to a site, where the nature of the country is less difficult to work over. I hope also that the "autumn manœuvres" may induce us to leave off the pernicious system of always crying down our own army to the extolling of other nationalities, any one of whom would have found it hard to have put 33,000 men of such *quality* in the field; and moreover force every thinking soldier to the fact, that now more than ever, there is reason for the maxim of the great Napoleon, that "L'Artillerie prend sa place."

October, 1871.

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